universität wien

MASTERARBEIT / MASTER'S THESIS

Titel der Masterarbeit / Title of the Master's Thesis

„TheHub - Design and Implementation of an Academic Project Hub“

verfasst von / submitted by

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angestrebter akademischer Grad / in partial fulfilment of the requirements for the degree of

Master of Science (MSc)

Wien, 03-2022 / Vienna, 03-2022

Studienkennzahl lt. Studienblatt / degree programme code as it appears on the student record sheet:	UA 066 921
Studienrichtung lt. Studienblatt / degree programme as it appears on the student record sheet:	Masterstudium Informatik
Betreut von / Supervisor:	Univ.-Prof. Dipl.-Ing. Dr. Wolfgang Klas

Acknowledgements

Firstly, I would like to express a huge "Thank you" to my supervisor, Univ.-Prof. Dipl.-Ing. Dr. Wolfgang Klas. He was the first to believe in the relevancy of my topic, spent much time in discussions with me, provided me with very valuable as well as substantial input, and allowed me to act very autonomously, which I really appreciate.

Additionally, I am grateful to all interviewees, supervisors/professors and students alike, who took some of their valuable time to be a part of this work's qualitative study and expressed their opinions and views. Their input was certainly crucial, and I hope I was able to do their contribution justice.

I, of course, want to thank my parents for their extensive support all throughout my studies and life as well.

My acknowledgements also would not be complete without mentioning my dear tomcat Ushnu, also known as Minko. He was with me during the entire process, provided me with valuable emotional support, and especially motivated me to take necessary breaks.

Lastly, I also want to express my gratitude to my colleagues and friends that I met along the way of my academic journey. They certainly made the overall process more enjoyable and provided support at various times.

Abstract

The topic issuing process for thesis projects at the Faculty of Computer Science of the University of Vienna is handled very heterogeneously by its 14 research groups. There is, in general, a lot of improvement potential, especially when it comes to the students' processes of initially searching for and deciding on a fitting topic and supervisor. For example, relevant information for students is scattered throughout various university web pages, especially the available and issued topics. This, among other factors, makes it very difficult for students to search for and find topics and relevant materials. Therefore, this work describes the design process and implementation of a prototype for a web application titled *"TheHub"*. This application handles the processes of topic search and issuing, and serves as a central hub for all aspects of conducting a thesis. The overall goal of *TheHub* is to streamline the overall thesis-work process, starting from the issuing/finding of a topic to finishing the thesis for supervisors and students alike, and increase the number of high-quality outcomes and positive experiences.

The implementation of *TheHub* aimed to follow state-of-the-art modern agile software development values, principles, and practices. These practices include experimental deployment on a public cloud utilizing a CI/CD pipeline and Test-Driven Development.

Additionally, adaptations concerning the overall thesis-work environment are suggested and discussed. These suggestions intend to improve the process of academic projects by supporting students in their decision-making and motivating them to start their search for topics earlier. The suggestions were developed with a focus on being easy to put into practice and in accordance with the current circumstances and rules.

The work was performed based on the findings of a qualitative study based on unstructured interviews with students and professors/supervisors. This study was part of an extensive Design Thinking approach characterizing the overall process.

The quality of the delivered IT artefact in the form of a web application was ensured by following well-established Design Science research guidelines and evaluation methods.

Kurzfassung

Der Prozess der Themenveröffentlichung für (Master-)Thesis-Projekte an der Fakultät für Informatik der Universität Wien wird von deren 14 Forschungsgruppen sehr verschieden gehandhabt. Allgemein, gibt es viel Verbesserungspotenzial, insbesondere wenn es um die anfänglichen Prozesse der Themensuche und des Entscheidens für ein passendes Thema von Studierenden geht. Zum Beispiel ist für Studierende relevante Information auf vielen Webseiten der Universität Wien verteilt, besonders die ausgeschriebenen und verfügbaren Themen. Dies, unter anderem, macht es für Studierende schwierig, Themen und relevante Informationen zu suchen und zu finden.

Daher beschreibt diese Arbeit den Design- und Implementierungsprozess eines Prototyps einer Web-Applikation namens *"TheHub"*. Diese Applikation unterstützt die Prozesse der Themensuche und des Veröffentlichens von Themen und agiert als zentrales Hub für alle Aspekte des Durchführens eines Thesis-Projekts. Das übergeordnete Ziel von *TheHub* ist es, den gesamten Abschlussarbeitsprozess, angefangen von dem Ausschreiben und Finden von Themen bis hin zum Abschließen der Thesis, für Studierende und Professor*innen/Betreuer*innen zu modernisieren und die Anzahl positiver Erfahrungen und Ausgänge zu erhöhen.

Die Implementierung von *TheHub* zielte darauf ab, den Werten, Prinzipien und Praktiken der modernen agilen Softwareentwicklung und dem neuesten Stand der Technik zu folgen. Die angewendeten Praktiken beinhalten experimentelle Bereitstellung der Applikation auf einer öffentlichen Cloud unter Verwendung einer CI/CD Pipeline und testgetriebene Entwicklung (TDD).

Zusätzlich werden Verbesserungsvorschläge für die gesamte Master-Phase an der Fakultät gemacht und diskutiert. Diese Verbesserungsvorschläge beabsichtigen den allgemein Prozess von akademischen Projekten, wie etwa eine Master-Thesis, zu verbessern, indem sie Studierende bei ihrem Entscheidungsprozess unterstützen und diese motivieren, sich früher mit der Themenwahl zu beschäftigen. Der Fokus bei der Erstellung dieser Verbesserungsvorschläge lag darin, einfach umsetzbar und in Einklang mit den aktuellen Gegebenheiten und Regeln zu sein.

Die Arbeit wurde auf Basis einer qualitativen Studie durchgeführt, die auf unstrukturierten Interviews mit Studierenden und Professor*innen/Betreuer*innen basierte. Diese Studie war Teil eines umfassenden Design Thinking Ansatzes, der den gesamten Arbeitsprozess charakterisierte.

Die Qualität des erstellten IT Artefakts, in Form einer Web-Applikation, wurde durch das Befolgen von etablierten Design Science Forschungsrichtlinien und Bewertungsmethoden sichergestellt.

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Acronyms

API Application Programming Interface. 22, 142, 148

BI Business Informatics. 22–26, 28, 42, 45, 60, 65–67, 77–80, 147

CD Continuous Deployment. iii, v, x, 20, 148–151, 156

CI Continuous Integration. iii, v, x, 20, 148–151, 156

CMS Content Management System. 29, 33, 34, 91, 122, 129, 130

CRUD Create, Read, Update, and Delete. 140–143

CS Computer Science. iii, viii, 1–7, 10–12, 18–29, 31, 33, 36–38, 42, 44, 45, 47, 57, 59, 64, 66, 70, 74, 77–80, 83–85, 147, 154, 159, 163, 164

CSS Cascading Style Sheets. 147

CSV Comma Separated Value. 35, 99, 131, 141, 154

DBMS Database Management System. 146, 147, 149

DIY Do It Yourself. 20

ECTS European Credit Transfer and Accumulation System. 24–26, 28, 37, 70, 79

EFL English as Foreign Language. 8

ERM Entity-Relationship-Modell. xi, 112, 113

FAQ Frequently Asked Questions. ix, xi, 122, 125, 126

FTP File Transfer Protocol. 149

HTML Hypertext Markup Language. 2, 29, 31, 129, 130, 140–143, 147, 148, 152

HTTP Hypertext Transfer Protocol. 148, 154

HTTPS HyperText Transfer Protocol Secure. 149

IDE Integrated Development Environment. 151

IPR Intellectual Property Rights. 93

IT Information Technology. iii, v, 5, 19, 21, 24, 41, 73, 86, 101, 157, 164

JSON JavaScript Object Notation. 129, 131, 141, 142, 154

LSI Latent Semantic Analysis. 132, 136, 152, 153

NLP Natural Language Processing. ix, x, 119, 145, 152, 161

ORM Object-Relational Mapping. 146

PR1 Practical Course 1. 2, 22, 24–28, 35, 37, 45, 52, 57–60, 63–65, 67, 69, 70, 72–74, 79, 86

PR2 Practical Course 2. 2, 22, 24, 25, 27, 28, 35, 37, 45, 52, 57–61, 63–65, 67, 69, 70, 72, 73, 79, 86

REST Representational State Transfer. 142

SQL Structured Query Language. 147

SSC StudienServiceCenter. 27, 28

SSL Secure Sockets Layer. 149

STEM Science, Technology, Engineering and Mathematics. 10

SVD Singular Value Decomposition. 152

TDD Test-Driven Development. iii, v, x, 20, 150, 151, 155

TEFL Teaching English as Foreign Language. 8

UML Unified Modeling Language. 47, 55, 132

URL Uniform Resource Locator. 122, 129, 143, 149, 154

VM Virtual Machine. 149, 157

WYSIWYG What You See Is What You Get. 114, 130, 140–143, 146, 152

1 Introduction

The first chapter of this work introduces this Master's thesis project. Firstly, Section 1.1 describes the context and motivates the work. The second Section 1.2 briefly defines the core research questions and is followed by Section 1.3 providing a short overview about the methods used.

Section 1.4 states the contributions provided by this project and lists the summarized core contributions.

Lastly, Section 1.5 explains the structure of this thesis by briefly describing its chapters and their contents. In addition, paths through this thesis for readers of various backgrounds are recommended.

1.1 Motivation & Context

Every university degree programme successfully ends with an academic thesis to write. This work certainly poses a significant milestone in one's career and life, or at least higher education path [ÅSEKN16]. It is also often recognized by students to be their biggest challenge at University [Hug01]. For many students, it is also inherently one of the first opportunities to truly utilize the acquired competencies and skills through year-long studying, and as such crucial in many ways.

Conducting such an academic project by oneself, be it in the context of one's Bachelor's or Master's thesis, can be one of the most challenging [BB20, ABRK15] and daunting [Sac02] aspects of acquiring a university degree under adverse circumstances or an equally highly exciting and satisfying experience under favourable ones. It certainly requires and introduces a novel approach to learning [ÅSEKN16], which can always be troubling. Furthermore, since it is usually one's first truly independent (academic) work, it inevitably leads to the experience of new challenges [TSB06].

This Bachelor's and Master's thesis phase also has been in the focus of the "Aktives Studieren" (German for "Active Studying") projects of the University of Vienna[1]. This focus was justified, as another recently performed study [Hac20] had placed the Master's thesis right below the most common reasons for the decrease in study activity for Computer Science (CS) students at the University of Vienna, Faculty of Computer Science.

Therefore, ways to improve this for students challenging and often novel process of conducting a larger independent project, no matter its scope, should be discovered, adequately discussed, and if possible, translated into solutions that are then implemented.

[1] A series of projects with the overall goal of increasing the number of acquired degrees, published works, and exam-activity.

Specifically, at the Faculty of Computer Science of the University of Vienna, there appears to be considerable potential for streamlining many aspects of the Bachelor's and Master's thesis phase. There is especially a lot of improvement potential when it comes to the students' processes of initially searching for and deciding on an appropriate as well as fitting topic and supervisor.

For example, currently, topics for Bachelor's and Master's theses, as well as Practical Course 1 (PR1) and Practical Course 2 (PR2) are issued by each of the 14 research groups of the Faculty of Computer Science individually, meaning on a different space in a different form. This is further complicated by the fact that it is not necessarily obvious what kind of topics each group issues. Therefore, students do not know where to look for a specific type of topic, have to visit all pages and subsequently scan them individually. Further increasing this difficulty, is the circumstance that there are nearly no search methods for topics or groups available. This results in students often having to scroll and browse through all topics and groups without any supporting tools or strategies at their disposal.

Additionally, other highly relevant information and material for the conduction of a Master's thesis, such as how it is formally registered or templates for it, is also scattered throughout various webpages and other sources. This creates a further need for compiling and organizing it within the Faculty of Computer Science at the University of Vienna.

Facilitating the topic search process for students is especially highly significant. Choosing an ideal and appropriate Master's thesis topic can be seen as one of the most important decisions that students make in their studies, as stated by S. Lei [Lei09]. Suppose a topic captures the personal interest of a student and makes them intrinsically motivated. In that case, the student spends more time and effort on research, as stated by Todd et al. [TSB06], and cognitive processes are boosted, as well as the overall research productivity is increased, as determined by Ormrod et al. [OD04, OAA06]. The process of finding and deciding on a topic had also been described as quite stressful and time-consuming by students in the United States, as investigated by Poock et al. [PL01].

Therefore, any hindering and complicating factors are even more severe and any types of support that make taking this impactful and significant decision easier, very meaningful, and appreciated by students. Enabling students to make better decisions regarding their topics is also beneficial for supervisors, since supervising a motivated student who is happy with their choice is inherently more pleasant.

Besides the difficulties students encounter in their search for topics, the current situation is not ideal for the professors/supervisors as well. They have to manage their issued topics primarily by editing text, in most extreme cases even raw HTML. This further presents improvement potential.

However, improving the current situation is by no means an easy task. The research groups of the Faculty are rather individualistic. Almost all of them handle the process of issuing and assigning topics to students differently. In addition, the research groups cannot be forced to consider any improvements in whatever form, especially if they are not officially instigated. Therefore, any measures aiming to improve the current situation need to consider all the research groups. Besides considering the groups, the measures also need to benefit them in at least some way. Otherwise, the groups would see no use

in them.

Finally, in the author's view, the Faculty of Computer Science should be at the forefront of novel digital solutions. The topic finding/issuing process has probably not changed in recent years. Therefore, it should be at least reconsidered and re-evaluated, considering new technologies and possibilities that are now provided and more readily available.

1.2 Research Question

The core research question of this Master's thesis project is, in general, *"How can students be supported in finishing their theses successfully, especially how can a software solution help them find a suitable topic and supervisor?"*.

This project aims to answer this question in two ways in the context of the Faculty of Computer Science of the University of Vienna.

Primarily, support shall be provided through a **web application**. This leads to many other questions, such as what kind of functionalities this application should provide, what kind of content does it need to have, and how it is supposed to be designed. Especially professors/supervisors need to be significantly considered in its design too, as it cannot operate without their acceptance and use. Additionally, in the scope of the designed and implemented web application prototype, a heavy focus is laid on creating a solution that would be directly usable and fits the current circumstances and the overall landscape of the context.

Secondary, this thesis also aims to provide **suggestions for improvements and adaptations concerning the overall environment**, such as how topics are issued, how students could be better prepared for writing their theses, and how supervisors could be aided in issuing and managing topics .

To answer the aforementioned questions better, this work also attempts to answer the related questions of what kind of difficulties and challenges students face when writing their theses and deciding on a topic, as well as how the Master's thesis and topic issuing process is perceived by supervisors and students alike. This is done to gain a more holistic view and a better understanding of the current situation that further increases the quality of the resulting artefacts.

1.3 Method Overview

To explore the problem at hand and develop a feature set and requirements for the web application, a "Design Thinking" approach, as described by A. Pressman [Pre18] and T. Brown [Bro08], supported by an exploratory qualitative study, based on R. Yin [Yin15] had been used. For the qualitative study, unstructured interviews with students and supervisors were the core data collection method. A focus had also been given to adhering to the research guidelines of "Design Science", as defined by Hevner et al. [HMPR04]. Design Science further complemented the used Design Thinking approach by utilizing its well-known and established design evaluation methods to demonstrate and prove the soundness of the resulting prototype.

The development and implementation of the application itself had followed and adhered to agile values, principles and practices, as described by the original agile manifesto [BBVB+01] as well as other works by Abrahamsson et al. [ASRW17] and Thomas et al. [TH19].

The exact methodology and used methods, along with their underlying reasoning, are explained and motivated in more detail in Chapter 4.

1.4 Contributions

Firstly, this project provides a qualitative study with the overall goal of obtaining an understanding and holistic view of how professors/supervisors and students perceive and feel about academic projects, such as Master's theses and practical courses, what motivates and drives them to act the way they do and to capture relevant experiences. A focus was especially placed on the topic issuing and search/finding aspect. In the scope of the study, 19 participants were interviewed. Out of these 19 participants, 8 were students and 11 professors/supervisors.

The interviews conducted as part of the qualitative study were also used to gather ideas, wishes, and requirements regarding the to be developed web application. In addition, the interviews were used to gain a solid understanding of the current state at the University of Vienna, Faculty of Computer Science.

Furthermore, an international comparison was conducted, investigating how the Master's thesis phase and especially the issuing of topics is handled at five selected additional European universities. The goal of this comparison was mainly to gain further inspiration for potential application features and generally to inform the web application's design. The comparison was used alongside the insights gained from the qualitative study for developing improvement suggestions for the current situation at the Faculty of Computer Science of the University of Vienna. Overall, these suggestions aim to further enable students in making the best possible choice regarding their project topics and increase the number of positive outcomes. The ideas were developed with a focus on being relatively easily implementable.

After establishing the requirements to be fulfilled by it, a web application was designed. The design followed a Design Thinking [Pre18, Bro08] approach and was based on the previously gained insights and gathered information. The application was designed with the primary goal of improving the topic search process for students and the topic issuing and management process for professors/supervisors. Additionally, it provides some support for students during the actual conduction of their theses. It mainly achieves these goals by being able to cover all the various ways of issuing topics of the research groups and combining them meaningfully. The application provides an interface to students that gives them a more centralized and uniform access to the topics. A special emphasis was placed on creating a solution that could be accepted and appreciated by all. This also proved to be the biggest challenge faced during the project since it necessitated careful balancing of requirements and resulting trade-offs.

This designed application is called *"TheHub"* and was fully implemented and experi-

mentally deployed on the Azure Cloud. The implementation was done with a focus on utilizing modern state-of-the-art practices and technologies, mainly inspired by Agile Software Development [BBVB+01, TH19, ASRW17].

To ensure the quality of *TheHub* a focus was placed on constant critical evaluation and self-reflection throughout the whole process as motivated by the chosen Design Thinking approach [Pre18, Bro08]. To further ensure the quality of the resulting IT artefact in the form of a web application, well-established evaluation methods and guidelines from Design Research [HMPR04] were considered as well.

Key Contributions To briefly summarize, this Master's thesis project contributes the following:

- **Explorative qualitative study** aimed to gather and represent the perspectives and views of professors/supervisors as well as students regarding the overall process of topic search/issuing.
- **International comparison** of the University of Vienna, Faculty of Computer Science, with five selected European universities offering Computer Science degree programmes regarding the overall Master's thesis phase. A special focus was placed on the topic search and issuing process.
- **Design and implementation of a web application** called *TheHub* that applies innovative technologies and aims to address the observed problems and improve the overall processes of topic search/issuing and thesis writing.
- **Proposal and discussion of adaptations and improvements** to the current process and system based on the insights gained through the qualitative study and international comparison.

1.5 Thesis Structure

Structure

This Master's thesis firstly introduced the topic in this current Chapter (1). Afterwards, Chapter 2 *"Related Work"* gives an overview of related work, followed by Chapter 3 *"Foundations"*, which briefly describes the used methodologies and some of the most essential technical terms. Chapter 4 *"Methodology"* then builds on the methodologies described in the previous chapter by explaining and justifying their concrete utilization. The following Chapter 5 *"Analysis of Current State"* provides a detailed explanation of the current state at the University of Vienna, Faculty of Computer Science. Additionally, Chapter 5 delineates the circumstances under which the web application was developed.

Subsequently, Chapter 6 *"Qualitative Study and Information gathering"* firstly describes the conducted qualitative study in detail, followed by a description of the results. Lastly, the chapter provides improvement suggestions and adaptations to the current process.

Based on the gathered and presented information of the previous chapters, requirements and desired features of the developed web application are described, formulated and justified in Chapter 7 entitled *"Requirement and Feature Analysis"*.

Using primarily the requirements established in the previous Chapter and also taking into account the desired features described there, Chapter 8 *"Design"* describes the overall design process and establishes the goals of the design. Lastly, it presents the developed web application named *"TheHub"* based on its final features and provides the rationale behind them.

Afterwards, Chapter 9 "Implementation" provides more technical insights into the concrete implementation process and describes details of the implementation such as the used technologies and frameworks as well as explains how some features were implemented.

The next Chapter,10 *"Quality Assurance"*, then describes the various ways of how the quality of the web application was ensured and how it can be further evaluated through the built-in telemetry system.

In Chapter 11 *"Discussion"* the hoped impact of this project is discussed alongside its limitations, and an outlook on possible future work is given.

Finally, Chapter 12 *"Conclusion"* concludes this work by briefly summarizing its contents and containing the author's personal reflection on the project.

Paths Through the Thesis

Readers familiar with the situation and the circumstances at the Faculty of Computer Science of the University of Vienna can skip most parts of Chapter 5, as it aims to provide basic context to readers not familiar with the relevant, specific setting at the University of Vienna.

For readers just interested in the design of the resulting web application, only Chapters 7 and 8 are relevant. Readers who want to gain further insight into implementation details can find them in Chapter 9.

Chapter 6 is rather standalone and does not directly address the web application's design. Instead, Chapter 6, along with Chapter 5, contains the collected information for the design. Therefore, both chapters can be read to understand better the rationale behind the requirements established in Chapter 7 and the resulting design described in Chapter 8.

2 Related Work

The following sections categorize different types of related works. Within these sections, a selection of related works and projects is presented and briefly described. The last section then concludes and provides takeaways from the related work.

2.1 Related Work with Technical Aspects

Highly related work was conducted by Svärdemo et al. [ÅSEKN16], who created a website to serve as a multi-modal and self-regulated learning resource on academic writing as part of a project undertaken at Stockholm University. The project's goal was to strengthen the quality of students' undergraduate theses. With their work, Svärdemo et al. specifically wanted to help alleviate the balancing issue discussed by Todd et al. [TSB06] and possibly make it feasible to develop the ability of students to work autonomously as well as support their writing process. Overall, the website aims to enable students to work independently on structural and formal aspects of their work. After finishing constructing the website, it was briefly evaluated through student and mentor/supervisor questionnaires and a mentor/supervisor focus group. In the focus group, mentors were observed while using the website. The overall result was that the website proved to be useful to mentors/supervisors and students alike. Svärdemo et al. [ÅSEKN16] followed a design-based research approach, related to the Design Thinking methodology of this project. Furthermore, their gained insights could partially provide a sound basis and understanding of how the web application designed in this project could be constructed and arranged. Additionally, Svärdemo et al.'s [ÅSEKN16] work serves as general proof that such a website can be useful and offer improvements to professors/supervisors and students alike.

Another highly related work was performed by the Multimedia Information Systems research group of the University of Vienna, Faculty of Computer Science. In 2017, they built a web application with the similar goal of handling the topic search process of students and the following assignment of topics to students. Since their application is highly related to this project and of the uttermost importance to the design of the web application being implemented in the scope of this work, it is described in more detail in Section 5.3 as part of the analysis of the current state.

2.2 Work Dealing with Linguistic Challenges During the Thesis Writing Process

Firstly, as Bakhou et al. [BB20] nicely stated, much of the past research has focused solely on the pure thesis-writing part and the resulting challenges as well as difficulties of an academic project such as a Bachelor's or Master's thesis. Such works include ones that focused solely on a specific section of the written thesis. They were, for example, conducted by Shahsavar et al., [SK20], who aimed to identify difficulties in the writing of the literature review section specifically, Bitchener et al. [BB06], who focused on the discussion section and M. Ra'uf [Ra'20], who looked at the writing of abstracts, Sadeghi et al. [SSK15], who made a general analysis of writing problems by going through submitted theses of three Iranian universities and comparing them using both qualitative and quantitative research approaches and lastly S.C. Komba [Kom15], who also performed a qualitative study, employing a document-based research method where the contents of English theses and dissertations of Tanzanian students were analysed and compared.

2.3 Work with a more Holistic View of the Thesis Writing Process

To shed light on other occurring difficulties, besides the ones faced during the thesis-writing part, Bakhou et al. [BB20] investigated the thesis-writing experiences of English as Foreign Language (EFL) Master's students. In their work they emphasized students' non-linguistic writing difficulties and their respective challenges, issues, and concerns in the whole process of conducting a thesis project. Bakhou et al.'s [BB20] overall goal was improving the quality of thesis writing. They mainly observed and identified that students writing their thesis had problems in three additional categories to linguistic difficulties: sociocultural challenges (family obligations, uncooperative respondents, inadequate supervisor support, and bad-quality academic preparation/education), lack of preparation (insufficient academic writing skills, research skills), and personal/psychological problems (which they intended to report elsewhere due to lack of space). In their work, Bakhou et al. [BB20] asked fellow researchers to investigate thesis writing as a whole process from a holistic view, instead of as a product, as they deem more studies on aspects other than rhetorical and linguistic challenges of thesis-writing necessary.

A related study to the one of Bakhou et al. [BB20] was performed by Bigdeli et al. [ABRK15] who attempted to explore which factors might lead Teaching English as Foreign Language (TEFL) Master's students from Iranian universities to resort to ghost-writers. Ghost-writers are external third parties that perform the thesis work for a monetary exchange instead of the student. Bigdeli et al. also followed a qualitative approach using purposive sampling to conduct semi-structured interviews with 13 students who did not write their theses themselves. As a result, Bigdeli et al. discovered three dominant themes to resort to ghost-writers, namely supervisor-, supervisee- and higher education-related factors.

Another work with a more holistic view was done by Todd et al. [TSB06]. Their focus was overall similar to the one of Bakhou et al. [BB20]. Todd et al. [TSB06] explored the experiences of undergraduate social science students in the United Kingdom of writing a dissertation/thesis as a form of independent learning and assessment, discovering the various challenges they encountered and inquire their perceptions of support given by peers and tutors. It was not solely focused on challenges and difficulties, but rather aimed at capturing the general perception. Todd et al. [TSB06] followed an exploratory approach by firstly sending a postal questionnaire to students. Based on the returned results, they designed semi-structured interviews that they conducted with the students who returned the filled-out questionnaire and the relevant staff. The interviews were analysed individually using qualitative methods. Their findings were that students perceived writing a dissertation/thesis as worthwhile because of the developed skills and gained subject knowledge, the perceived authenticity, a high intrinsic value and a strong feeling of ownership, bringing about the motivation that led to the process being seen as overall gratifying. Challenges discovered by Todd et al. [TSB06] were collecting research data, finding relevant literature and secondary material, defining a proper research question and scope, a feeling of uncertainty, and time management issues. Finally, Todd et al. [TSB06] conclude that the challenges imposed by independent unstructured learning are better dealt with by preparing students for this kind of learning at earlier stages instead of making the process more supervisor led and therefore lose some of its unique and valuable characteristics. Todd et al. [TSB06] argue that the most difficult factor in thesis-writing is balancing the encouragement of autonomy and freedom and the need to adore to some kind of established structure and requirements.

This balance discussed by Todd et al. [TSB06] has also previously been considered by P. Hughes [Hug01] who explored how differently independent learning is accentuated and defined in various disciplines. Additionally, P. Hughes [Hug01] evaluated the effects of an independent study module preparing students for their dissertations. This module was designed in a way so that it can be offered for all degree programmes. In the module, students receive counsel and practice in composing a proposal, gathering material and information, and presenting.

Secondly, J. Sachs [Sac02] created a general path model to determine what kind of factors influence the attitude of students towards writing a thesis. The purpose of this path model was to proactively identify students who are likely to have a negative attitude towards thesis-writing and lack confidence, as well as enabling to provide them with extra help. As J. Sachs [Sac02] wrote, the significance of the task of identifying such students, specifically ones who have ineffective study strategies, and the provision of methods to deal with this overall issue was proposed by Tait et al. [TE96].

2.4 Drop-out Rate Studies

Another set of related studies dealt with the reasons why students drop out of university. Consequently, such studies explore the challenges and difficulties students experience as well. However, the explored challenges in these studies are more general and not

only specific to conducting a thesis project. Such studies regarding student drop-out are also related to this project, since they mostly share the participants and methodological approaches. Additionally, factors that lead to drop-out might also be connected to or lead to challenges when writing a thesis.

M. Lumpe [Lum19] performed such a study in the scope of his Master's thesis for the University of Potsdam, where he tried to discover why Science, Technology, Engineering and Mathematics (STEM) students have exceptionally high drop-out rates. M. Lumpe [Lum19] interviewed students from mathematics, physics, and chemistry who had dropped out of their studies to uncover the motives for signing up for the specific degree programme and the carried out deregistration. Additionally, interviews were conducted with university staff, such as members of the deanship and academic advisors, and secondary school direction. As a result, M. Lumpe [Lum19] establishes four primary causes for the aforementioned high drop-out rates: an inadequate technical establishment for academic studies in the STEM sector, the ambiguity of universities in terms of research- or occupational-oriented education and resulting wrong ideas about the studies of students, the bad occupational perspectives after the acquisition of some natural science degrees, and lastly the financial need for universities to operate at full capacity. The gained insights were then also discussed with the president of the University of Potsdam.

Another similar thesis was also written by S. Zimmerman [Zim08], who had a similar goal to M. Lumpe [Lum19] but the ETH Zurich as context. His study was conducted by developing a detailed questionnaire that was used to qualitatively discover why students from the ETH Zurich (from all Bachelor's programmes) were dropping out of their studies. The performed study was quite large in scale. The questionnaire was sent out to 1562 former students in total. Additionally, S. Zimmerman [Zim08] proposes measures to reduce the drop out rates.

Additionally, K. Jonkmann [Jon05] performed a similar study in the scope of the Humboldt University to Berlin, where she tried to uncover how long study durations and high drop out rates arise. She collected her data by sending an online questionnaire to 714 Computer Science students of the Humboldt University to Berlin. Evaluating was done primarily using quantitative methods. In her work, she refers to results of studies using data from the German HIS ("Hochschul-Informations-System" - German for University-Information-System), for example, performed by Heublein et al. in 2005 [HSSS05]. K. Jonkmann [Jon05] also wanted to answer what kind of measures could be taken to alleviate these factors and improve the degree programme from a student perspective. Some of the most notable and interesting results are that nearly 40 per cent of the students stated that they thought about dropping out of their studies at one point, that those thoughts happened mainly in the earlier terms, especially the third one, and that they arose primarily because of the degree programme being too difficult and having too many theoretical contents as well as being poorly organized and/or overfilled. Some mentioned difficulties and issues are in line with the work of M. Lumpe [Lum19], such as wrong ideas about the studies by students.

U. Heublein, whose work [HSSS05] was a basis for the previously mentioned study of K. Jonkmann [Jon05] also did his own study [Heu14] where he investigated the drop-out

rates at German higher education institutions. U. Heublein [Heu14] firstly analysed how drop-out rates vary in different types of higher education institutions (universities and universities of applied sciences), degrees (Master's and Bachelor's) and types of degree programmes. Secondly, U. Heublein [Heu14] tries to clarify the different social and institutional causes for student drop-out by creating a detailed model of the process that leads to the decision to drop out of a study programme. U. Heublein [Heu14] stated that student drop-out is to be recognised as being a special relationship between institutional conditions and personal qualifications, instead of seeking the main reason in the student's character and/or the respective university. This further supports the claim of Aina et al. [ABCP18], described in the next paragraph. Lastly, Heublein [Heu14] focuses on above-average drop-out perils in certain at-risk student groups by defining and describing different major types of drop-out students and what kind of preventive measures could be taken to increase the rate of academic success.

Additionally, Aina et al. [ABCP18] performed an extensive survey that compiles and discusses empirical as well as theoretical literature about drop-out rates of students, delayed graduations and determinants of student success in general. Aina et al. [ABCP18] firstly report a theoretical framework, based on the human capital investment model, that models the willingness to invest in higher education as a sequential process made under a gradually declining grade of uncertainty on costs and potential future returns. Secondly, Aina et al. [ABCP18] summarize various empirical studies done on the topic and dissect and cluster the determinants leading to delayed graduation and student drop-out by influencing, directly or indirectly, the students' advantage and costs of education investment. The identified determinant clusters were student characteristics, family background, institutional characteristics, and features of the employment market. Lastly, Aina et al. [ABCP18] propose economic policy guidelines based on their findings, mainly an all-inclusive orientation opportunity for students to be undertaken before enrolling.

Furthermore, C. Hackl's [Hac20] work, performed within the scope of a Master's thesis, is also considered highly related, as it shared the same context with this work: The Faculty of Computer Science of the University of Vienna and Computer Science students. In her work, C. Hackl [Hac20] investigates positive and negative factors influencing Master's degree students' activity. This investigation was performed by interviewing inactive students, meaning students not attending courses and therefore not advancing their studies even though they are currently enrolled. The goal of C. Hackl's [Hac20] work was to show how the gained insights could be used to improve higher education didactic measures to activate students. The used approach was qualitative, using guided interviews consisting of mostly open-ended questions. Especially notable in C. Hackl's [Hac20] work is the fact that the Master's thesis was right below the most commonly stated reasons for the decrease in study activity: employment, negative exams, and family. C. Hackl [Hac20] also interviewed some inactive students about the Master's thesis phase specifically. Her findings were that four out of seven interviewed students stated that the writing process was the most challenging aspect, followed by the topic selection, the general process, and the missing connection in this phase. Lastly, the structure was also mentioned once as the most difficult part of the Master's thesis phase. As a final artefact, C. Hackl [Hac20]

created a fact sheet based on her findings that can be used as a data basis for further advancement of didactic policies to elate the activation of students in higher education institutions.

Additionally, there are many other works regarding drop-out rates not described in more detail. For a more detailed overview, see the previously described survey paper of Aina et al. [ABCP18].

2.5 Other Related Work

S. Lei [Lei09] did a literature review on the strategies for finding and selecting an ideal thesis or dissertation topic. His work may give great direction in the design of the web application and overall improvement suggestions.

2.6 Conclusion & Takeaways

No project was found (as of February 2022) performing a similar analysis and study, and implementing a prototype aiming to amend the current situation in a Computer Science context. There is, however, still work with a similar subject.

The linguistic challenges and difficulties of writing a thesis seem to be well explored and researched by literature. In contrast to that, works with a more holistic view are relatively rare and were not conducted in a western or Computer Science (CS) degree programme context.

Research on student drop-out was conducted plentifully as well. This is probably due to increasing the number of people holding tertiary education qualifications and thus mitigating the lack of academically qualified personnel has been on the political agenda of many countries, as described by U. Heublein and [Heu14] Aina et al. [ABCP18].

Additionally, previous work by Svärdemo et al. [ÅSEKN16] was found indicating that the general idea of a web application to support students in the thesis project phase is overall fruitful and could lead to improvement.

Therefore, this project is apparently one of the first attempts to examine the thesis-writing and especially topic-search phase of CS students from a more holistic perspective and propose adaptations and improvements to the overall process, as well as support students with a web application that can also provide further administrative support to supervisors. Therefore, this project can be seen as unique, especially when considering the chosen methodologies.

3 Foundations

This chapter provides short overviews of the technologies and techniques used in this thesis to foster a better understanding of the discussed topics.

3.1 Design Thinking

Since there is no consensual definition of the Design Thinking process, as there are many variations across disciplines, this section describes the general approach as described by A. Pressman [Pre18] in his book *"Design Thinking, A Guide to Creative Problem Solving for Everyone"*. The book aims to act as a primer for a broad audience and support courses on Design Thinking.

Design Thinking is a general but powerful type of applied research recently gaining much traction in general education, business, and engineering courses [Pre18].

Because Design Thinking supports and stimulates the comprehension and outlining of problems, it enables innovative and creative solutions. These solutions are developed to be truly responsive and adapted to the issues and needs of all the involved stakeholders. Another characteristic of the Design Thinking approach is that it truly allows for new perspectives on the underlying problem landscape.

It is a very fundamental and universally usable approach. Design Thinking is utilizable loss-free by a single individual, thus not requiring a full team. Furthermore, it places a big focus on communication and understanding. Design Thinking can be employed in many different disciplines to solve real-world problems and harmonize between requirements that are potentially conflicting.

Design Thinking purposely embraces the absence of strict formulas, templates, or algorithms about its execution. Such strict instructions are deemed to severely limit the innovative and creative ways of solving the underlying problem. Instead, Design Thinking fosters an inherently dynamic and adaptive process, where elements can be selected, weighted and combined in a way that is most fitting for the prevailing circumstances and individuals involved. Therefore, the end result is a unique process adapted to the problem and circumstances at hand.

Design Thinking is divided into five building blocks by A. Pressman [Pre18]:

- **Information Gathering** — Arrive at a deep and extensive understanding and rich background of all the relevant constraints, issues, and conflicts that surround the problem by researching the context, consulting stakeholders and analysing the current situation.

- **Problem Analysis and Definition** — Identify the most striking problem that may be non-obvious and thoroughly question the current situation. Additionally, constantly challenge initial assumptions and attempt to reframe the problem.
- **Idea Generation** — Come up with as many ideas, not questioning their quality, as possible, informed by the previous two phases.
- **Synthesis through Modelling** — Refine the most promising ideas, resulting in prototypes, models or draft solutions.
- **Critical Evaluation** — Test and question the model-solutions from the previous phase and see it as an opportunity to improve them by subjecting them to a critical view of others and oneself. Embrace feedback and especially constructive criticism to make meaningful revisions and changes.

These blocks, however, do not represent a clear linear execution path but should rather be seen in a nonlinear way, where they can be interconnecting, overlapping and emphasized differently. Problem solutions should pass through the blocks as often as appropriate. The overall process can also be disruptive, as evaluating a potential solution can lead to an adaptation of the initial problem if necessary.

Additionally, because of its inherent flexibility and dynamicity, Design Thinking lends itself to being used in conjunction with other, discipline-specific methodologies and thus aid in combining multiple perspectives to solve more complex problems.

3.2 Design Science (Research)

The Design Science paradigm has the overall goal of creating new and innovative artefacts, thus extending the boundaries of human and organizational capabilities alike. It is a major paradigm in information system research, along with the Behavioural Science paradigm. In contrast to the Design Science paradigm, the Behavioural Science paradigm seeks to develop and verify theories explaining or even predicting the behaviour of individual humans or whole organizations [HMPR04].

The core principle of Design Science Research, as described by A. Hevner et al. [HMPR04] is that the designing, building, and application of an artefact leads to the understanding and knowledge of a problem domain and ultimately to its solution. This artefact can take various forms such as an algorithm, interface, process model, or even complete application in the context of information system research.

Design Science is not a fully specified approach. Instead, it is a problem-solving paradigm that aims to create innovations. Despite it not being a fully specified approach, there is, however, a conceptual framework developed by A. Hevner et al. [HMPR04] for conducting Design Science Research. This framework contains a set of guidelines for conducting and evaluating high-quality Design Science Research, focusing primarily on technology-based design. The seven guidelines of their framework that are directly derived from the core principle of Design Science Research are:

1. **Design as an Artefact** — The result of Design Science Research must be an innovative and purposeful artefact.
2. **Problem Relevance** — The artefact was created for a specified problem domain to solve an important and relevant problem.
3. **Design Evaluation** — The artefact must be thoroughly evaluated to ensure utility, quality as well as efficacy.
4. **Research Contributions** — As the artefact is required to be innovative, Design Science Research needs to make verifiable and clear contributions to research.
5. **Research Rigour** — The artefact is constructed and evaluated using rigorous methods. The result is an artefact that is thoroughly defined, represented in a formal way, coherent and internally consistent.
6. **Design as a Search Process** — The process by which the final artefact is created incorporates or enables a search process that constructs a problem space and provides a mechanism to find an effective solution.
7. **Communication of Research** — The results of Design Science Research has to be communicated effectively to audiences of various backgrounds, e.g., technology-oriented or management-oriented backgrounds.

For the evaluation of the designed artefact, A. Hevner et al. [HMPR04] present many evaluation methods. For the evaluation observational (case and field studies), analytical, experimental, test-driven, and descriptive (through informed arguments or scenarios) methods can be used.

3.3 Qualitative Research

As the name suggest, in contrast to its quantitative counterpart, that concerns itself purely with numerical data, qualitative research, as defined by S. Ivan [Iva21], deals with non-standardized data in the form of descriptive and conceptual findings and its evaluation. Generally and simplified said, quantitative research aims to answer the *"what"*, *"where"* and *"when"* questions while qualitative research concerns itself with the stories and experiences of its participants, thus answering more the *"why"* and *"how"* [Iva21]. Common data collection methods for qualitative data, as described by S. Ivan [Iva21] and R. Yin [Yin15], include questionnaires with open questions, interviews, and observation.

As it is difficult to come up with one single succinct definition of qualitative research, as there are many specialized types and variants (such as action research, case studies and ethnography), it can best be characterized by five distinct key features specified by R. Yin [Yin15]:

- Qualitative research, in general, focuses on studying and investigating the lives of people (the study's participants) while performing their actual real-world roles under

real-world conditions. There is nearly no intrusion by artificial research procedures, and the participants can, for example, say whatever they would like to say and express themselves independently of any research agenda. An example for this feature would be the use of open questions, where participants are not restricted to a predetermined set of answer possibilities to very specific questions.

- The priority and major purpose of qualitative research lies in representing the opinions, perspectives as well as views of the study's participants. The insights gained by qualitative research can represent the meanings given to events occurring in the real world by people who actually experienced them instead of capturing the preconceptions, meanings, and values of the conducting researchers.

- Contextual conditions, such as social, institutional, cultural and environmental ones, are specifically embraced as they can strongly influence people and their views. Such conditions are often either blended out or restricted to a limited set in experiments of other types of research.

- Qualitative research is not just a report about what everyday life is like. Instead, it is driven by a desire to explain social behaviour and thinking through either new and emerging or already existing and established concepts.

- Instead of relying on a single source of data alone, qualitative research acknowledges the value of using data from a variety of sources. A simple, practical example of this feature would be the incorporation of field observations and artefacts instead of just using the results of a questionnaire.

The arguably biggest strength of qualitative research, according to R. Yin [Yin15], stems from its ability to capture the true underlying meanings held by the participants and the overall focus on meaning, instead of just occurrence and/or probability. Furthermore, R. Yin [Yin15] states, that qualitative research calls upon its researchers to always retain an open mind to attend to newly emerging and unexpected information. Qualitative research, as explained by S. Ivan [Iva21], has an important role as there is a lot of rich detail shared by individual participants, which could be lost otherwise, that can actually aid in the capability of thinking through complex problems as well as investigating the effects of various policies, systems, and programmes in-depth.

However, one of the biggest weaknesses and criticisms of qualitative research, described by R. Yin [Yin15], is the loss of methodological strengths and validity. This loss occurs as there is no uniform method of data collection, the collected data being inherently subjective, and its evaluation being built primarily on interpretation. In an effort to alleviate this weakness, systematic, rule-based approaches, for example, the qualitative content analysis according to P. Mayring [May04], and best practices as well as guidelines, to overall strengthen the validity of qualitative studies were developed. An example for such guidelines are the ones proposed by J. Maxwell [Max12]. The book *"Qualitative Research from Start to Finish"* from R. Yin [Yin15] is an example for the description of best practices.

3.4 Agile Software Development

The following section about Agile Software Development uses the survey paper from P. Abrahamsson et al. [ASRW17] about agile software development methods and the detailed report from D. Cohen et al. [CLC03] to briefly describe Agile Software Development.

The term of Agile (Software Development) started emerging from the Agile Software Development Manifesto [BBVB+01] published by a group of software practitioners and consultants in 2001. In their manifesto, they coined the term "agile" and formulated the four core guidelines for Agile Software Development:

- **Individuals and interactions** *over processes and tools*
- **Working software** *over comprehensive documentation*
- **Customer collaboration** *over contract negotiation*
- **Responding to change** *over following a plan*

Along with the four core guidelines, the manifesto [BBVB+01] also contains twelve principles to follow. These guidelines and principles aim to tackle the challenges met by traditional "waterfall" software development methods, where large products are delivered after a long period of time. In the view of the authors of the agile manifesto, the traditional methods, often result in worse solutions as circumstances and customer requirements often see changes before the product can be delivered (especially in more modern times). To combat this, agile methods aim to deliver a more fitting product through incremental and frequent delivery of smaller blocks, developed by smaller teams, that are cross-functional as well as self-organized, rather than delivering a whole product developed by one large team. Additionally, to better meet changing requirements, customer feedback is heavily emphasized, incorporated, and reacted upon during development.

There are many different Agile Software Development Methods, such as Scrum, Extreme Programming, the Crystal family and the Rational Unified Process. All the methods are based on the four core guidelines and principles of the Manifesto for Agile Software Development [BBVB+01]. To provide a general and in-depth overview as well as a comparison of the various methods, P. Abrahamsson et al. [ASRW17] wrote a survey paper concerning Agile Software Development Methods.

3.5 (Azure) Cloud Services

In order to provide a brief description about cloud services, their definition from I. Ahmad et al. [ABM17] and Red Hat Inc. [Hat19] are used in this subsection.

Cloud services in generally are services provided through the internet by a third party. These services can be computational infrastructure, platforms, or software available through the internet. A main characterization is that the only requirement for their utilization is a working internet connection.

The advantages of renting cloud services, instead of hosting and managing the necessary infrastructure on one's own, are higher scalability, as additional computational power and/or storage can be increased on the fly, less cost because there is no need to acquire expensive infrastructure or software licences, and an increase in flexibility, as additional resources or no-longer needed ones can be acquired or cancelled at any time. In addition to providing the necessary computing-resources or platforms, cloud services often also ease their management by offering graphic management-interfaces to their users, that also provide auxiliary functions.

Azure[1] is a public cloud service provided by Microsoft (popular competitors are, for example, Amazon AWS[2] and the Google Cloud[3]).

3.6 Telemetry

Telemetry can generally be defined as: *"the science or process of collecting information about objects that are far away and sending the information somewhere electronically"*[4].

In the context of this work and Computer Science generally, this *"information about objects"* is automatically and passively collected, fine-grained low-level data attached to a timestamp. This data is either sent in regular intervals or when a specific event (e.g., a request for it) occurs. Such data can, for example, be the amount of data sent in and out, the number of requests, the response time, or specific resource utilization. The data is typically continuously sent through the internet or accumulated locally and then sent on demand.

Telemetry data can be aggregated and used for analysis, serving a variety of purposes. Examples of possible insights would be at which time an application is used the most, what the peak load is, and how much this load strains the application.

Because dynamic resource allocation and utilization is one of the most significant advantages of (public) cloud services, identifying a surplus or a shortage of resources is of paramount importance. Therefore, to identify a potential surplus or shortage, cloud services often include telemetry collection, aggregation, and even automatic evaluation in their offered services.

Furthermore, the approach of using telemetry can also be extended to be used on an application- rather than a hardware-level to gain important insights regarding user behaviour. For this use-case, consider, e.g., collecting data about what kind of searches users of a website perform or, in an e-commerce context, the products bought.

[1] `https://azure.microsoft.com/`, accessed 13/12/2021
[2] `https://aws.amazon.com/`, accessed 13/12/2021
[3] `https://cloud.google.com/`, accessed 13/12/2021
[4] as defined in `https://dictionary.cambridge.org/dictionary/english/telemetry`, accessed 13/12/2021

4 Methodology

This chapter aims to give insight into which methodology was used for which part of this project and substantiate its use.

As an overall methodology, this project used a "Design Thinking" approach, as described by A. Pressman [Pre18] and T. Brown [Bro08]. Design Thinking was deemed to be the best way to facilitate a creative and innovative outcome, placing a heavy emphasis on providing fresh perspectives on the overall Master's and Bachelor's thesis phase and the topic issuing process. It was deemed especially fitting for this project because it heavily emphasizes and is responsive to stakeholders and their respective issues and needs. This is especially ensured as it is a type of applied research, putting communication and understanding at its centre. Another defining characteristic of Design Thinking is the focus on creating something not just solving the present functional problem, but rather something more meaningful. This is partly achieved by focusing on the quantity of ideas instead of their quality, which leads to more innovative, creative and offbeat solutions.

Additionally, Design Thinking was a good choice because it is a general problem-solving methodology. It is not restricted to Computer Science (CS) problems, and does not solely focus on the creation of a (better) Information Technology (IT) artefact. This ability to be used on general problems differentiates it from other related methodologies, e.g., "Design Science", which heavily focuses on IT problems [Kai19]. Consequently, Design Thinking could help in the generation of possible adaptations and improvements to the overall Master's thesis process as well.

While Design Thinking is a methodology not (yet) widely used in CS, recent studies, for example, performed by E. Sandnes et al. [SEM19] showed that it could lead to better solutions, especially when the focus is on the quantity of generated ideas instead of their respective quality. Since the chosen Design Thinking methodology [Pre18, Bro08] does not explicitly cover the creation and evaluation of IT artefacts, the overall process additionally adhered to the research guidelines of Design Science, as described by A. Hevner et al. [HMPR04]. These guidelines were used especially to demonstrate and prove the soundness of the resulting web application prototype by utilizing well-known and established design evaluation methods.

The study, used to inform the design process, took the shape of a generalized qualitative research study, as defined by R. Yin [Yin15], with some aspects of action research, as described by N. Abercrombie [ATH06, Yin15]. A qualitative approach was followed as it was deemed necessary to account for real-world contextual conditions, be close to the actual situation, and not limit expressiveness by artificial research procedures. Additionally, it was truly a goal to capture the general views, perspectives, and motivations of the participants. The developed application needed to consider the overall context and why the concerned stakeholders act the way they do, as well as their overall intentions.

These are aspects not captured adequately by too structured an approach consisting of close-ended questions. Many of the principles and features of qualitative studies also directly support or are aspired by the Design Thinking [Pre18, Bro08] methodology.

The focus on unstructured interviews, with a more conversational mode, was particularly well combinable with the Design Thinking [Pre18, Bro08] approach, likewise requiring interviews in its "Information Gathering" phase and generally having a strong focus on communication. Much like interviews for qualitative research [Yin15], Design Thinking [Pre18, Bro08] allows for more in-depth discussions, additional observations, more flexible questioning, and the ability to ask specific follow-up questions. The goal of these measures is to illuminate and discover different aspects of the problem and gain a holistic view of the whole process.

In addition, face-to-face conversations are also deemed to be the most efficient and effective method for conveying information to software development teams according to the agile manifesto [BBVB+01].

For the implementation and partly for the design of the prototype Agile (Software Development) values, principles [BBVB+01], and practices were used to complement the Design Thinking [Pre18, Bro08] approach taken. Utilization of Agile values and practices ensured a high-quality outcome, focusing on stakeholder needs. In addition, it allowed gaining experience in state-of-the-art modern software development methodologies. The concrete approach did not follow a specific Agile Software Development method, as they focus on and require entire development teams, consisting of different people with diverse roles. Such methods also require a significant constant time commitment for a longer duration of time of all the involved stakeholders. This was especially difficult to accomplish since professors/supervisors are generally very busy, and this project was not officially commissioned by the University of Vienna, Faculty of Computer Science in any way. Instead, it was more of a personal single-handed DIY project in the scope of a Master's thesis, motivated by personal interest and experiences.

Since the use of a specific Agile Software Development method was not deemed possible, the aim was instead to follow the best practices and course of action presented by A. Hunt and D. Thomas (two of the original authors of the agile manifesto [BBVB+01]) in their book *"The Pragmatic Programmer"* [TH19].

Practices that were used include Test-Driven Development (TDD), Continuous Integration (CI)/Continuous Deployment (CD) employing a pipeline and incremental development [TH19, ASRW17]. These practices are further described in Section 9.3.

5 Analysis of Current State

This chapter provides an overview of the current state to foster an understanding of how processes regarding Master's theses are currently executed to better understand the qualitative study of Chapter 6, and further motivate the possible benefits of the prototypical web application designed in Chapter 8.

In the first section of this chapter, the overall organizational circumstances around the web application and how it is supported are briefly delineated.

The following second section explicitly describes the situation and circumstances at the Faculty of Computer Science of the University of Vienna and how its offered degree programmes are structured around Master's theses. Within the second section, a special focus is given to aspects concerning the topic search of students. These aspects, for example, include the way topics are issued on the research group web pages.

Finally, the last section takes a brief look at how other Computer Science degree programmes of other European university-level institutions handle the Master's thesis phase and, in particular, the topic search process.

The analysis provided by the current chapter is also a part of the *"Information Gathering"* phase described mainly in Chapter 6. Because to come up with an innovative and fitting solution to the problem at hand, it is paramount to look at and understand the current situation in all its detail. For reasons of granularity, it forms an independent Chapter, enabling readers not familiar with the current situation at the University of Vienna, Faculty of Computer Science to better understand the contents, contributions and surrounding conditions of this project. In contrast to Chapter 6, this chapter focuses more on purely objectively delineating the formal and official definitions as well as outward-facing aspects, rather than the more hidden subjective and personal perceptions, executions as well as specifics of professors/supervisors and students.

5.1 Organizational Circumstances Around the Project

This project is not in any way officially commissioned by the University of Vienna, Faculty of Computer Science but more of a personal single-handed project in the scope of a Master's thesis motivated by personal interest and experiences of the author.

Therefore, the involved stakeholders cannot be obliged to utilize the resulting application and adapt or change their current practices. The use of the web application can only be achieved by the stakeholders using it totally voluntarily and on their own accord.

Furthermore, another significant implication of this project not being officially supported is the fact that there is no direct access to the IT system of the university and the data contained within. Besides there being no direct access, the IT system does not support

API authorization protocols. Such protocols, like *OAuth*, would enable students to specifically allow the web application to access their data and authenticate them.

Lastly, the lack of official support additionally affects the long-term support and maintenance of the web application. There will most likely be no employee tasked and paid to support as well as maintain the application later on.

5.2 Current Situation at the University of Vienna, Faculty of Computer Science

This section delineates how the degree programmes of Computer Science (CS) and Business Informatics (BI) of the Faculty of Computer Science, University of Vienna, currently handles the Master's thesis phase. The University of Vienna offers a Masters's degree programme for Media Informatics as well. However, since its structure around the Master's thesis is the same as in the CS degree programme, it is not explicitly distinguished. This section is mainly targeted towards readers without comprehensive knowledge of the Faculty of Computer Science of the University of Vienna, its offered degree programmes and organizational circumstances.

Firstly, the general Master's thesis phase is described in Subsection 5.2.2, generally explaining the path students take from first inscribing for the respective Master's degree programme to conducting their Master's thesis projects. A focus is placed on the practical courses 1 and 2 that CS students need to finish, the required Master seminar, the process of writing the thesis itself and lastly, the shared kick-off meeting for Practical Course 1 (PR1), Practical Course 2 (PR2) as well as the Master seminar.

Subsequently, Subsection 5.2.3 depicts how the topics that students can choose for their projects and the research groups providing supervisors are offered and presented. The projects for which students pick topics comprise PR1, PR2, and the Master's as well as Bachelor's thesis. Afterwards, Subsection 5.2.4 examines the various ways of how these topics actually come into being. A detailed comprehension of specifically these aspects is of immense significance, as it is the primary aspect that the designed and developed prototypical web application can influence.

5.2.1 General Structure

The Faculty of Computer Science, of the University of Vienna, as of 06/02/2022, consists of 14 individual research groups, that are active in the scope of the CS and BI degree programmes[1]:

- Communication Technologies (CT)
- Cooperative System (COSY)
- Data Mining and Machine Learning (DM)
- Entertainment Computing (EC)
- Knowledge Engineering (KE)
- Multimedia Information Systems (MIS)

[1] Taken from: `https://informatik.univie.ac.at/en/research/`, accessed: 06/02/2022

- Neuroinformatics (NI)
- Scientific Computing (SC)
- Security & Privacy (SEC)
- Software Architecture (SWA)
- Theory & Applications of Algorithms (TAA)
- Visualization & Data Analysis (VDA)
- Educational Technologies (CSLEARN)

The research groups provide the supervisors for practical courses as well as Bachelor's and Master's theses. Generally, the research groups have very distinct focuses and research areas, therefore making specific topics easily attributable. However, there are some rather general areas where the competencies of the groups overlap.

Thematic areas are categorized by clusters, into which the courses of the CS Master's degree programme are divided into – one course can, however, also be part of multiple clusters. The BI degree does not have these clusters, as there are no specializations that students can choose, e.g., "Data Science", that confine the courses they can visit to progress their studies. The existing clusters, according to the most recent version of the official curriculum from June 2019[2] are:

- Algorithms
- Computer Graphics
- Data Analysis
- Information Management & Systems Engineering
- Internet Computing & Software Technology
- Multimedia
- Networks
- Parallel Computing

Topics to be worked on by students in the scope of projects should be assignable to a cluster as well. This assignment also reasonably determines which research groups should be responsible for the supervision of which topics.

Generally, the research groups and supervisors have a large amount of freedom in a variety of aspects and work rather individually. A very notable example for this would be that it mostly lies in the responsibility of the respective supervisor to determine whether a given topic is actually assignable to a cluster they can supervise.

Additionally, the research groups and professors/supervisors vary a lot in how they handle the issuing and assignment of topics. These processes are described in more detail in Subsections 5.2.3 and 5.2.4. The professors/supervisors generally also have a dislike for stricter guidelines imposed on them that reduce their freedom and individuality.

Furthermore, the research groups and supervisors vary in their motivations, aims, and perceptions. These differences are the focus all throughout Chapter 6.

[2] Available at: `https://informatik.univie.ac.at/studium/studienangebot/master/master-informatik/curriculum-master-informatik/`, accessed: 06/02/2022

5.2.2 Master's Thesis Phase

CS Master's students, following the recommended semester schedule[3], start their studies with a first semester solely consisting of regular courses. From the second semester on, however, they first have *"Practical Course 1"* valued six European Credit Transfer and Accumulation System (ECTS) points, followed by *"Practical Course 2"* in the third semester valued twelve ECTS points. The practical courses are described more thoroughly in 5.2.2. Then in the fourth semester, CS students usually work primarily on their *Master's thesis*, valued 27 ECTS points in total. Besides working on the Master's thesis, students orientating themselves on the recommended semester schedule[3] also visit the *Master seminar*. The Master seminar is a course worth three ECTS credits and is described further in Section 5.2.2. After finishing their Master's thesis CS students have to take a Master's exam valued three ECTS points. The Master's thesis and exam are described further in their dedicated Section 5.2.2.

BI students have a different experience since they do not have the practical courses (PR1 and PR2). As a consequence, their paths to their Master's theses are more pre-determined, instead of notably influenceable and distinct, compared to CS students.

BI students, unless they start contacting potential supervisors and inform themselves independently beforehand, are starting their Master's thesis phase with the shared kick-off meeting that is a part of the Master seminar and then directly ends with the Master's exam. This Master seminar, as described in Section 5.2.2, is the same attended by CS students. The fourth semester, according to the official recommendation[4], of Master's BI students, shares the same structure and ECTS credit distribution as the fourth semester of CS students.

Additionally, both BI and CS students have a course scheduled for the third semester called *"Academic Research and Writing"* valued three ECTS points. In this course, students are introduced to the rules of scientific publishing and practices. Since it does not really impact the final Master's thesis topic choice of students, it is not described in further detail.

Practical Courses 1 and 2

The formal definition of Practical Course 1 (PR1) as well as Practical Course 2 (PR2) is:

> "The aim is to conduct an IT-oriented project in the field of Computer Science / Media informatics. Based on the experience gained during the implementation of the project, students should learn to carry out IT-projects on their own. The aim is also to combine previously acquired knowledge from the various courses during the study.
>
> The aim is to demonstrate a comprehensive understanding of the problems

[3] Available at: `https://informatik.univie.ac.at/en/study/courses-of-study/master/master-computer-science/advanced-courses/timetable-informatik-in-general/`, accessed 04/01/2022

[4] Available at: `https://informatik.univie.ac.at/en/study/courses-of-study/master/master-business-informatics/timetable-master-business-informatics/`, accessed 04/01/2022

> posed by the project tasks, as well as to enable the application of the necessary concepts, techniques and methods in order to achieve suitable solutions."[5]

In the shared kick-off meeting for the practical courses and the Master seminar, the practical courses and their intentions are explained in more detail. The kick-off meeting itself is described further in the next section. Apart from the information derived from the official descriptions[5] of the practical courses, the presentation in the shared kick-off meeting adds that, as a first option, the topic for the Master's thesis comes from PR2, which in turn builds on PR1. As a second option, students can switch the topic and/or supervisor to get "their feet wet" in different topics as well as research groups and experience various research approaches.

Based on the topic, the practical course project is assigned to specific clusters serviced by different research groups, providing the supervisors. These clusters are also used to specify which topics can be chosen by students from specialized CS degrees and which research groups can supervise them. For example, a general CS student can conduct projects for practical courses in any cluster. In contrast, data science CS students can conduct them solely in the modules of Algorithms, Data Analysis and Parallel Computing.

PR1 and PR2 share the same prerequisites for registration of twelve ECTS credits, meaning two courses (as each of them is generally valued six ECTS points), in the chosen specific field/cluster, e.g., "Data Analysis". Their successful completion rewards students with six and twelve ECTS credits for PR1 and PR2, respectively.

The actual execution and perception of the practical courses vary significantly between the research groups. This is explicitly described in Section 6.3.2 *"The Practical Course System and its Role"* of the qualitative study.

Master Seminar

The already briefly introduced three ECTS Master seminar is scheduled for the fourth semester for both CS and BI students. It, much like PR1 and PR2 for CS students, starts of with the shared kick-off meeting, which is further described in Subsection 5.2.2 below. The goals of the Master seminar are officially described the following way:

> "The goal is to write a survey paper. Instead of a survey paper, you or your supervisor can suggest a different scientific format for your paper which is equivalent in terms of workload. Any alternative to a survey paper needs to be consulted with your supervisor. This paper will be submitted for peer-review. The received reviews should be incorporated, and the final version presented in a conference style setting at the end of the semester. Survey papers of other participants of this course should be reviewed. The topic of the survey paper should optimally be the topic of your Master's thesis or a related topic. This can be clarified with your respective supervisor." [6]

[5] Taken from `https://ufind.univie.ac.at/en/course.html?lv=053021&semester=2021W`, accessed: 04/01/2021

[6] Taken from `https://ufind.univie.ac.at/en/course.html?lv=053049&semester=2021W`, accessed: 04/01/2021

Furthermore, in the kick-off meeting, it is expressed that the Master seminar has the goal of solidifying and communicating the chosen Master's thesis topic and to make students aware of related work and what other students are working on.

Requirements for registering for the Master seminar course are successful completion of PR1 and a software engineering course planned for the second semester for CS students. BI students have to complete the software engineering course and three other courses, all scheduled to be completed after their second semester.

The general flow of the Master seminar is that firstly, within two weeks, students have to register their topic and supervisor or request to get a topic assigned. Then, after six weeks, students are supposed to submit their paper. This paper is usually a survey paper regarding the chosen topic, but it can also be of a different format of equivalent workload if the supervisor consents to it. Within two weeks of submitting their paper, the students have to review the submissions of other students. Lastly, students have to present their work one month after the deadline for submitting their reviews. The topic of the paper written by the students is ideally but not necessarily highly related or identical to their Master's thesis topic.

The Master's Thesis

This subsection describes the actual Master's thesis process of CS and BI students, following the recommended semester schedule and therefore conducting their thesis projects in the fourth semester in combination with the Master seminar. The Master seminar was described in the previous Subsection. As already mentioned, it is not obligatory to start the Master seminar and Master's thesis in the same semester and work on the same topic in both of them. However, since it is highly recommended and the most common practice, this case is explicitly described. The Master's thesis is worth 27 ECTS credits in total.

Prerequisites for registering a Master's thesis topic and, therefore, writing the thesis are identical to those required for the Master seminar.

The topics that a student can register for their Master's thesis, similarly to topics for practical courses 1 and 2, have to match the chosen specialization of the student. The scope of the topic has to be chosen in a way that enables the student to be able to finish it within the timeframe of six months. However, there is no formal and enforced deadline for the actual submission of the Master's thesis, meaning that it can be worked on for much longer as well.[7]

Since the Master seminar and Master's thesis usually go hand in hand, students actually face a deadline, as imposed by the Master seminar, to register their topic and supervisor within two weeks after the start of the semester. This deadline is necessary, as it is required to allocate the work hours to the supervisors in the scope of the Master seminar, as, e.g., a supervisor supervising five students conducts more "course teaching" than a supervisor with one student. This deadline for the topic registration also coincides with

[7] Curriculum of the CS Master's degree programme, available at: `https://informatik.univie.ac.at/studium/studienangebot/master/master-informatik/curriculum-master-informatik/`, accessed: 06/01/2022

the general deadline until which students can cancel their enrolment in courses without any negative consequences. The actual Master's thesis topic registration itself, much like its submission, has no formal deadline, as it is not assigned to a course taking place in a specific semester and is attributed to supervisors differently on a per-submission basis. This two-week deadline, as reported in Section 6.3.3, can be perceived as stressful by some students who have not already thought about their topic choice and supervisor before the start of the semester.

As already briefly touched upon, the actual formal registration of a Master's thesis topic is completely decoupled from the Master seminar topic and supervisor. The required procedure and formalities are not in any way addressed in the kick-off meeting and have to be looked up on official web pages by the student or answered by the respective student's supervisor. In order to formally submit a Master's thesis topic, students have to fill out a registration form and sign that they acknowledge and are going to adhere to the rules of scientific practice. Additionally, they have to provide a summary/exposé of the topic. The respective student's supervisor then has to sign the registration form and the topic summary/exposé. After all the documents are accordingly signed, they have to be submitted to the StudienServiceCenter (SSC) for approval.

In contrast to Bachelor's theses, PR1, and PR2, only professors can formally act as supervisors for Master's theses. Postdocs can, on request and approval, only officially co-supervise Master's theses and act as the main supervisor for the lower levels (Bachelor's theses and practical courses). While PhD students officially do not act as (co-)supervisors of Master's theses, they often act as collaborators and support the supervision process. PhD students are also a common source for the issued topics to be worked on by students. These circumstances are described and motivated in more detail in Subsection 6.3.2 of the qualitative study.

Other relevant information is also available on various official web pages, such as official templates for the written part of the thesis and information regarding its submission. The web pages containing this information are somewhat scattered and often only available in German.

How working on the thesis itself is handled is a very individual affair between students and the respective supervisors. In general, supervisors have a lot of freedom in defining the scope, aims, and topics. The only official guidance regarding its scope and aims is found in the official curriculum[7], which defines it this way[8]:

> (1) The Master's thesis serves as proof of the ability to work on scientific topics independently and in a manner that is justifiable in terms of content and methodology. The task of the Master's thesis is to be chosen in such a way that it is possible and reasonable for the student to complete it within six months.
>
> (2) The topic of the Master's thesis can be found in one of the modules of the chosen specialization subject. If another subject is to be chosen or if there

[8] Translated from German

> are ambiguities regarding the assignment of the selected topic, the decision on admissibility lies with the responsible body according to study law. ...
>
> (3) The Master's thesis is worth 27 ECTS points.

After completing their thesis, students have to sign up for a Master's exam, which is worth three ECTS credits not included in the 27 credits of the Master's thesis. In order to schedule a Master's exam, students have to mediate a date for it with their supervising professor, another professor to act as a second examiner, and the study director to act as chair. After a date is set, students have to register the exam at the SSC. The Master's exam is implemented as a Defensio and consists of two parts. In the first part, students must present their thesis in 25 to 30 minutes. In the second part, the examiners ask students questions regarding their thesis and adjacent subjects[9].

Shared Kick-Off Meeting

Both practical courses and the Master seminar start with a shared kick-off meeting, typically within the first two weeks of the respective semester. In this meeting, one person, usually the current vice dean of educational affairs of the faculty, generally introduces the ideas behind the modules (PR1, PR2, Master seminar and Master's thesis) as well as their requirements and rough timelines. Afterwards, it is briefly shown which research groups can supervise topics assigned to specific clusters. The last part of the presentation then consists of going through slides, one per research group, where the possible supervisors from that group, along with their contact information, are listed. Besides the supervisors, these slides always contain a link leading to a web page. On this page, the responsible research group lists available topics or generally informs about their areas of interest. The slides of some groups additionally contain a date on which either group-specific kick-off meetings or the office hour of supervisors take place that students interested in supervision should visit[10].

It is important to note that only a few supervisors from the research groups tend to be present at this meeting. After the presentation is finished, a question and answer session starts, where students can ask the presenter questions. These questions are most commonly of a more formal nature regarding the registration for the courses and whether the student fulfils the prerequisites.

Since, as already mentioned, this meeting is shared for PR1, PR2 and the Master seminar for students of both the CS and BI Master's degree programme CS students, in particular, attend this meeting up to three times during their studies. Therefore, inherently a lot of its contents can be unnecessary for some students, as they either already finished their practical courses or are BI students.

There are other drawbacks to this format. In particular, the information it conveys by presenting the research groups and providing the links to the respective topics comes

[9] Information taken from: `https://informatik.univie.ac.at/studium/hilfe-fuer-studierende/wegweiser-masterstudium/anmeldung-zur-masterpruefung/`, accessed: 06/01/2022

[10] Presentation slides available at: `https://ufind.univie.ac.at/en/course.html?lv=053049&semester=2021W`, accessed: 06/01/2022

quite late, as students already should have been searching for a topic. However, the meeting cannot occur earlier regarding the start of the respective semester. The laws and regulations require it to take place in the actual semester itself, since the modules are actual courses for which students need to register and confirm their registration.

For the course dedicated to writing the Bachelor's thesis, a very similar meeting is held. In this meeting, basic formalities are presented, and all research groups are mentioned along with basic information about the available topics.

5.2.3 Presentation of Topics and Research Groups

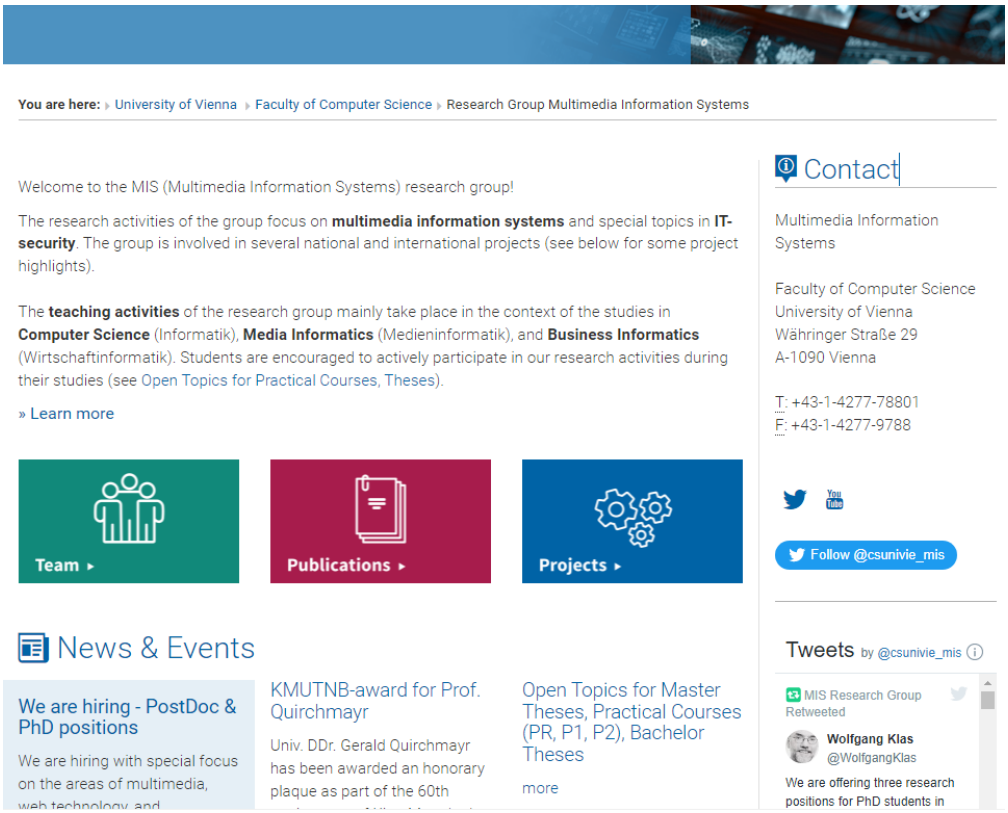
Research groups present themselves on the internet through individual web pages that are connected to the main web page of the University of Vienna. The appearance and structure of these pages are partially predetermined and fixed, somewhat trading the freedom and individuality of the respective research groups for a more uniform and professional web presence.

There are some deviations in the general appearance and structure of these pages. Generally speaking, a set of fixed tabs lead to specific subpages. There is a "Research" tab, which always links to specific standardized pages, listing the publications of the research group members or current and past research projects. A "Team" tab lists all research group members, and a self-explanatory "News & Events" tab informs visitors about what is currently happening. The tab most relevant for students seeking topics is undoubtedly the "Teaching" tab. Under this tab, there is most commonly a first element entitled "Courses", listing all taught courses by members of the research group per semester and a second element called "Open Topics". In the "Open Topics" section, the respective groups should present their topics to students. Some groups have additional elements in the "Teaching" tab, such as previously completed as well as current works by students and additional group-specific information regarding theses and PhD students.

An example of a research group's web page is depicted in Figure 5.1.

Research groups add and manage the content of their web appearances with a Typo3 Content Management System (CMS), which generally is very mighty regarding functionality, but often not used optimally. For example, the listed open topics are often added and updated by editing raw HTML and sometimes, if necessary, JavaScript, in text fields that offer no features like autocomplete, automatic formatting, and error detection. This leads to the fact that handling the appearance of topics is a task that most commonly only the technician of the respective research work can do. To circumvent this quite tedious and difficult practice, some groups add a link to their "Open Topics" page, redirecting to a web page outside the official web appearance, e.g., generated by a wiki-software. Such a wiki page is usually much easier to handle and manage than the page served by the Typo3 CMS. Another way of circumventing the official page is by creating a Moodle course for currently open topics, offering higher-level content editing and hiding topics from people external to the university. Another more simple way to circumvent the intense active use of Typo3 is to provide a link to a PDF file and simply edit and re-upload the file instead of having to change the web page directly. In other cases, in order to save effort, the groups only list their supervisors and general fields of interest instead of specific topics

Figure 5.1: An example of a research group's (Multimedia Information Systems) web page (Taken from: `https://mis.cs.univie.ac.at/`, accessed 09/02/2022)



as they are current for much longer and do not need to be adjusted on a per-term basis. However, some groups actively use Typo3 to manage their open topics and are generally very exerted when it comes to their topics' presentation, and, e.g., even manually program search or tag capabilities into them.

As already briefly touched upon, the format and shape of the open topics are also very different between the research groups. Inherently, as some of the groups use, e.g., a wiki page for their display, the overall design and appearance is different to the topics of groups using the official standardized web page generated by Typo3. However, even between the Typo3 generated web pages, none look alike because even though the style of the used HTML elements is standardized, the types of elements and the way they are actually used is different. Unsurprisingly, the actual contents of topics and how they are described varies a lot between the various research groups as well.

Generally, there are two types of research groups. The first one issues topics in the way of thematic areas, for example, *"Architecture Patterns for Blockchain-Based Systems"*. These broader areas leave the focus of the works as well as the included tasks open and mostly require discussion and agreement between the student and respective supervisor. Such topics are most commonly presented with just a title. However, they can be accompanied by additional information such as a brief description, possible directions and focuses, as well as further references.

The other way of issuing topics is already way more specialized and already in some way specifies the concrete direction of the work. Students can usually directly pick such topics, as they are already specified and described enough. Because these more specific topics cannot be specified well enough through just a title, they are always accompanied by at least one sentence further describing them, in contrast to the first way mentioned. While there is always a description provided for such topics, its length varies. The descriptions can be one short sentence or an entire paragraph. Some groups also provide additional information, such as course prerequisites, technologies/programming languages to be used, tags, further references, services provided, and a listing of concrete tasks.

Two examples of how open topics are presented to students on the research groups' web pages are visible in Figure 5.2[11] and 5.3[12]. Figure 5.2[11] shows a rather detailed topic issuing, whereas Figure 5.3[12] depicts a more broad way of specifying topics.

Besides the already inherent difficulty generated by topics being scattered around various web pages, the fact that they are all in diverse formats further makes the topic search process of students more challenging, as they cannot quickly scan the pages. Instead, they need to adapt to different topic formats constantly.

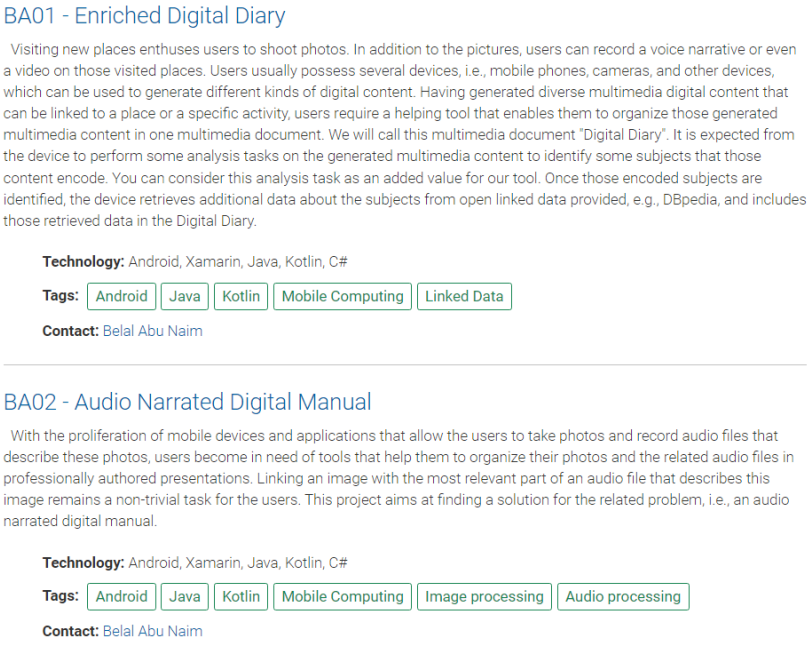
A further complication arises from the fact that it is often not visible to students whether a topic is still current and not already taken by another student, and whether the web page with the open topics is already final for the upcoming or current semester.

Not knowing if the web page is final for the respective semester makes students not know whether additional topics will get released before they have to decide on a topic

[11]Taken from: `https://mis.cs.univie.ac.at/teaching/open-topics-practical-courses-theses/`, accessed 09/02/2022

[12]Taken from: `https://sc.cs.univie.ac.at/teaching/open-topics/`, accessed 09/02/2022

Figure 5.2: Example detailed topic issuing (From: `https://mis.cs.univie.ac.at/teaching/open-topics-practical-courses-theses/`, accessed 09/02/2022)



BA01 - Enriched Digital Diary

Visiting new places enthuses users to shoot photos. In addition to the pictures, users can record a voice narrative or even a video on those visited places. Users usually possess several devices, i.e., mobile phones, cameras, and other devices, which can be used to generate different kinds of digital content. Having generated diverse multimedia digital content that can be linked to a place or a specific activity, users require a helping tool that enables them to organize those generated multimedia content in one multimedia document. We will call this multimedia document "Digital Diary". It is expected from the device to perform some analysis tasks on the generated multimedia content to identify some subjects that those content encode. You can consider this analysis task as an added value for our tool. Once those encoded subjects are identified, the device retrieves additional data about the subjects from open linked data provided, e.g., DBpedia, and includes those retrieved data in the Digital Diary.

Technology: Android, Xamarin, Java, Kotlin, C#

Tags: Android | Java | Kotlin | Mobile Computing | Linked Data

Contact: Belal Abu Naim

BA02 - Audio Narrated Digital Manual

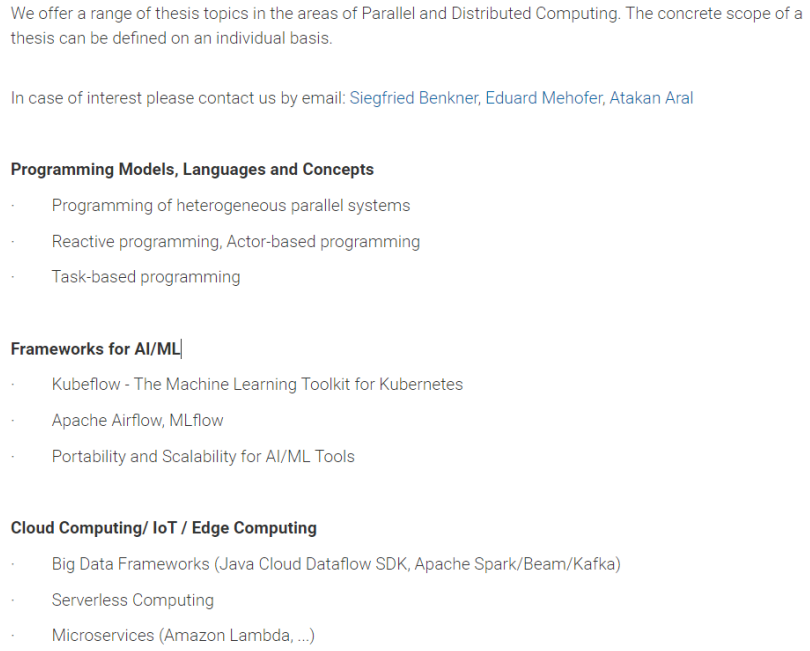
With the proliferation of mobile devices and applications that allow the users to take photos and record audio files that describe these photos, users become in need of tools that help them to organize their photos and the related audio files in professionally authored presentations. Linking an image with the most relevant part of an audio file that describes this image remains a non-trivial task for the users. This project aims at finding a solution for the related problem, i.e., an audio narrated digital manual.

Technology: Android, Xamarin, Java, Kotlin, C#

Tags: Android | Java | Kotlin | Mobile Computing | Image processing | Audio processing

Contact: Belal Abu Naim

Figure 5.3: Example of broader topic issuing (From: `https://sc.cs.univie.ac.at/teaching/open-topics/`, accessed 09/02/2022)



We offer a range of thesis topics in the areas of Parallel and Distributed Computing. The concrete scope of a thesis can be defined on an individual basis.

In case of interest please contact us by email: Siegfried Benkner, Eduard Mehofer, Atakan Aral

Programming Models, Languages and Concepts

- Programming of heterogeneous parallel systems
- Reactive programming, Actor-based programming
- Task-based programming

Frameworks for AI/ML

- Kubeflow - The Machine Learning Toolkit for Kubernetes
- Apache Airflow, MLflow
- Portability and Scalability for AI/ML Tools

Cloud Computing/ IoT / Edge Computing

- Big Data Frameworks (Java Cloud Dataflow SDK, Apache Spark/Beam/Kafka)
- Serverless Computing
- Microservices (Amazon Lambda, ...)

and whether they should recheck the page and if so, when exactly. However, this is not the case for all the research groups. Some of them include this beneficial information by providing a date stating the time of the last update, or by letting students know when the final update for the current semester is to be expected.

Additionally, aside from the appearance and shape of the open topics, their amount differs dramatically. Some groups offer, e.g., three very general areas of interest, while others have 37 rather specific open topics issued.

Another aspect where the groups differ is whether students are explicitly invited to share their own project ideas. While none of the interviewed professors/supervisors stated that they are not open to student suggestions during the interviews described in Chapter 6, only two research groups actually invite students to suggest ideas or at least write that it is possible on their open topics pages.

Likewise noteworthy, is the fact that the research group web pages are not designed for and therefore similarly do not serve the purpose well of presenting them specifically to students interested in supervision. Instead, the aim of the web pages is more focused on presenting themselves to external parties.

However, students would benefit from information that helps them decide whether they want to conduct their projects within a group and, should they have their own topic idea, know where and to whom to propose it to. For making such decisions, students would need to easily obtain information about what a research group is actually about, what they currently do, and what kind of areas a supervisor is specifically interested in. The way this information can be obtained currently is by an "about us" text, which not all groups provide sufficiently for this purpose and going through current projects and publications, which can be pretty tedious. Additionally, the supervisors themselves, along with their supervision methods, which both form an important aspect in the students' decision-making processes, are not directly addressed by these web pages at all.

5.2.4 Topic Publishing and Assignment Process

Inherently, besides the actual form and presentation of issued topics, the research groups' internal processes of establishing and assigning topics to students vary as well. All the information within this subsection stems from the interviews conducted in the scope of Chapter 6.

The way how these topics emerge and why is explained in vast detail in Subsection 6.3.2 as part of the qualitative study. This subsection deals with how they arise on the research groups' web pages, detailing what the actual publishing process is like in the first part and how they are afterwards assigned to individual students in the second part.

Topic Publishing The processes of how the topics arise on the research groups' web pages can be generally divided into two distinct groups, which are defined by who is responsible for updating the issued topics: the individual supervisors themselves or a special employee, most commonly the group's technician or secretary. Most commonly, groups using the Typo3 CMS forward their change requests, while supervisors from groups

handling the topic issuing process externally from the official group web page, e.g., on a Wiki, perform their desired changes directly themselves.

Inherently, the process where supervisors can directly perform changes on their issued topics and add new ones is more efficient, as they do not need to communicate these changes and additions to another responsible person, which then has to perform them. However, suppose this is enabled by moving the issued topics to an external location to circumvent the use of the Typo3 CMS. In that case, this leads to the reduction of a uniform appearance and a bypassing of university brand guidelines. Therefore, it is not free of drawbacks.

Alongside this categorization, there are also differences in when these changes actually occur. For some research groups and supervisors, it is done in a rather unstructured and individual manner. If a topic arises, it is possibly issued, either by themselves or by forwarding a change request to the one responsible. In other research groups, it is a more structured process, starting towards the start of a new semester, where students will search for topics. In that case, the start of a new semester triggers the responsible members to contemplate their changes. Consequently, these changes are then discussed with the research group lead or the whole group, sometimes even in a dedicated group meeting, and then performed. Some research group leads require approving the changes, while others place the responsibility for the topics purely in the hands of the respective group members.

Topic Assignment Regarding how students interested in a research group's open topics are allocated, different approaches exist as well.

Firstly, research groups that issue general topics and areas do not really have to concern themselves with student allocation, as the topics are individually discussed with the students. As long as the supervisor has capacity, they can accept students' requests for being supervised.

Should the research groups issue more specific topics, this task can be more of a challenge. The most straightforward approach is obviously "first come, first served". Occasionally, however, value is also placed on the interested students' respective qualifications for the topics. In this case, the assignment results from speaking with the students or collecting information about their qualifications by other means, e.g., by them having to write an application for the topic. In this application, they describe their interest in the topic and their relevant prior experiences. The last and most sophisticated way to assign students is performed by one research group, which makes students pick two to three topics and rank them by priority in Moodle. An algorithm then handles the specific assignment in a fair manner.

5.3 Previous Work on Creating a System for Topic Search

A previous attempt of creating a system to unify the process of handling open topics between research groups was made by the *"MIS – Multimedia Information Systems"*[13] research group of the faculty. The system was developed in the scope of a small scale, informal and paid student project. It was developed in 2018 and used in 2019 by the MIS group, and could not capture the interest of other research groups.

The primary reason for its shutdown was that organizational changes occurred quite often, necessitating adaptations to the system. These adaptations could not be performed as there was no staff available to implement the required changes in the software. Additionally, it was perceived that the other research groups were not motivated enough to utilize it, as they did not see the necessity of amending the topic search and assignment process.

In order to gain access to the system, students had to register themselves with their ID and a chosen password. However, only students whose ID has been already imported into the system could register. The IDs were imported by uploading CSV files. These can be directly generated from the course management system of the University of Vienna. The CSV files list all students and their IDs attending a given course and enable students with IDs within them to register after being imported. Because of this, the system only handled the assignment and issuing of topics for Bachelor's theses, PR1, and PR2 as these scopes are represented as actual courses, requiring students to register for them beforehand.

After entering the system, students had to choose the course/scope and research group from which they wanted to select a topic. Then they had to choose a certain number of topics and rank them by priority. This number was set by the research groups beforehand.

Topics were represented as titles along with a description and supervisor. Within a course, students had a free-form text search, which filtered the topics of that course based on all of their fields simultaneously.

The system did not directly handle the assignment of the students to topics and supervisors. However, it significantly facilitated the decision-making process behind it by allowing to export the students and their chosen topics along with the priorities as a spreadsheet.

While handling the concrete way of issuing topics and assigning students well, it failed in combining the different approaches of research groups, as it enforced a specific method of handling the overall process.

Additionally, it did not serve well in providing any kind of orientation for students and only helped them marginally in their overall search processes. The reason for these shortcomings was that students, to utilize the system, already had to decide on a group using the system beforehand. To access the system and topics, they had to register for the respective course offered by the research group. As ideally, the search process of students should start and be supported much earlier, only being able to enter the system after the term has already started, in which students need to pick a topic, is very late.

[13] `https://mis.cs.univie.ac.at/`, accessed 06/01/2022

Furthermore, the system provided no help in finding out about general thematic areas of research groups and the possible supervisors.

Furthermore, it was not easy to maintain, as every semester required creating new courses within the system. This led to always having to enter all topics manually anew, as there was no import or copy functionality. Adding to the maintenance difficulty, the system still required the official group web pages with open topics to be updated and be synchronized with the system. Students still needed the official group web pages to initially decide on the research group to gain access to the system, as previously mentioned.

Lastly, it was also quite unintuitive in how it was supposed to be used by professors/-supervisors and not well documented.

Although not in use anymore, the system still provided many valuable lessons and aided in the design of the new application, which should aim to amend its shortcomings.

5.4 International Comparison

As part of the Design Thinking [Pre18, Bro08] approach, it is also heavily recommended and emphasized to take a look at how other people/organizations handle the same or similar problems and situations. Looking at how others tackle the same or at least similar issues can lead to great insights and ideas. In this case, if one looks at how, e.g., other related university-level institutions handle the topic search and issuing process. Those different institutions might have different solutions to slightly different or very similar problems that one would not think about if looking at, for example, solely the University of Vienna, Faculty of Computer Science. One's look is always focused on the problems/issues at hand because they are the closest and seem the most relevant, while often overlooking other aspects that might be highly pertinent as well. It could also be that those other entities solved the problem we deem as most relevant. However, in doing so, they maybe had to face another problem that could be avoided by already taking it into consideration beforehand.

Because of this, a brief look was taken at how degree programmes for Computer Science (CS) from five different European universities handle the overall Master's thesis process. The information was gathered by briefly interviewing (former) employees of the other universities and openly talking about how the Master's thesis process is handled there. These interviews were either standalone or included as part of the interviews conducted for the qualitative study described in Chapter 6, should the respective interviewee have had relevant experiences in other European universities.

5.4.1 Institutions No. 1 – 3

The first three institutions are generally very similar to the University of Vienna, Faculty of Computer Science in how they handle the overall Master's thesis phase and, specifically, the topic issuing process.

All three institutions share the same general schema, where individual research groups

issue the topics very independently on their own web presences. There is no central system for this task.

Even a system similar to the practical courses is present in Institutions No. 1 and No. 2, depending on the specific degree programme. In contrast, Institution No. 3 has two more extensive Master's seminars in the last two semesters of the Master's degree programme instead of practical courses. Institution No. 3 likewise starts the Master's thesis process earlier by already allocating a third of the Master's thesis' ECTS credits to the third semester.

Noteworthy ideas were that in Institution No. 1, more specific kick-off meetings are held for students interested in being supervised. In Institution No. 3, open topics are not solely issued virtually on the internet. Instead, they are visible on a centrally placed bulletin board in the university building as well. Since both of these ideas are also greatly usable for the university of Vienna, they are further motivated and described in Subsection 6.3.5.

5.4.2 Institution No. 4

The fourth institution is not as similar to the University of Vienna, Faculty of Computer Science as the previously mentioned institutions.

Regarding the general structure of the Master's degree programme, specifically the Master's thesis, Institution No. 4 already dedicates a big part of the third semester for the Master's thesis. However, students are invited to split it up however they like, but officially it is strongly recommended to split it over at least two semesters. There exists no equivalent to the Master seminar of the University of Vienna, Faculty of Computer Science. Likewise, there is no similar obligatory practical course system. There is a course where a digital system is designed and implemented as part of a larger project, which has a similar official description as PR1 and PR2. However, this course is much smaller in scale, only granting three ECTS credits upon completion. Depending on the CS specialization chosen, this course is either obligatory or purely optional.

The most interesting aspect of Institution No. 4 is that topic issuing and even registration is centrally handled by the information system of the institution. The system briefly presents topics by title, responsible supervisor, course prerequisites, and tags. Both tags and course prerequisites are not required to be specified. Students can obtain further detail of topics by clicking on them, then an official or preliminary description/assignment and other information optionally entered by professors/supervisors is visible. Much like at the University of Vienna, Faculty of Computer Science, these issued topics vary significantly in their granularity. Some have very detailed official assignments that seem very fixed, while others only have brief preliminary descriptions and broader titles.

At the point of inquiry, there were 228 available topics issued at Institution No. 4. Even though professors/supervisors can specify tags, the issued topics cannot be explicitly filtered by the tags, research groups or supervisors. Instead, the topics are fixed to be grouped by the respective supervisors. To view all of them, one has to scroll through the entire list of topics. While this system fulfils its purpose, it also nicely shows improvement potential, very relevant for the design of this project's web application.

Even though students have to register for thesis topics in the information system, the assignment is still handled rather manually, and students and professors/supervisors usually meet to discuss further details.

Besides listing currently active topics, the system also enables searching for already assigned and even finished topics. Past theses are available in an official archive dedicated to them as well. However, much like the official archive for theses of the University of Vienna, it only allows for very limited targeted search possibilities. For example, both archives do not allow to search by research groups.

Another distinct difference between Institution No. 4 and the University of Vienna, Faculty of Computer Science regards industrial topics provided by partner companies. At Institution No. 4, such industrial topics are not only officially encouraged, but even have a dedicated web page where they are presented to students.

Likewise very interesting and inspiring, was the provision of six fundamental thesis types by Institution No. 4. These types generally inform students of Institution No. 4 about what can be done in the scope of a Master's thesis. The types are briefly described in an official document containing other organizational information regarding Master's theses. The six fundamental types are the following:

- Implementation work
- Experimental & evaluation work
- Theoretical work
- Concept design & prototype implementation
- Overview work
- Work with an artistic focus

5.4.3 Institution No. 5

The last Institution, much like Institution No. 4, has a system that handles the issuing and unified display of topics, serving as a sort of marketplace for topics. However, the respective respondent noted that this system is not utilized much because other channels are much better for finding students, resulting in a lack of motivation to use it.

Additionally, this system is only for already clearly specified topics. The topics even have to be specified by a one to two page long contract. Therefore, in contrast to the Faculty of Computer Science at the University of Vienna, adapting topics to individual students is very difficult and seldom possible. The respective respondent even stated that they would appreciate more flexibility in this regard.

Another reason why the system is often circumvented is that a huge part of the overall student topic search process happens in personal discourse. Overall, the aspect of personal contact is perceived to be very important.

Similar to Institutions No. 1 to No. 3, Institution No. 5 offers practical courses as well. These are, however, slightly different. They are group projects shared between students and not directly connected to Master's theses. Institution No. 5 is also distinguished by the Master's thesis being fully scheduled for the last (fourth semester) of the Master's degree programme with no prior courses connected to it, such as a Master seminar.

The brief look at Institution No. 5 further motivated that this project's web application for topic issuing and search should also somewhat incorporate and support the more direct and personal channels for students to find topics and supervision. The look at Institution No. 5 confirmed that even if a system is in place and usable by everyone, it can never fully replace these other channels.

6 Qualitative Study & Information Gathering

Chapter 6 describes the qualitative study and information gathering process. In contrast to Chapter 5, where the formal and official definitions as well as outward-facing aspects, such as the various ways of issuing and presenting topics by the research groups, are examined, this chapter focuses on the Master's thesis process and related relevant aspects as lived and experienced by the stakeholders.

At first, Section 6.1 delineates the overall study design and characteristics, followed by Section 6.2 that circumstantiates the design and process of the conducted interviews with professors/supervisors and students, providing insight into and reasoning behind how the interviews were conducted, how participants were selected, what goals were pursued and how the interviews were processed.

Section 6.3 reports the gained insights and results from the processing of the interviews in terms of overall perception and views of the Master's thesis and topic search phase. The determined requirements and desired functionalities regarding the to be developed web application for both professors/supervisors and students are described thoroughly in their own Chapter 7.

Finally, Section 6.4 provides a concise summary of the study and briefly mentions the key takeaways.

6.1 Study Design

The study is to be understood as a generalized qualitative research study, as described by R. Yin [Yin15], with the general focus of representing the perspectives and views of professors/supervisors as well as students. The overall goal is to obtain an understanding and holistic view of how they perceive and feel about the overall Master's thesis phase, especially the topic issuing and search/finding aspect, what motivates and drives them to act the way they do, as well as capture relevant experiences. Generally, as proposed by R. Yin [Yin15], the study design explicitly aims to account for real-world contextual conditions that might influence the behaviour, view, perspective, and motivations of the relevant actors.

Additionally, there are aspects of action research, as defined by B. Turner et al. [ATH06], included, since the study aims to lead to the suggestion of potential improvements and provide valuable insights to feed into the design of an IT-artefact in the form of a web application. This application aims to improve and transform the process for the involved people in a positive way. Therefore, according to B. Turner et al. [ATH06], the study

can not be seen as solely observatory but also interventionist, as it was directly joined with action with the goal of devising, implementing, and somewhat monitoring positive change. Furthermore, the author was a student, making him directly fully involved in the process. This involvement is explained in more detail in Section 6.3.1.

The overall approach was inductive and exploratory. There were no initially defined concepts or categories as a clear focus was given to capturing the data with an empty mind devoid of any theories to check or confirm.

The primary collection method for the data is unstructured interviews with a more conversational mode. The design of these interviews is described further in Section 6.2 below.

Validity of the study is strengthened by following the core strategies to combat threats to it as proposed by J. Maxwell [Max12, Yin15] as often as possible, namely:

- **Intensive long-term involvement** — The researcher/author is a student himself and therefore was "in the field" for many years (for more repercussions of this fact, see Section 6.3.1).
- **Respondent validation** — Whenever possible, participants were asked for allowance of follow-up questions. Additionally, confirmatory questions were asked as often as possible to minimize misunderstandings and misinterpretations.
- **Search for discrepant evidence and negative cases** — The way participants were selected was aimed at collecting a diverse set of participants. Additionally, there was no "positive" case to be proven, as the study was of a mostly exploratory nature.
- **Triangulation** — A focus was placed on only considering theories and findings if multiple sources support them. If this was not possible, this fact was emphasized and made visible by following the subsequently described principle of "numbers".
- **Numbers** — The reported results and findings of the study are not reported solely by vague adjectives but supported by concise, actual numbers.
- **Comparison** — Interview participants were chosen to be as diverse as possible to enable comparison of emerging results across different groups and settings.

One strategy not fully covered is the one of **"Rich" data**, as this project had time and effort limitations and there was no access to statistics on the topic. The interviews and personal field observations of the author are the only data sources. In terms of the documents considered, the curriculum and other publicly available information about the degree programmes of CS and BI at the University of Vienna were used and included.

Since the study is focused on the Faculty of Computer Science at the University of Vienna, the study has one broader unit and 19 narrower units. For a detailed description of the current situation at the Faculty of Computer Science at the University of Vienna, see Chapter 5 *"Analysis of current State"*. The narrower units consist of eleven professors/supervisors and eight students who were interviewed. Due to the studies'

limited sample size and inherently its qualitative and explorative nature, it does not claim to be representative.

6.2 Interview Design and Process

In general, the interviews followed the tips and best practices described by R. Yin [Yin15] on the one hand and by A. Pressman [Pre18] on the other in order to combine the methodologies of Qualitative Research and Design Thinking.

There was no guide of questions strictly followed during the interview process. Instead, a set of topics to roughly go over as part of a research protocol, as recommended by R. Yin [Yin15], was used for orientation. The Interviews were conducted in a way such that they feel like a genuine conversation and discussion to the participants rather than a formal questioning or survey to really allow for self-expression, openness, and honesty - aspects that are somewhat lost in too structured interview formats.

The topics within the research protocol [Yin15] helped to lead the overall study, especially the data collection in the form of the interviews, efficiently by covering the broad line of inquiry as a mental framework. However, there was still much attention given to retaining an open mind to properly capture the perspective of the participants and the overall field, as well as to react to fresh and unexpected information properly. A fixed set of questions was avoided because the interviews are supposed to evolve with each conducted interview, as with each one, insights were gained on what is deemed important and where sentiments most likely differ.

All interviews, besides one conducted via telephone, took place through online conferencing tools, e.g., *BigBlueButton* or *Microsoft Teams* as current (Spring 2021) Coronavirus regulations in Austria made personal "offline" meetings not feasible. The specific tool was primarily chosen based on the personal preference of the interviewed person. If the participant allowed and accepted it, the interview was recorded and later on transcribed. For the transcription process, the audio was initially converted to text with the *Speech to Text* service, part of the *Cognitive Services* of the *Microsoft Azure Cloud* and then manually checked, formatted and corrected. As some interviewees did not agree on their interview being recorded, notes were taken instead and later reviewed by the respective participant.

The interviews were also used as an opportunity to explicitly gather and discuss ideas for (innovative) features and functionalities of the web application as well as determine requirements for it. Furthermore, if the interviewee was formally employed at a different higher education institution, comparable to the University of Vienna, they were also asked about the overall process there, whether it differs and if so how.

To summarize, the interviews were used for up to four distinct purposes:

- The qualitative study, as described in this chapter.
- The overall Design Thinking approach - to gather information about the problem at hand, generate novel ideas together with the participants and evaluate thoughts and ideas by getting feedback from the participants.

- The analysis of the current state, containing the comparison to other higher education institutions.
- The requirement analysis and generation of ideas for features of the web application implemented and designed in the scope of this project.

The results of the parts not covered in this chapter are described in Chapter 5 for the current state analysis, Chapter 8 for the implications on the overall design of the application, and Chapter 7 for the requirements and features.

6.2.1 Professor/Supervisor Interviews

The eleven participants for the professor/supervisors interviews were selected purposefully by writing an e-mail request to at least one professor/supervisor of each research group from the University of Vienna, Faculty of Computer Science. This was done to make sure that many different views and sentiments are captured, that are as independent of each other as possible and give everyone the opportunity to state their requirements and wishes. The eleven interviewees stemmed from ten different research groups (with the two from the same group having a very distinct focus) out of the fourteen that exist at the Faculty of Computer Science of the University of Vienna. The specific recipients of the interview/talk inquiries were selected based on their "information richness", meaning that professors/supervisors who were assumed to deliver the most relevant and plentiful data were prioritized.

The duration of each interview varied between 30 minutes and one hour, depending on how much time the respective interviewee had. All interviews were conducted within a timeframe of about three weeks in spring 2021.

All interviews were conducted in German, as it was the native language of all participants except one (who did it voluntarily in German rather than English) and therefore allowed for the best and most unrestricted expression.

Since each one of the professors/supervisors was contacted in an individual, private and timely spaced-apart manner, their reports were attempted to be as purposefully non-collusive as possible.

For the professor/supervisor interviews, topics to talk about were:

- Current procedure of how topics are issued.
- Motivations for issuing of topics.
- Requirements, learning goals and definition of a Master's thesis.
- Stance on the current state.
- Experience with supervising – common pitfalls and difficulties of students.
- Stance on own topics suggested by students.
- Wishes/Requirements/Suggestions for the web application.

6.2.2 Student Interviews

Overall, the student interviews were executed similarly to their professor/supervisor counterparts. The length of the eight interviews varied between half an hour to one hour and a half. The student interviews took place in a window of three weeks in May and early June 2021.

The selection process of the eight participants was purposeful, with the aim to maximize the information gained and cover the most views possible. Therefore, care was taken to ask students with various backgrounds and different paths regarding their thesis topic selection to be interviewed. This was ensured by, for example, choosing interview participants who switched research groups between Practical Course 1 (PR1), Practical Course 2 (PR2), and/or the Master's thesis, stayed within the same research group, or even have their Bachelor's degree from another university-level institution. Additionally, to equally represent the different types of students at the Faculty of Computer Science, it was ensured that the participants come from both the BI Master's degree programme and different specializations of the CS Master's degree programme.

A focus and preference were given to students currently writing their Master's thesis. However, to gain access to a broader range of possible interviewees, students that are advanced in their Master's studies and shortly before this phase were also interviewed. All interviewed students were at the time enrolled at either the CS or BI Master's degree programme of the University of Vienna.

With students, the following topics were discussed:

- Personal experience with topic search and academic project conduction.
- Beneficial and hindering factors of the overall Master's thesis process.
- Factors for deciding on a topic.
- Stance on creating own project ideas and topics.
- Expectations of supervisor and overall supervision.
- Wishes/Requirements/Suggestions for the web application.
- Student-relevant features suggested by professors/supervisors.

6.2.3 Interview Analysis and Evaluation Methods

After compiling the data by transcribing the interviews, or if the interviewee disagreed with being recorded, writing up an interview summary and allowing the interviewee to review it, the collected texts were disassembled into codes to gain insights and sort the qualitative data.

After the disassembly through coding the data, the collected codes were reassembled. This was done by grouping codes together with the aim of discovering themes and theoretical concepts that might lead to new insights.

Since recommended and suggested by many researchers experienced in doing qualitative analysis, analytic memos, as described by R. Yin [Yin15], were written down during the disassembly of the data to prevent ideas from being lost during the process.

The coding was performed with the *QDA Miner Lite* [Res17] software. It is free to use, provides the necessary functionalities, namely coding and defining code categories, and proved simple to use as well as easy to learn. Other tested alternatives where *AQUAD* [GLH], a completely free open-source software for qualitative and quantitative text analysis (even providing extension for analysis of videos, audio, and pictures). However, in contrast to *QDA Miner Lite* [Res17], it proved to be more complicated than necessary and harder to use and learn. Another alternative was *Taguette* [RRD21], which is a fully free open-source tool as well. It was developed at the University of New York, created purely for the simple coding of text. Sadly, it did not support categorizing of codes and therefore was not well utilizable in this project. Apart from this downside, *Taguette* [RRD21] was very user-friendly, pleasant to use and even provided cloud functionality, therefore not needing any kind of local installation at all.

6.3 Interpretation & Conclusion

6.3.1 Reflexive Self

Especially in qualitative research, as described by R. Yin [Yin15], where the direct observation and interaction between the circumstances being studied and the researchers themselves is valued, it is necessary to give readers insight into the particular research lens used and potential biases. Therefore, this chapter aims to briefly describe the author's relationship with the topic at hand.

The study's author is a male Master's level student at the University of Vienna himself and was rather successful in his studies, even working part-time as a tutor at the university. Because the author acquired his Bachelor's degree at the same faculty, he was already known to most of the interviewed professors/supervisors.

Finding a project idea or topic was always difficult for him. Out of four academic projects, the author switched research groups four times. The switches occurred for various reasons, including the supervisor leaving the university, negatively perceived supervision experiences, topics not being able to be further extended or worked on and lack of interest by the author.

Therefore, the author felt strongly about making a contribution to possibly improve the current situation and identify potential issues in the overall topic-issuing as well as project conduction process.

6.3.2 Professor/Supervisor Perspectives

This subsection summarizes the findings of the conducted interviews with the eleven professors/supervisors. At first, the supervisor's role, as described by the professors/-supervisors themselves, is specified.

Secondly, an overview of professor/supervisor goals and requirements of thesis projects is given. Consequently, the personal motivations of professors/supervisors, answering the question about why they actually supervise students, are explored as well.

Next, directly tied to the personal motivations of supervising students, the relationship of theses to scientific papers are described, followed by the explanation of a seeming lack of direct incentives specifically perceived by one participant.

Afterwards, the participants' stances on their issued topics and their intended aim, as well as perceptions of how students actually seek topics, are explored. Consequently, the professors'/supervisor's views on project ideas put forth by students are described.

Furthermore, difficulties that students encounter, as perceived by the professors/-supervisors, are collected and perceptions on the current situation at the faculty of Computer Science described. A special emphasis is put on the implemented practical course system and its role in its own respective subsection.

Lastly, other interesting statements and views of the participants that could not be categorized or put into the preceding subsections are explained in the last subsection.

The Supervisor's Role in the Supervision Process

Regarding statements about the functions of the supervisor in the thesis supervision process, three participants stated that they accompany the students in the overall process. Two of those three participants said that they give students hints and support to ensure they do not get lost *(regarding the overall scientific process meant by one and mathematical difficulties meant by the other professor/supervisor)*. One participant even stated that a supervisor could and should entrain students. Another participant saw yet another task in their function: connecting students to experts and other relevant third parties and other students with similar works.

Besides accompanying the student in the thesis project, the other most common statements regarding supervisor functions, stated by three professors/supervisors, was ensuring that the topic and its scope were appropriate for a thesis.

Additionally, as expressed by three participants, enforcing and deciding on a correct methodical approach (such as creating artefacts using UML models or other established tools and conducting the project based on a well-defined methodology) is seen as a responsibility during the supervision of student projects.

Furthermore, there were statements from different participants in stark contrast to each other. One supervisor saw it as their function to provide and define appropriate topics, while another expressed that it was not their responsibility as it is a shared project with a student and therefore the topic should be developed together. Related to this theme, two other professors/supervisors stated they support the student in creating and defining the final topic to be worked on.

Goal of a thesis

As stated by six of the supervisors, the most prevalent goal of a thesis was to make students understand the overall methodology of scientific work. This includes the knowledge of

how to work with and search for scientific literature, a general understanding of how research work is conducted, and the general use of scientific concepts. Another aspect of this is the teaching of academic writing, which was stated to be a goal by two of the supervisors directly.

Another set of goals were skills on a higher level, such as the ability to complete and endure a more extensive project from scratch *(stated by two participants)*, the capability to act on a broad basis *(mentioned by one participant)*, fostering creativity *(said by one participant)*, dealing with uncertainty and ambiguity *(stated by one participant)* and the mindset of being an actual expert in the field of the thesis *(uttered by two participants)*.

Lastly, a common theme were goals on a more practical level, such as the acquiring of relevant practical knowledge, the preparation for the future professional life and, intertwined with the scientific skill goals, the ability to cooperate with a research institution *(stated by one different participant each)*.

Requirements of a Thesis

Directly connected to the goals of a thesis, we have the requirements and expectations deemed by the professors/supervisors.

Firstly, there are requirements for the project or thesis topic itself. Many such requirements concern the scientificity of the work, such as the requirement that it is a scientific work with a research question *(stated by two participants)*. Three participants described this more broadly, as the thesis having to be scientifically interesting or to be something scientific. This was mostly seen as the counterpart of a work focusing on practical aspects, as expressed by one of the participants:

> "So for Bachelor's and Master's theses, it has to be scientifically interesting and not just programming of something. I would not accept that." - P2

Another set of statements regarding the "scientificness" of the work mandated that it had a scientific aspect and required a scientific approach to be taken, as expressed by two of the professors/supervisors:

> "... that it is shown, that one can sort of work oneself in a scientific topic, understand the scientific literature there and then also in a way find out something new. Having this aspect of the Master's thesis, and this does not have to be worthy of the title page of 'Nature' or something, but simply show that one understands this scientific process and can execute it." - P9

Additionally, as five of the participants stated, the most commonly expressed requirement was that it should be an independent work of the respective student.

One supervisor, in particular, saw a difference between scientificity and innovation, stating that they just require it to be innovative, rather than scientific:

> "I see research on one side, scientific research, and innovation on the other. Meaning from a Master's thesis, I want to expect that the problem, even if it

> comes from the industry or is an industrial problem, is solved by an innovative solution. This does not have to be something scientific. It can, for example, be a totally new idea.... The eligibility to be innovative has to be put into our responsibility, into the responsibility of the supervisors. It is exactly the same as the scientific quality, that is also put in our responsibility." - P3

Another requirement, imposed by the faculty, is a practical implementation aspect, as stressed by four participants. However, two different participants stated that a Master's thesis should not just be programming and stressed the importance of other aspects as well.

The actual definition of (minimal) requirements, as stated by the curriculum/law, was mentioned by three participants.

Secondly, there are requirements posed upon the student conducting the thesis project. In this regard, there was interest by the student required by four professors/supervisors, thematic prerequisites (for example acquired by finishing specific courses at the university) required by one, enough effort put in by the student stressed by one and lastly, the ability to combine creativity and acquired knowledge mentioned by another participant.

The professors/supervisors views also diverged when they talked about Bachelor's theses, as some require them to be scientifically interesting as well[1]. At the same time, at least one professor/supervisor accepts works focusing more on practical aspects in the context of a Bachelor's thesis as well:

> "I mean such standard issues stories like implementing the 27th database for a company, that is at most at the level of a Bachelor's thesis. There I also partially accept that. I currently supervise a student, writing a Bachelor's thesis, who brought a very interesting topic ... for a Bachelor's thesis that's okay, but for a Master's thesis it maybe is not innovative enough for me." - P3

Motivations for Supervising a Student's Thesis

In contrast to the previous aspects, the participants were way more unified in their motivations for supervising students' theses. As stated by eight participants, the most common motivation was overall "scientific" interest in the topic, meaning that it can on some level advance science in the field of the respective supervisor/professor. On a more detailed level, two participants stated that (paid) research projects are a motivation, as theses can often contribute to them.

Furthermore, two participants mentioned possibly gaining a future PhD student as motivation. One of them also stated the possibility of gaining connections to companies (by the previously supervised student being employed) with whom a research project might be conducted in the future as an incentive for thesis supervision.

Especially the inclusion of a Master's thesis into PhD students' dissertations appears to be a prevalent theme, as this modality was mentioned by seven out of the eleven participants. The most apparent advantage was that it could help advance the respective

[1] See the first quote of this subsection

dissertation, which was expressed by 4 of the interviewed professors/supervisors. Another advantage of this theme, as stated by two of the professors/supervisors, is that the PhD student can act as an unofficial co-supervisor, who is often highly knowledgeable and able, as well as motivated, to spend more time on the supervision. One participant also mentioned that thanks to the dedicated supervision of the PhD students and their ability to formulate very good topics based on their own work, such co-supervised theses often end up being published. In contrast to that, however, one participant said that they deem this practice of outsourcing the supervision of a student as irresponsible and that a professor should always supervise mainly by themselves.

Another very often stated motivation, as expressed by five interviewed professors/-supervisors, was that theses could help explore possibly interesting topic areas. Since three out of those five participants especially stated this in relation to dissertations, this aspect can also be seen as highly related to the previously described motivation of the students work being part of and help in the advancement of a PhD student's dissertation. For example, one of the professors/supervisors partially motivated supervision of student projects this way:

> "... the PhD students that work on a dissertation entrench themselves somewhere *[thematic area]*, and in the context of such a dissertation many interesting questions emerge. Naturally, one can offer students to play a part in that context... In the beginning, a PhD student does have little conception. They first need to get their feet on the ground... then they have an increasing personal interest to work on a project with the possibly best students because that is, of course, an implicit resource to gain better understanding of the thematic area... Instead of trying out every experiment by themselves, one can much easier let everything be tried out within student projects ..." - P4

Another very common motivation was personal interest in the thesis topic, as mentioned by five participants. Three of those participants clearly differentiated this type of interest from the previously mentioned "scientific" interest and others. This was expressed by one of the participants in this manner:

> "... and I say that quite openly, that is maybe something you *[author]* can take away. I do not do Master's theses just because I have to, but I do Master's theses only if I truly have a personal interest... I am more about having my fun fulfilled through the Master's thesis." - P3

Lastly and interestingly, only three of the eleven professors/supervisors expressed that student education is a motivation for supervising theses. One exemplary statement of an interviewed professor/supervisor, talking about the reasoning why they have some broad topics issued that are not quite their current research focus, would be:

> "... because maybe students are interested in something a little bit different and then I now also do not want to say: 'No, you are only allowed to work on what I specifically need for my next paper or something like that.', rather it

> is a bit of training and education too. Also, according to the principle, if the topic is a little bit different, maybe is not quite on my mainline, but cannot really be supervised by anybody else at the university, then that is also okay." - P9

The Relationship between Student Theses and Published Papers

Directly tied to the most common motivation being overall "scientific" interest was the relationship of publishing scientific papers and Master's theses. This is a topic where the participants once again diverge in their opinions.

On the one extreme, we have one participant stating that the contents of a thesis must be publishable, not requiring that it actually happens. Should the thesis contents, however, have no possibility to be published at a conference, they have no interest in the topic:

> "If that is not possible, the probability that I am interested in that topic decreases rapidly... Maybe there are communities that really need it, for which it *[topic]* is interesting, but if it is not possible to publish it in some way on a conference at least possibly possible, then it does not interest me. By the way, the same applies to Bachelor's theses, this does not mean that it is a requirement, that it actually happens, but it just means that it should be in the realm of possibility." - P2

An additional professor/supervisor stated they always try to achieve the publishing of a thesis's contents all while not requiring the topic to be scientific, in the sense of being publishable, but rather be innovative and something new[2].

Two participants aid students in publishing the results of their theses if the respective students wish to do so. One of them explicitly stated that whether or not a thesis should be "publishable" depends entirely on the student's goal, which determines the focus of the thesis. If the student wants to pursue an academic career, a paper built on the contents of the thesis should be submitted to a conference of higher ranking. This, however, is not just with the publishing of a paper in mind, but also with the goal that the student can gain first insights into what this process is like, as it is relevant for their future endeavours. On the other hand, if the student sees their future more in the realm of industry, this demand is discarded, and the focus is only on understanding how to work scientifically. The other professor/supervisor mentioned that they initially prioritize the student finishing their thesis but support them afterwards in their effort to publish it, should they wish to do so.

The most common stance, as expressed by four participants, is that it is certainly good and nice if publishing the contents of a Master's thesis is possible, but that they do not intensely chase or require it in any way. One of those four participants even stated they prioritized student interest in the topic over the possibility of an additional publication. Another participant stated that the thesis' contents should have the entitlement, level and

[2]See the last quote of P4 in Subsection *"Motivations for Supervising a Student's Thesis"*.

quality of a publication, but that they do not pursue its actual publication. Furthermore, this professor/supervisor clearly expressed that they valued their interest in the topic higher than the possibility of it being published.

On the other extreme, there is one professor/supervisor clearly stating that the requirement for and focus of a topic to be publishable at a conference is bothering them and that it is only really possible, if a student is already very advanced and deep in the topic, by already having performed a PR1 and PR2 on it beforehand. Two other participants expressed that advancing science in such a way is more the task of a dissertation from a PhD student rather than that of a Master's thesis.

Lack of Direct Incentives

Connected to the high importance of "scientific" interest, be it in a general sense, exploring a possibly interesting topic area or taking part in the dissertation of a PhD student, one participant provided further insights into why these motivators are so prevalent for thesis supervision.

They stated that student education is often deemed a necessary evil by their colleagues since the incentive system of the university only rewards and monitors research-related achievements and activities, such as publications, while not actually rewarding good supervision or education of students by itself. Thus, for a supervisor to put more than minimal effort into student supervision, they require some form of motivation, which most commonly is the advancement of their own research activities. Putting additional effort into the supervision of a purely student-sided, for the group's research irrelevant, project is deemed as pointless, even damaging, as it leads to less time that can be dedicated to performing actual research and is not usable by the research group afterwards in any kind of way. The respective professor/supervisor describes this as an insane conflict that is built into the system, which has nothing to do with them personally or the faculty itself, but instead is a system error that they personally try to mitigate by only supervising topics that are fully relevant to the research activities of their research group.

Stance on the Issued Topics, their Target & Perceptions of how Students Seek Topics

As further described in the analysis of the current state in Chapter 5 professors/supervisors present their issued topics to students in a very heterogeneous manner. Similarly, they also have very diverse perceptions about the issuing of such topics and how students seek through them.

One professor/supervisor perceives a competition between the web pages with currently open-topics of the research groups, as their ultimate goal is not just to acquire a high number of students, but rather to get a serious good interest of actually interested students. To acquire this interest, they stated that it was necessary to invest in the depiction and presentation of their topics. The feeling of competition between research groups for (good) students was likewise mentioned by another participant *total of two*.

The goal of attracting interested students through issued topics was also expressed by four of the participants.

Two participants expressed that they wish to supervise and find good students. In contrast, one participant explicitly stated that it is okay to supervise "not so good" students, as that is part of education as well.

Since many research groups do not issue specific topics, but rather only broader areas or even just state the possibility to contact them in case of being interested in being supervised, there are also cautions regarding the issuing of (too) specific topics. For example, two of the participants stated that the topics are often outdated because of "slatternliness" and carelessness. In contrast, two other participants explicitly described how they keep the topics recent through regular group meetings, where the topics are reviewed. There are also professors/supervisors disliking more specific topics in general. In the opinion of one supervisor/professor, topic descriptions are often misunderstood by students. Another participant stated that they think that topic details are not too important from a student's perspective, as the essential takeaway is more like: "Is this generally okay and interesting for me?". Two other participants share the opinion of students generally just wanting to pick the seemingly easiest topics and that apparently more complex and challenging topics are less popular. Another two participants share a similar view of issued topics being more for "not so interested" students, as interested students do not need them but rather contact supervisors more directly. This was expressed in the following manner by one of the professors/supervisors:

> "I am uncertain if an overview of current topics, so to speak, is very meaningful for the really interested students. For those *[other students]* that say: 'I want to finish my studies now somehow, I need the topic now, what looks like little effort?' such a platform might make sense. For those *[really interested students]*, I think, simply should have an overview of the professors and what they do and meet them. Then that works itself out, at least with me." - P1

One supervisor/professor furthermore stated a general dislike of issuing more specific topics, as they deem it to be boring. They perceive it as letting a student perform more extensive work for basically free instead of employing someone specifically for it. As stated by one of the participants, a different reason for refraining from issuing specific topics on the public research group web page is good ideas potentially being stolen by third parties.

Additionally, five participants mentioned that they use courses they teach to find students for projects. Be it more passively by mentioning currently issued topics or the mere possibility for supervision, or even more actively by directly asking students who stand out positively. Three supervisors/professors even stated that most of their supervised students come from the context of courses taught by them. Courses as means to find students to supervise for projects was described in the following manner by one of the professors/supervisors:

> "That's actually the alternative *[for topic issuing]* . . . that works the best. . . because everyone has their special courses and those are visited just by the people, that

> are interested in that subject and then over time in the course conversations occur and either a student says: 'Yes, I would like to do a project in this direction' or the instructors themselves advertise their topics... This, I think, is so far the way that works best." - P5

Another sentiment shared by two of the interviewed participants is that students prefer topics that are applicable in the real world, have an actual use, and are overall more practical. One of these professors/supervisors stated that they perceive a discrepancy between a student's wish to perform work that is actually useful as well as usable and the inherent property of science requiring more experimentation and the trial of new things that might not be inherently useful.

Lastly, three of the interviewed professors/supervisors expressed that not only the topic was relevant to students, but that the supervisors themselves are also an aspect of the students' choice since supervisors and students need to be compatible with one another. This compatibility is expressed in a personal manner (e.g., sympathy) and more formally in terms of supervision style. This, for example, includes the meeting frequency and the overall inclusion of the supervisor in the process. One of the participants stated it in this way:

> "It's not just about the topics, it also is about the personal factor so to speak, can one work with the supervisor, are they sympathetic to one ..." - P1

Stances on Students' Project Ideas

Project ideas from students is another theme, where the overall views of the interviewed participants diverge.

One supervisor/professor said that topic ideas from students are ideal, as they show that the respective student has already engaged with the topic and knows what they want to do. However, the same participant also stated that, should that be a truly standalone project, not integrated into any kind of research project or ongoing dissertation, it is not as profitable for the student.

Another set of the participants who do not offer specific topics on their respective web pages deem that every thesis they supervise is actually a student idea. In fact, two of the professors/supervisors explicitly stated that it was their goal that students gained "ownership" of a topic and steered it in their own direction.

Generally, four of the eleven participants expressed themselves as welcoming to student project ideas, while two mentioned they were open to them. No participant was closed off towards student project ideas . However, one explicitly stated they preferred it when students took their issued topics, as they were already elaborated, thought through and fitting to the actual expertise and research focus of their respective research group. The same participant furthermore remarked that student project ideas often need to be adapted in order to be appropriate. Contrary to this, another professor/supervisor had no preference between student project ideas and their own issued topics. Likewise, one other professor/supervisor explicitly would like more student input when it comes to potential thesis topics. Regarding the actual representation on the respective web pages, only two

of the eleven participants explicitly invite students to propose their own ideas besides their open topics.

Scepticism regarding student topic ideas and suggestions is, however, also perceived. Firstly, three participants expressed that it was difficult for students to develop a scientific topic with an appropriate scope. Secondly, as shared by two participants, another reason for scepticism were topic ideas from students generally arising from the students' workplaces. Such ideas were perceived as merely attempting to "sell" one's work as a Master's thesis.

These "industry" related topics are described, differentiated and observed by many *(eight)* of the participants. Seven of these have a negative view towards them, with two professors/supervisors stating they are often not as interesting for them. Another criticism about these topics, as expressed by three participants, is that they often have no research aspect. One participant expressed dislike towards them but stated that some of their colleagues gladly supervised them, as they can lead to paid research projects later on. Another participant who likewise described them as problematic said they could work if the expectations by the included company are not too fixed. This sentiment is somewhat shared by another professor/supervisor, who stated they could be adapted to be okay, but that these situations rarely occurred. The reasoning for this rare occurrence was that those topics are mostly already very fixed and just used by the student to get a degree without putting too much additional effort into it. One of the participants expressed no negativity towards these industry-related topics, saying they were generally welcoming towards them as long as they required a scientific approach. However, they also added that many such topics are declined by them.

Commonly Perceived Difficulties of Students

Regarding difficulties that students often encounter while conducting their Master's thesis, only two were mentioned by multiple *(three)* of the interviewed professors/supervisors. Firstly, the difficulty of students to autonomously and correctly use formal, well-established tools, frameworks, and methodologies, the knowledge of which they should have obtained during their studies. This, for example, includes using professional mock-up tools (instead of drawing prototypes by hand), formal use case descriptions, UML diagrams, conceptional models utilizing mathematical notation and common scientific methodologies such as Design Science. Secondly, motivational problems and a lack of personal drive from the side of students was stated by two participants as a common difficulty.

The other difficulties have only single mentions. On the one hand, these difficulties are more technical and practical in nature. Such difficulties include technical implementation difficulties arising from too challenging topics, mathematical issues, the overall design process taking a very long time, as well as expressing oneself correctly and concisely in academic writing.

On the other hand, the difficulties also include more personal student-related aspects. Such stated difficulties were dealing with uncertainty and ambiguity when starting to work on a scientific project, not having a concrete ending and path defined beforehand, and too high expectations on oneself regarding progress. In addition, one professor/supervisor

perceived that some students generally have difficulties working in an organized manner, such as taking notes after going through a paper in order to know months later what the key takeaways, if any, were regarding one's own project.

Views of the Current Faculty Situation

Overall, the interviewed participants were not very specific in stating what they like about the current faculty situation and system in place. Four professors/supervisors mentioned good experiences with students, where the results of thesis projects were very well received. One professor/supervisor noted that the curriculum prepared students well for writing a thesis. The practical course system is also mentioned positively by four of the participants - these statements are further described in the Subsection *"The Practical Course System and its Role"* below.

However, there are many perceived issues. Two of the participants felt they lacked opportunities to present their topics and themselves to students, as they are currently not teaching many courses. Similarly, two participants questioned the current kick-off meeting for project work as they felt students do not gain much from it and because it is not really possible to present one's overall research focus and person there. Additionally, they stated that they would prefer either a workshop-like session where each group gets a presentation slot or smaller research group-specific sessions. Another participant described that the whole atmosphere appeared very closed off as there is a lack of shared common open events, where it would be possible for them to exchange themselves with their colleagues. Such open events would enable them to find out what their colleagues' PhD students are currently working on, and also allow students to appear to get to know potential supervisors and topics.

As described in the specific subsection *"Lack of Direct Incentives"*, one professor/-supervisor feels that supervision of students itself is not incentivized enough by the overall system. Similar, more systematic issues are perceived by another participant who feels like the guidelines and laws are sometimes too strict, leading to too narrow a timeframe for students to settle on a topic. A different participant thinks that the time it takes to adapt the curriculum is too long. Another issue, perceived by two participants, is that the general process of assigning project topics to students is very uncoordinated in how students are distributed between and within groups, with e-mails as the primary vehicle to settle assignments. Lastly, one participant described the whole system of formally registering a Master's thesis topic as outdated since it requires a lot of e-mail writing, printing, analogue signing, and scanning-in that should not be necessary.

Additionally, two of the participants shared the sentiment that the current official research group web pages make it difficult for students to find out what a research group is currently working on and find out what a particular potential supervisor is doing as part of their research.

Furthermore, one of the professors/supervisors perceived that the strict scientific aspect of Master's theses is overly emphasized and enforced. This sometimes unnecessarily scares students by posing too high expectations and ultimately suppresses students who truly perform great work because it "maybe is not necessarily scientific".

Lastly, one participant observed that Master's students who got their Bachelor's degree externally from another faculty or university often lack formal prerequisites to perform a Master's thesis project.

The Practical Course System and its Role

The implemented practical course system, further described in Chapter 5, likewise comes with different opinions on it.

Overall, the system is perceived well, as five of the participants stated that they valued the overall idea of the practical course system, with two of them even saying that it worked well while none stated the contrary.

While the system and its idea are perceived well, the participant's opinions diverged when it came to the aspect of switching research groups, supervisors and/or topics between the different levels. Two professors/supervisors stated that the system was good, especially because switching between the levels is possible.

This switching between the different levels is where the participants diverge in their opinions. On the one hand, four professors/supervisors stated that switching is part of the system. However, one of these participants expressed that theses come out better if the student also finished the practical courses on the topic and that they actually prefer if students complete the practical courses and their Master's thesis on the same topic. On the other hand, one of the participants clearly stated that it was difficult to do a Master's thesis without the respective student having completed the practical courses in the research group beforehand. Therefore also expressing a strong preference for students who never switched and completed their practical courses in their research group.

Another critical view, shared by two participants, is that completing the whole Master's thesis path in one research group was strongly advertised as the main way. They argued that this pushed people early into a specific direction, effectively discouraging students from switching. One of those participants described that students often appeared to be slightly embarrassed and unsure when asking if they could switch to their research group for a PR2 or Master's thesis without having completed another project there before. That respective participant also stated that they thought it would have potential to more openly advertise the possibility of switching and conducting projects within different research groups. Embracing switching more would lead students to spend their time at university exploring diverse aspects of Computer Science, therefore acquiring broader knowledge, instead of becoming an expert in a more narrow field and limiting the quality of their education. Additionally, they stated that it is also difficult for supervisors to "let a good student go" as better students have a higher chance of conducting substantial work that advances the research of the respective research group. This, once more, stresses the importance of "scientific"' interest in the Master's theses of students. One of these professors/supervisors made a case for "normalizing" switching research groups and/or topics between the levels in the following manner:

> "However, I see it *[Practical course system]* definitely a little bit critical. Why? Because we set students already on some track with PR1 and then always

> consistently work on that track and if I have to think holistically, in terms of whether the education that a student reached is of high quality, then it is not only about so to speak knowing one track perfectly. Rather it would be quite okay if one could also be acknowledged to other tracks... therefore, I see a bit of potential here if one would be more permissive and not only propagate: 'PR1, PR2 and Master's thesis to topic X' but rather absolutely motivate students to say: 'I make PR1 to topic X, PR2 to topic Y and Master's thesis to topic Z'." - P4

Another aspect of the practical course system, where there seem to be different stances, is in how far practical course topics relate to Master's theses. Three of the participants stated that it was to be seen as a preliminary work for the thesis, while three others mentioned that this needed to be somehow discussed beforehand, as they also gave out standalone "chunks". However, this can also be seen as a direct extension of the discrepancy mentioned beforehand, as professors/supervisors who encourage conducting the whole path in one research group subsequently have to design their supervised projects in a way that enables a continuation of a previous level.

Other Interesting Views and Statements

This subsection briefly records other interesting views and statements from the participating professors/supervisors that could not be grouped into their own subsection.

Five of the participants stated that a thesis project had a better outcome if the student was interested and motivated. Three professors/supervisors expressed that there was a better outcome if the supervisor was interested and motivated.

Criticism about the current way science worked, especially the conference system, was expressed by two of the professors/supervisors.

Three of the interviewed participants shared the preference of less imposed guidelines and overall more freedom, as well as the possibility for personal choice. Be it in the way of format guidelines for theses, scientific aspiration of topics, or supervision in general. One of them described it as "one size fits all" being an inherently bad approach that killed personal innovative capacity, which is an essential aspect of Master's theses and their supervision.

6.3.3 Student Perspectives

This subsection summarizes the findings of the conducted interviews with the eight students. Firstly, an overview is given about how the participants moved through the practical courses to the Master's thesis by describing if, how and why their topics or supervisors changed. Then, the students' behaviour about how they actually search and pick their project topics is explained, followed by a description of what was perceived as beneficial and hindering during this process.

The following subsection illustrates the concrete ways of how the interviewed students actually found their respective supervisors and topics.

Additionally, because the supervisor was perceived as an important aspect when deciding on a topic during the interviews, the students' expectations and wishes concerning supervisors were also explored in more detail.

Lastly, the students' stances on coming up with and conducting their own project ideas as well as overall perceptions about project-based work are explained.

Practical Course Experiences

Surprisingly, none of the interviewed students *(out of three Computer Science (CS) students where this would be possible)* experienced the case, where Practical Course 1 (PR1), Practical Course 2 (PR2) and the Master's thesis are conducted on the same overall topic or topic area as well as research group.

One of the interviewed students performed both practical courses and the Master's thesis in one group, though the topic was changed after PR2. Another participant came close, but they had to switch research groups because their PR2 supervisor was not a professor and therefore could not be the main supervisor of a Master's thesis. Additionally, a professor of another research group was more involved in the topic's area, further motivating the switch. However, the supervisor from the practical courses still officially acted as a co-supervisor. Likewise noteworthy, is that this student's topic changed after their PR1. Out of the other CS students, one who currently also conducted their thesis switched groups for PR1, PR2 and the Maser thesis. Two others, currently at the stage of their practical courses, have not switched so far. However, these two students strongly considered switching at some point.

Regarding PR1 four *(out of five)* students switched topics. Either they or their supervisor did not see a possibility for continuation on a thematic level. Two of those four students mentioned above even changed not just the topic but also the research group and therefore supervisor. Regarding reasons for potentially switching groups at all levels, besides simply not seeing a possible continuation on a thematic level, unhappiness with the supervisor because of too little technical knowledge as well as the supervisor's research focus and interest having moved into a, for the student, undesired direction was reported by one student each. Additionally, one participant mentioned a supervisor becoming unavailable due to having too many supervised projects already.

One of the students also shared the opinion of one of the interviewed professors/-supervisors, that conducting Practical Course 1 (PR1), Practical Course 2 (PR2) and the Master's thesis on one topic in one research group is seen as the main realization[3]. The same student also echoed this professor's/supervisor's opinion in that they deem it difficult to switch between topics and groups and that it provides a better education. Supporting the sentiment that switching is somewhat deviant, another student called it a "natural step" to continue the Master's thesis based on their PR2, as there was no need to start anew, and they were already well-qualified in the topic area - the same student also had their supervisor actually propose continuation topics for PR1, already based on the student's Bachelor's thesis, and PR2. Another student used uncertainty

[3]For further reference see subsection *"The Practical Course System and its Role"* of Section 6.2.1.

regarding continuation possibilities after PR1 to propose an own project idea to their supervisor, which was used for PR2. Then, later on, this idea was even adapted to be a Master's thesis project. Thus, this student also heavily deviated from a very linear PR1 to Master's thesis path.

Three of the interviewed students were enrolled in Business Informatics (BI). Therefore, they had no experiences to share regarding the practical courses.

How Students Search for and Pick Topics

Concerning student search behaviour and topic preferences, students share certain characteristics.

Firstly, three of the interviewed students stated that they considered only research groups from which they finished a course and therefore already knew the potential supervisor. Differing from that are two students who considered all research groups and one who considered all research groups about whom they did not hear "anything bad". Another set of students did not have to ask themselves which research groups they should contact. They either knew their primary area of interest and therefore only considered the one group that was engaged in that area *(one student)* or they already knew whom they want as supervisor exactly *(two students)*.

The supervisor specifically plays an important part in the students' choice, as four of the student participants made statements implying that the supervisor, besides the topic itself, also was a critical aspect considered when searching for a topic to work on. Similarly, three students even stated that when making their choice, they considered the supervisor to be more important than their interest in the actual topic. Such students valued basic sympathy and knowledge that the supervisor is a person they can talk and work with well over the topic or thematic area, and generally decide on a supervisor first before caring about the topic to be worked on.

Students form such positive assessments about possible future supervisors in many ways. Most obviously and commonly stated *(by seven students)* is having direct experience with the supervisor in a past project. More indirectly, but also stated by seven of the students, are accounts of other students, either in the form of these students directly having relevant experiences with the supervisor or the general repute of a supervisor among students.

Another commonly mentioned way to shape positive views of potential supervisors, which six out of eight interviewed students expressed, is to finish courses managed and taught by them. The reasoning for why these courses made an instructor appealing as a supervisor was most commonly the supervisor being perceived as sympathetic and likeable to the respective student *(said by five students)*. Other reasons were the course contents being perceived as interesting *(stated by two students)* and the supervisor appearing competent because of a well-designed course *(mentioned by one student)*. Lastly, four of the students were at some point also employed by the research group or even the supervisor directly. This made the respective groups and supervisors more attractive as potential supervisors as well. One student expressed this search factor in the following way:

> "I mean what surely is an aspect too, that one naturally strongly thinks about, at least I did, is who is going to supervise me directly... this has to somehow work personally, one needs to have somehow got a good impression of that person I think or at least know them from a lecture or a course. This person, I think, must have been sympathetic, or one needs to have heard good things about them somewhere." - S5

Courses and their respective contents themselves, as mentioned by two students, also guided their search process, as they can serve as an entry point to begin the search and lead to areas that are perceived as potentially interesting. One student, for example, described it like this:

> "Everything *[potential topics]* came from courses, meaning much had to do with 'Am I interested in the contents of this course?'. This was the crucial point, and if that was given, the next question is also 'how sympathetic or how competent does the instructor appear to me?'." - S5

The preference for specific supervisors, which most often stems from the student already knowing the respective supervisor and work ethic, either directly or indirectly, is also reflected in another search preference shared by six of the students: safety and less ambiguity. This means that generally speaking, topics are strongly preferred if the student can somewhat anticipate that they can perform it well and eliminate as many ambiguities and risks as possible.

This search preference manifests itself in many ways. As already mentioned, if a student knows a supervisor, either through a course or past project or even just heard good things about them, they feel more inclined to choose a topic of that supervisor, as they already, at least broadly, know what to expect. To put it in the words of a student, who reasoned why they decided to continue in the same research group instead of starting a PR2 in a group that was potentially more interesting but seemed more "strict" without any evidence of the contrary:

> "I already know them *[supervisors]*, I know how it works there and they are not overly strict... they are generally more laid back, I mean, I don't know how it works in the other group, maybe they are laid back too, I don't know..., but because I knew them and worked with them, it so arose that I continue there." - S2

Four of the students stated that they prefer and would like more concrete and detailed topics instead of, for example, just areas or brief titles with no additional information. Three of those students also gave insights explaining their reasoning for this preference, as the more detailed a topic is described, the better is a student's ability to form a conception about what their contribution to this respective topic is going to be. This eliminates perceived ambiguity, making this topic more of a "safe choice" and attractive. One student explained this search preference in the following way:

> "Basically interest and what is also a primary factor for me is that I can somewhat imagine how I can do it. I don't want a topic where I have no plan

> or clue about how to implement it in the end, but rather one where I can think 'Okay, I can approximately imagine how to do something like that' that was actually my main focus." - S8

One of the students even stated that they deem the perceived "safety" of a topic more important than significant interest by saying that they prefer to play it safe rather than working on an extremely interesting topic that could potentially reveal itself to be too difficult and take much more time.

Apart from a more detailed description, this also implies that topics more related to content and technologies that students learned and used in courses or elsewhere, e.g., work, seem less ambiguous as well. Also tied to this preference of less ambiguity and opting for more safe choices, one student decided on a topic because they could work on an already established codebase instead of starting completely anew. Therefore, already existing artefacts and material on a topic does make it more appealing as well.

Directly related to the preference for less ambiguity and more safety is the simple preference for topics perceived to be relatively easy. Three of the interviewed students have made statements indicating a preference for easier topics on at least some level. In three of those statements, the perceived lower difficulty stemmed from the supervisor, and in only one of the three, it was regarding the topic, in this case, a project idea proposed to a supervisor. As an example, one of the students, after sharing a story they heard from someone about the respective supervisor, motivated their supervisor choice in the following way:

> "And I thought: 'Yes, okay, they seem very relaxed' and I honestly go to what *[topics]* is not so demanding. I am not so ambitious there that I want to strain myself there *[project work]* additionally. More so, going the way of the least resistance combined with a certain basic interest is what is more tempting for me." - S3

Interest was, in some form, always *(by all eight participants)* stated, but it seems to be seldom the primary preference. Instead, it is more of a tiebreaker used when already settled on a supervisor or research group or mentioned in a very weak way. For example, two of the participants stated that they just require a certain "base interest" or the topic to be interesting to them at least a tiny bit. Generally, this statement of interest seems to be more regarding the overall background and area rather than the specific work, as "fun in doing it" was in contrast only stated by two students. Additionally, two students directly stated that they do not really have any area that interests them. For example, one of the students, when asked about not having a concrete interest, replied in this way:

> "Yes, I think I truly don't have such a thing *[concrete interest]*, at least not, yes not really. Like I can exclude some things with algorithms and so on... but yes, overall there is no big interest into any specific field there." - S3

Additionally, two of the interviewed students expressed that while they have a hard time choosing a topic, they can easily exclude certain topics.

However, some students do not seem to exhibit a "safety first" approach and a preference for what is perceived to be less demanding but rather actually truly chase after their interest, which they also know. One of the interviewed students was an example of this as they proposed their own project idea for PR2, directly tied to their interests, after finishing a PR1 project which was more supervisor driven. This PR2 project was adapted to be a Master's thesis later on. Having discussed their idea with the respective supervisor and also having an alternative offered by them, this specific student chose their own idea even if their supervisor stated that they could not estimate the current research situation in this area, the needed effort, and how well new contributions could be made, thus making it a more risky choice. Additionally, this particular student preferred more brief and broad topic descriptions, consisting of a short abstract at most. They did not feel the need to get a clearer conception of what is to be done, but rather just quickly want to find out if it is interesting to them and worth pursuing. The only question that this student wanted to be answered by looking at topic descriptions was: "Is this generally interesting to me?" and as long as the answer to that question is "yes", more concrete details about the topics do not matter at this point.

Other stated overall preferences were artistic freedom as well as a visible result stated by one of the participants and the possibility for practical use by another one.

In terms of why specific topics were chosen, not really being describable as a preference, one student stated they decided based on "gut feeling". Also interesting was the statement of another student, who mentioned that they feel that their final decision was not really made by them but rather by chance, as they contacted multiple supervisors and research groups but only got one reply, effectively eliminating any choice they could have had. Another apparent reason stated for choosing a specific topic, based on the statements of two of the participating students, was the supervisor directly asking for continuation by proposing a topic. Additionally, one student's decision on why they chose a Master's thesis topic was driven by it being well combinable with the respective student's job. Another student, who initially tried to propose an own topic idea, was persuaded to take an issued topic as the supervisor seemed way more enthusiastic about it.

Beneficial and Hindering Factors in the Topic Search Process

When reflecting on what helped them in their search process, three students appreciated that there are groups issuing topics in a more or less detailed manner[4] with one of them especially appreciating one research group that issues many in a very detailed manner. Another student appreciated being able to establish personal connections to peers in courses, especially on the Master's level. Lastly, one student appreciated their general approach in hindsight, where they first thought about their hobbies as well as what they perceived to be fun and then later on connected that to potential topics to work on.

Regarding hindering factors that students perceived, there was generally a lot more input.

[4] As described in Chapter 5, not all groups issue topics.

The most criticism was perceived for the shared kick-off meeting[5] for PR1, PR2 and the Master's thesis, as five of the eight students criticized it in at least some way. Most mentioned by three of those students was the perception of it being somewhat too late, as they afterwards felt like they should already have a topic by that time, therefore also feeling like they have very little time to settle on a topic. One of the students said the following when asked about what they would improve about the current situation:

> "That we *[students]* have this kick-off meeting at the start of the semester and actually nothing before that and you sit there in the first unit, and then it *[kick-off meeting]* says: 'So, actually you should already have your topic, have fun, the first deadline is in 2 weeks!' which is absolutely useless because there is nothing to do up until that point, but you need to have something put in as a topic. Then you totally haste yourself so that you have a topic within two weeks, which is absolutely unnecessary." - S8

Another criticism was that it did not convey a lot of useful information and is generally perceived to be rather indirect as stated by two of the participants, with one of them saying that *"If you simply directly send the information from the slides, it basically is the same."*, emphasizing how it did not provide any additional value to them by not actually helping in finding a topic. On a related note, another student felt that it lacked information regarding the formal registration of a Master's thesis, making them feel partially lost in the whole process. One of the interviewed students also stated that they perceive it to be repetitive, as CS students basically have to listen to the same kick-off meeting three times. Lastly, another student, not directly saying that they missed this information in the meeting, felt that the overall rules and guidelines of Master's theses were unclear to them, regarding, e.g., if it would be allowed to write a CS Master's thesis with a supervising professor from another related faculty of the university.

Supervisors not replying sufficiently fast to students further increase the previously described perceived difficulty of students having little time to settle on a topic and a late start to the overall process. This was experienced by three of the students, partially even in this critical time between the kick-off meeting and the deadline for the topic submission.

Additionally, two students felt they could not get enough information about the research groups and what they are currently focusing on concretely and therefore interested in. Related to the presentation of the groups, three students disliked the fact that the topics of the different research groups were scattered on different web pages and presented in very different manners, both optically and in terms of granularity, making it difficult to gain an overview. One of those students specifically expressed that they perceived many topics to be very abstract, making it difficult for them to understand what the respective supervisor's expectations were. Another one of those students also criticized that topics were often outdated and updated late. This made it less appealing to start early with the search for a topic, and overall rendered the search for a topic more cumbersome. The

[5] For a more detailed description, see Chapter 5.

last perceived hindering factor regarding the way topics were issued, as expressed by two of the students, was that they were often not described in a "beginner-friendly" manner, which deterred and prevented them from being interested in the respective topics. This was argued by one of these students in the following manner:

> "... but if in the end, you find virtually nothing, except some cryptic titles, where you actually have no clue what they mean, you will most likely not be able to build interest by reading some title you know nothing about if you didn't have an idea or more concrete conception beforehand. " - S8

Furthermore, two of the students expressed that they perceived it difficult to work scientifically or generally on a thesis project, as they never had to do it before, therefore making them feel a bit unprepared.

Moreover, two students expressed that they only knew a small number of possible supervisors personally, especially due to them studying Business Informatics (BI), which, as further described in the previous Subsection *How students search for and pick topics*, is an important aspect for students when deciding on a supervisor and topic.

Lastly, one of the interviewed students expressed that they lacked the confidence to work in their true interest areas. The very same student also criticized that some courses are badly taught and managed, therefore not building enough base knowledge to be able to work on topics in potentially very interesting areas:

> "It surely is also hindering if you simply, I don't know, looking at the whole operation of the university, if you, so to speak, have a very bad basis, which I think we have in some areas because truly the teaching is partially quite bad here. Then this is surely very hindering if you want to find a topic or something there *[thematic area]* because, as already said, you simply have no foundation there... Such things are in any case hindering because you are simply not prepared enough in an area, that actually is so thrilling, that could yield much." - S3

How Topic and Contact Information of Supervisors is Obtained

This subsection illustrates the concrete ways of how the interviewed students actually found their respective supervisors and topics for all their academic projects, including the Bachelor's thesis, PR1, PR2 and the Master's thesis.

Three of the interviewed students found their supervisors through a course, meaning that they contacted the respective supervisor directly because of a course they attended or looked at the issued open topics after they were presented in the attended course. Out of these three participants, one is a special and unique case because the topic arose directly based on assignments that were to be done by the students in that respective course.

Two of the participants stated that they contacted a research group/supervisor or looked at their issued topics based on the general reputation of a supervisor or experiences of other students.

Five students stated that they directly went to the open topic web pages without any seeming influence from a course or other students. Four of those students looked at the issued topics of multiple research groups. The other remaining student directly knew which one to look at based on their interest areas, therefore not needing to look into the ones of other research groups. One of those students mentioned they accessed these pages through the presentation slides of the kick-off meeting.

Interestingly, two of the three BI students relied on the web pages to find their Master's and Bachelor's thesis topics. In contrast to that, CS students used those in their quest for a Bachelor's thesis topic, but then later had a more "direct" way to their topics, never solely relying on the web pages anymore.

Table 6.1 illustrates how exactly the individual interviewed students acquired their topics and found to their respective supervisors.

What Students Wish and Expect from a Supervisor

Because the students placed massive importance on the respective supervisor of, as mentioned in Subsection *"How Students Search for and Pick Topics"* it was interesting to enquire what the actual wishes and expectations of students regarding their supervisor were and what they perceive as positive regarding their supervision.

Most common were statements regarding the supervisor being knowledgeable in the respective area of the project and being able to provide helpful input. Most generally, three of the interviewed students stated that they expected their supervisor to be generally knowledgeable in the area. One of the interviewed students specifically wished that their supervisor had technical know-how. On a more specific note, five students wanted their supervisor to be able to provide problem solutions and tips, with three of them wishing this input to be on a technical or implementation level or at least be connected to a person with such knowledge by the supervisor to solve technical questions. One student did not specifically want problem solutions and tips, but instead wanted their supervisor to help and provide assistance when needed.

In the same direction as the supervisor being knowledgeable, there was a wish for the ability of the supervisor to not only provide problem solutions and tips on demand, but actually show that they also care about the project by appearing involved and actively participating in it *(expressed by five of the eight students)*. This was mentioned in a variety of ways:

- Supervisor actively providing thoughtful suggestions and input *(two students)*.
- Supervisor showing appreciation and providing usable honest critique *(one student)*.
- Student is not just written off by supervisor *(one student)*.
- Topic is also interesting for supervisor *(three students)*.
- Supervisor generally has a sort of guiding function that leads them in the overall process and moves the project in a proper direction *(two students)*.

ID	Level	Method	Switch	Note
S1	Bachelor's thesis	Search	n.a	*Knew interest, looked at one web page*
	PR1	Direct		*Supervisor proposed doing PR1 together*
	PR2	Direct	×	*Co-Supervisor proposed topic, not continued from PR1*
	Master's thesis	Direct	×	*Supervisor proposed topic, could not directly supervise Master's thesis, resulting in research group switch, but topic was evolved from PR2*
S2	Bachelor's thesis	Course	n.a	*Option for supervision and topics were advertised in course*
	PR1	Direct		*Topic evolved from Bachelor's thesis*
	PR2	Direct	×	*supervisors remained the same, but the topic was not directly related to PR1*
S3	Bachelor's thesis	Search	n.a	*All groups considered*
	PR1	Course	×	*Topic arose directly from course that student attended, different research group*
	PR2	Course	×	*Directly looked at specific groups issued topics, different research group*
	Master's thesis	Direct	×	*Directly proposed topic (combinable with job), supervisor known from Bachelor's thesis*
S4	Bachelor's thesis	Direct	n.a	*Supervisor recommended by a friend*
	PR1	Search		*Browsed through issued topics of groups, proposed own topic to Bachelor's thesis supervisor*
	PR2	Direct		*Topic evolved from PR1*
S5	Bachelor's thesis	Search	n.a	*Considered groups based on course impressions and other peoples reports*
	PR1	Direct		*Based on good experience always directly contacted previous group. Topic changed after PR1. PR2 topic was evolved to Master's thesis*
	PR2	Direct	×	
	Master's thesis	Direct		
S6(BI)	Bachelor's thesis	Search	n.a	*Browsed through issued topics*
	Master's thesis	Search	×	
S7(BI)	Master's thesis	Course		*Based on supervisor impression from course direct contact*
S8(BI)	Bachelor's thesis	Search	n.a	*Browsed through issued topics*
	Master's thesis	Search	×	

Table 6.1: Overview of the students' academic project paths

- Supervisor is motivating in the sense of showing a liking in the student's work *(one student)*.

One student, in particular, expressed it this way:

> "My supervisors are very involved. Thus, I always had it rather nice. You get a proposal for a topic, then a little bit of literature to start with, and then I always had regular meetings where I discuss what I tried, what I did, what the results are and then maybe what problems I encountered, and then I consistently received suggestions about what I could do better, what I could do next or how I can solve some problems. Very involved." - S1

More specifically than the wish for involvement but indirectly also expressing and a considerable part of it, is, in particular, the wish for the possibility of having regular meetings with supervisors as stated by four out of the eight students. With some *(two)* of them specifically expressing that supervision, where they only meet a handful of times or even less with their supervisor during their respective project, would be worse. One of the students reasoned for it the following way:

> "...you absolutely need a lot of contact, which was the case, we *[student and supervisors]* had a lot of contact, meaning at least once per week during my thesis...I definitely want from my supervisors that they actually supervise me. So, it does not help at all, if you see or hear from them rarely, even if they end up giving you a good grade, but I think the total package is worse then, as I hear from many theses where they *[students]* hand in something, then end up getting the best grade but ultimately did not gain much from it because, for example, I learned a lot, not only about my thematic area but also about the whole stuff around: working independently, scientific work, that stuff." - S2

Possibly slightly connected to the wish for regular meetings is the expression of two students who want their supervisor to be generally available and react to inquiries in an appropriate amount of time.

Other stated wishes and expectations were the wishes for the supervisor to still enable some freedom instead of dictating a path, and in general, being able to have a relationship with the supervisor where the student is happy to meet with and talk to them as well as show their progress as stated by one student each.

Lastly, two students expressed that they wanted their supervisor to be able to listen to them, with one of them saying it in a general manner and another one explicitly wanting more openness regarding project ideas from students.

Generally, more wishes and expectations for supervisors could also be derived from the way students actually pick supervisors/topics as described in subsection *"How Students Search for and Pick Topics"* of this chapter, for example, the supervisor being a likeable and sympathetic person. Interestingly, this was not actually directly stated in contrast to the supervisor appearing competent in a course, which can be related to the more directly expressed expectation/wish of a supervisor being knowledgeable about the project topic.

Table 6.2 depicts the collected data regarding students wishes/expectations for supervisors in a more compact tabular form.

Statement	#Students
Supervisor can help / provide tips and problem solutions (general)	5
Supervisor meets regularly with student	4
Supervisor can help / provide tips and problem solutions (technical)	3
Supervisor is knowledgeable (general)	3
Supervisor actively provides suggestions/input	3
Supervisor is interested in topic	3
Supervisor is available	2
Supervisor has a guiding function	2
Supervisor is knowledgeable (technical)	1
Supervisor is motivating	1
Supervisor is able to listen to student	1
Supervisor is more open towards topic suggestions	1
Student should be happy to talk to supervisor and show progress	1

Table 6.2: Students' directly stated wishes/expectations regarding their supervisors

Stance on own Project Ideas

In this subsection, students' perceptions and opinions regarding the proposal and devising of their own project ideas are described. Out of the eight interviewed students, only two have experiences regarding own topics. The first student successfully implemented their own project idea in their PR2 and subsequently also worked on it in their Master's thesis. The other student was not successful on the Bachelor's level in proposing their own topic to their supervisor but managed to put their own idea through at the start of PR1. As reasons for preferring an own topic, one of the two students stated that it provides them with more freedom overall, is more interesting to them, and enables them to have more of a plan about what to do. The other student simply saw working on their own topic idea as a way to truly work in their areas of interest and have more fun in doing so. This student also stated that they could indeed say that they are more motivated and have more fun due to being able to work on their own topic:

> "I am looking less forward to the actual really scientific writing of the Master's thesis. But this is, so to speak, not the focus of my topic, rather the system that I want to develop and its evaluation. That is definitely fun for me, and that surely also motivates me more that I proposed my own topic and did not somehow choose an existing one." - S5

Additionally, another student expressed that they did not know about the possibility of proposing their own topics. Instead, they thought they could only choose the issued ones. They also added that they definitely would have proposed their own idea had they

known that it was possible, as it allows them to cover their interest more and provides more space and ability to lay the topic and its subsequent direction out in their terms.

Regarding reasons for not considering creating and suggesting their own topic ideas, two students stated that they had a lack of ideas. One of these students was more specific, attributing this lack to not having some kind of significant core interest in a specific area. The other of the two students did not consider proposing their own topic idea as they deemed the definition of the topics to be the job of the supervisors:

> "Actually, for all of the works *[Bachelor's/Master's thesis, PR1 and PR2]* I didn't know what I wanted to do precisely. Thus, the idea is more: 'Okay, I want to do something in this area' and such specific open problems are more the job of the scientific staff here *[faculty]* as they simply know: 'Okay, there is this and that, maybe one can get more out of this and do something.' and 'I have this and that idea, a student could try this out.'." - S1

The idea that supervisors are responsible for the proposal of a topic is seemingly more common. Even two other students who wrote to their future supervisors about being interested in conducting a project in a particular broader area, as these research groups did not issue more specific topics, reported that the supervisors proposed the final actual topic. These two students did not mention any process where they had to think about possible directions on their own.

Student Perceptions Regarding Project-Based Work

The last point of grouped statements and expression that arose was how the interviewed students felt about the process of searching for topics and doing project-based work overall.

Most *(five)* students stated that they deemed it difficult or challenging to select a topic. One of them referred explicitly to the search for a topic for their Bachelor's thesis, since their topics for later levels were always directly proposed by the respective supervisors, eliminating the need for search. One of the students who found it difficult to select a topic reasoned for it in the following manner, emphasizing the amount of importance they placed on that choice:

> "Because I am afraid to pick a topic that afterwards turns out to be the wrong choice regarding: 'Okay, this is maybe too difficult, this may not be quite my cup of tea, this is uninteresting' and that I then am truly enmeshed in for half a year. This is why I respect it *[topic choice]* so much, 'cause if you pick a wrong course, yes that's six ECTS, one can somehow cope with that but picking such a Master's thesis topic wrong, that would be quite bad I think.." - S4

Some students also do not seem to enjoy this type of work, as two of the students directly stated their previous projects to be uninteresting or even boring. Specifically, one of these students, that previously stated that they do not really have an area of interest regarding their CS studies, felt this way:

> "... it *[working on student project]* sadly is simply not a hobby for me, rather truly classic work. I don't like doing it, so I would not know what type of work I truly could find, where I can say: 'There, this is cool, and in my spare time in the evening I could maybe continue working on it a little bit!'. No, this will not happen to me anymore." - S3

Additionally, as one of the interviewed professors/supervisors mentioned that in other universities, one could de-emphasize, e.g., a Master's thesis and instead finish additional courses, it was interesting to ask some students whether they would prefer doing more courses instead of project-based work. Out of four students who were asked, three clearly stated they would prefer visiting more courses. The other remaining one expressed that currently they would definitely pick the Master's thesis, as they were already quite advanced in it and could combine it with a paid job. However, they added that they were unsure if they said the same in advance.

Another common statement, as expressed by three of the interviewed students, was that the actual work to be performed in the theses and practical courses was beyond skills acquired during visiting and finishing courses at university.

Lastly, on a positive note, six of the students were happy with their overall choices in hindsight, though one said that there was probably quite a bit of "luck" involved in terms of which supervisors replied to their initial queries. The students being happy with their choices was especially positive, as the other remaining two students did not state anything of the contrary. Another positive sentiment was that three of the students specifically appreciated the freedom and independence given to them by their supervisor in their respective project-based work. Furthermore, three of the interviewed students stated that they felt like they learned a lot from their projects, with one especially appreciating learning how to work scientifically. An example for such a positive statement is a student reflecting on their Bachelor's thesis, where they followed a gut feeling and took a risk by taking a topic not familiar to but very interesting for them:

> "... I had enormous luck, I really could, how does one say 'Standing on the shoulders of giants'... so I started something off at a very sophisticated method, that was essentially perfectly prepared, I did not have to implement anything on my own, was able to adjust some set screws, and the people were very thrilled, and during that, I truly learned a lot regarding the underlying theory and all the terms that exist in this special field. They are now mostly well known to me because I basically really occupied myself with it from zero onwards actually. Simply self-teaching in the scope of the Bachelor's thesis, but this helps me actually to this day, that I looked into that back then." - S3

Other Interesting Views, Statements, and Experiences of Students

This subsection briefly describes other findings arising from the student interviews that could not be grouped into their own subsection.

Firstly, two students described their conceptions about what a Bachelor's thesis topic needed to fulfil. Interestingly, those expressed requirements strongly contrasted with each

other, as one of the students stated that a Bachelor's thesis also needed to address a scientific problem based on what their supervisor had told them. On the other hand, the other student noted that a Bachelor's thesis does not need to be something new and that it probably would suffice to reproduce something.

Another set of two students expressed that they perceived it as difficult to pursue something for a more extended period of time. The first one stated this generally regarding projects. The other student partially explained it as a reason for switching topics at every level (Bachelor's/Master's thesis, PR1 and PR2). This is somewhat also reflected in statements made by two other students, who expressed that it is difficult to be motivated for such a long time when writing a Master's thesis.

Also interesting to note, is that four of the eight students were offered employment opportunities from their respective supervisors because of performing very well in academic projects of varying levels. Another student also got employed as part of their Master's thesis, though it is unclear whether this was based on standing out in a positive manner beforehand.

6.3.4 Conclusion

After going through the interviews and describing the extracted views and statements, this Subsection aims to connect the gained information from both the professor/supervisor and student interviews to each other. Where applicable, connections to existing literature were made as well.

Supervisor differences

It emerged, quite clearly, that the interviewed professors/supervisors differed in their opinions regarding many different aspects, as described in most of the subsections of Section 6.2.1.

An aspect where a lot of the professor/supervisors views diverge is the different emphasis that is placed on the "scientificness" of Master's theses and especially their relation to scientific papers. Some professors/supervisors stated that it must be technically possible and is facilitated highly to generate a publication out of a Master's thesis. At the same time, other professors/supervisors expressed that they dislike this practice or lessen the theses' scientific requirement and focus more on the practical aspect if the respective student does not see themselves in academia in the future. This divergence is arguably even more extreme in Bachelor's thesis topics, with some supervisors already requiring a scientific aspect there, while others are accepting projects that are interesting in a practical manner but not really scientific.

Differences were also observed in the way the practical courses and their specific role were perceived. Some professors/supervisors always see them as dependant preliminary work for a later thesis, while others issue them as singular chunks that can stand on their own. Another difference in the perception of the practical courses is how students switching groups is perceived. Some professors/supervisors say it is totally fine and might

even lead to better education, while others strongly prefer students who completed the whole path with them.

As explained in more detail in Chapter 5, professors/supervisors also vary a lot in the way and form the respective topics are, if at all, issued. Some professors/supervisors issue many detailed topics while, for example, one of the interviewed professors/supervisors deem this practice to be "boring" and therefore issue them in a more broad manner. In essence, two extremes could be observed, with one set of professors/supervisors wishing for automated assignment of students to topics, while others already find the current way to be too impersonal and wish for more personal exchange and discussion.

Additionally, another aspect where the views diverge is how much professors/supervisors value student input regarding project ideas. Some professors/supervisors basically require students to attempt to come up with their own topic or at least somewhat decide on the direction. In contrast, other professors/supervisors strongly prefer students to work on the specific topics issued by them, as these topics are definitely scientifically interesting and overall interesting for the respective professor/supervisor as well.

From the eleven supervisors, none were exactly similar to each other, handling manners differently. The ability to do so also seems to be highly valued by the participants, as three of them even expressed a dislike for imposed guidelines and overall cherish the flexibility they have.

Need for more transparency

The different goals, conceptions, and preferences of supervisors, as described in the previous subsection, is not to be seen as inherently wrong or bad, as it is their due right to have and live them. However, what should be seen as a detriment is that this factor is not in any kind of way visible or communicated to the students. As a student, one gets, mainly through the kick-off meetings and curricular descriptions, no kind of indication that these differences exist. For example, the formal definition[6] of Practical Course 1 (PR1) as well as Practical Course 2 (PR2) basically describes them as the conduction of an IT-oriented project through which students should learn to carry them out independently.

In the respective kick-off meetings, they are simply described as building on top of each other, helping to find a Master's thesis topic and posing the ability "to get one's feet wet". Parenthetically, it is mentioned that, should one of them not work out, switching is possible[6]. A more detailed description of the practical courses, along with their complete formal definitions and their shared kick-off meeting, can be found in Chapter 5.

These definitions in no way pay tribute to the fact that some supervisors issue them as individual topics that do not consider continuation possibilities, supervisors leaving the faculty, and some supervisors strongly preferring students who already performed the full path in their group. This makes the students effectively oblivious to the fact that the system is lived out in many ways, and somehow builds up a false image of a unified approach and an expectation of a linear path from PR1 to their Master's thesis. Which,

[6]Taken from `https://ufind.univie.ac.at/en/course.html?lv=053021&semester=2021W`, accessed: 28/12/2021

at least from the experiences of the five interviewed CS students, as depicted in Table 6.1, is far from the case, as actually four of them had to switch either topic or research group at some point.

Naturally, it is therefore not necessarily easy for students to, in the end, plan their path to their Master's thesis, as most likely the common conception is that this path is pretty much set after finding a PR1 supervisor and topic, just to then be faced with the fact that no continuation is directly possible and one is faced with the tough decision on finding or coming up with a new topic, possibly even a new supervisor.

Because choosing a topic can be seen as an important decision, as it directly impacts the course of the studies and the acquired skills, it should be able to be taken with as much time, care, and information as possible and in no case be rushed.

Theses as Means to an End and Possible Dangers

The student projects are truly a unique and diverse experience for students. Not just because they have to conduct them mostly independently, are faced with ambiguity on many different levels and genuinely have to work on something over a more extended period but also because, in comparison to courses, their aim is very much different. The unarguably whole objective of a university course is to teach students something and provide an opportunity to prove the acquisition of these skills and knowledge. Professors/Supervisors have to conduct and offer these courses, and there is not much more additional effort for each student attending that respective course. Additionally, professors/supervisors cannot decline a student to take their course, as long as they fulfil all prerequisites to attend it. The student projects of varying levels are vastly different, as professors/supervisors can pick their students, and for example, not answer to inquiries, every supervised student means linearly increasing effort, and there appears to be no requirement on how many students should be supervised. The fact that every student causes additional effort is even more significant, as there is no motivating direct incentive to supervise (more) students. This leads to the fact that supervisors create their own incentives for supervision, such as advancing their PhD students' dissertations or the possibility for publishing a paper at a conference. The seeming lack of direct incentives for simply supervising students, as described by one of the interviewed professors/supervisors, is explained in 6.3.2 *"Lack of Direct Incentives"*. All this somewhat arguably drastically changes the circumstances, as in contrast to regular courses, the reasoning behind student projects is possibly shifted away from educating a student to, e.g., trying out an experimental idea of a PhD student. This has a variety of impacts. It leads to more issuing of specific topics and scepticism regarding student project ideas, as they might not be as utilizable, possibly not answering general supervision inquiries and also indirectly moving the projects in directions so that these goals are fulfilled while maybe neglecting aspects such as student interest and autonomy.

Especially alignment of the topic to fit into the student's interest and goals should not be lost sight of, as not only four of the interviewed professors/supervisors saw the students' interest in the topic as a requirement, but four also stated that the outcome of such projects is generally better if the student is actually interested in the topic. The

importance of student interest in thesis topics is supported by literature as well. For example, by S. Lei [Lei09], who describes strategies for finding and selecting thesis topics. In their work, they state that even though topics are assigned to students, it has to be ensured that these topics are personally interesting to them. Furthermore, they reference literature underlining the importance of the student being intrinsically motivated, as that increases research energy and effort as well as enhances cognitive processes and productivity.

Furthermore, Lei [Lei09] states that the final topic should closely match the personal, academic, and career goals of the respective student, which is also something that could be undermined if the aim is too focused on research related goals of professors/supervisors. Additionally, this implies that for the final topic to match the goals of the students closely, it is also necessary that the students' decisions to select a topic are based on careful reflection and clarification of these aspects [Lei09]. This, arguably, does not seem to be the case for many of the interviewed students, as seldom the worked on topics or their selection was set in relation to well-defined future goals that go beyond finishing their studies as "safely" as possible.

Student independence should also not be diminished by issuing more specific topics and pursuing research-related goals. As not only the official definitions from the practical courses[7] and the Master's thesis[8] define the work as independent, but literature also describes a huge advantage and educational effect of independent work. Todd et al. [TSB06] discovered that for students, the significance of their Bachelor's theses derived from their sense of the work being independent and self-directed, feeling that this work both developed and demonstrated their personal ability to manage a relatively unstructured task, which was also an opinion shared by interviewed staff members. C. Rogers [R+69] noted that significant learning is maximized if students choose their own direction, discover their own learning resources, formulate their own problems, decide their own course of action and finally also live with all resulting consequences of these choices. Another evidence for the importance of student independence is provided by the self-determination theory developed by Deci et al. [DR08]. Empirical research on its application in education has concluded that autonomously motivated students thrive in education settings and that students benefit if teachers support their students' autonomy [R+02].

The specific topics that are issued are directly affected by the additional aims as well. Some professor/supervisors statements indicate that their published topics are not quite sophisticated and work as an experiment. As described in Subsection 6.3.3 *"How Students Search for and pick Topics"* students place massive importance on a topic being feasible for them personally, which is unsurprising, as being seemingly stuck with an assignment that proves itself to be unaccomplishable by oneself is daunting. It is daunting, especially if previous ways of assessing the performance of practical tasks in courses are very unforgiving in a "make or break" manner, meaning that one gets zero points if it

[7] Available at: `https://ufind.univie.ac.at/en/vvz_sub.html?path=262602` and `https://ufind.univie.ac.at/en/course.html?lv=053031&semester=2021W`, accessed: 31/12/2021

[8] Available at: `https://senat.univie.ac.at/fileadmin/user_upload/s_senat/konsolidierte_Masterstudien/MA_Informatik.pdf`, accessed: 31/12/2021

does not work and can expect at least nearly all of them if it does. Keeping in mind this priority and one of its possible origins, the following statements of supervisors, indicating ambiguity of some issued topics, could seem daunting and somewhat make the student preference for "safer choices" more comprehensible:

> "It can also be that the students say: 'Okay, I could not do this, that was not possible'. Well, then we will adjust the topic... But this, of course, means that the students already successfully made a few steps and that the original idea was not realizable, with that one must also live. So, I have no problem with that, if one of my ideas proves itself to be non-realizable, then one is going to think about a modification." - P2

> "Instead of performing every experiment and trying everything out oneself, one can much easier let everything be tried out in student projects, there are many interesting questions 'hmm let's try'. There are even situations where we determine: 'Okay that seemed easy, but the first student project already showed how complex that actually is' and the result was not what one would maybe expect, and then one will realize it has to be a bit adapted or maybe slimmed, and then one tries it again with another student in the following term and realizes: 'Ah, already considerably better'..." - P3

> "... and then, if we pursue a dissertation in such an applied field, it helps for example very much, if we try one and the same idea out in five different scenarios out of which three work that the PhD student can then further pursue." - P11

It has to be said that in no way do supervisors expect that students solve the problem imposed by the topic perfectly and that deviation, should it be necessary, is impossible, but this is once again not really communicated or self-evident for students. After all, as previously motivated, they are not accustomed to the mindset of a negative result also being a result and trial being an absolute necessity in science. It, however, in some ways, can indicate a mindset of being okay with a topic posing to be more difficult for a student or not necessarily focusing on a "perfect" outcome, with the student being able to create something they can be proud of in an informative experience but rather on performing an experiment for a PhD student. Once again, this somehow indicates a shift in priority of what the student project is actually for, advancement of the group's research or student education and training.

Additionally, these additional aims can alter expectations in the student. While in regular courses, expectations are clearly defined in terms of an assessment of performance beforehand, and nobody necessarily expects something from a student, as the course instructor is indifferent to students passing or not. Students effectively do courses solely to advance in their studies. This could possibly be different in a student project, be it in the scope of a practical course or thesis, if the professor/supervisor wants to get something additional out of it, be it a published paper, conducted experiment for a PhD

student or just general research contribution, as this can create expectations, that are not visible or clear beforehand, and can also be adjusted along the way. The student no longer does this project purely for themselves, to advance their studies or learn something, but has to face a certain additional level of expectation from external sources.

Whether or not the seeming effects of the additional incentives and motivations for student supervision have any actual impact cannot be quite said in the scope of this study. Still, it indeed is an aspect to be kept in mind. The pursuing of research related aims should not undermine or take considerable precedence over other important factors and goals such as the independent conduction of the respective projects, student education, and overall student interest.

Interest as Key Differentiation

While it cannot be precisely quantified, during the interviews with the participating students, it appears that knowing or even having interest areas is the key aspect that sets them apart. The students who exhibit knowing of specific interests and also act upon them seldom mention substantial difficulty regarding topic choice or the performed projects themselves. Naturally, suppose a student knows they are very interested in a particular area. In that case, they will want to conduct a project in that area. This already limits possible research groups to contact and reduces the importance placed on other aspects, such as a clear conception about the topic and the perceived difficulty.

It appears a bit paradoxical that students study a subject but are not enthusiastic about any subarea they could indulge themselves in. However, this was perceived to be the case for two of the three BI students and two of the four regular/general CS students.

Therefore, to help students in the topic search process, supporting and enabling them to develop a serious interest in an area plays a crucial role.

Limitations and Open Questions

As this qualitative study was more of an exploratory nature, none of the discovered phenomena could be and were investigated in more detail. Therefore, the first inherent option would be to conduct a study with a more concrete and precise research question. An example would be the exploration of why some students seem to feel no strong interest in any particular area and are indifferent and somehow goalless regarding their studies. As this study explored the issues and circumstances at hand, the more directed study could also be conducted in a more quantitative manner to properly quantify its insights and results to make more substantiated claims and statements.

Secondly, as indicated by the fact that five students were employed for their academic projects or based on their excellent performance in them, more than half of the participants of this study are able to be regarded as good students. Furthermore, all students were still enrolled at the university, with no clear indications of having thoughts on giving up or having to take a longer break. As such, the participants of this study do not represent any type of student who has been lost or had to endure extreme hardship - it is also

unclear if such students actually exist. Specifically searching for less successful students might lead to different insights or show a clearer tendency towards certain aspects.

Lastly, as already stated in Section 6.1, this study is only to be seen as a small contribution towards the overall goal of this work, which is the implementation and design of a working prototype web application to serve as a central hub for academic projects. Therefore, efforts had to be inherently limited, especially the sample size and the conducting of follow-up inquiries had to be restricted. Nonetheless, this study revealed interesting circumstances and tendencies and can hopefully serve as an invitation and call to explore the issue at hand more thoroughly.

6.3.5 Improvement Suggestions

Based on the gained insights, we propose the following improvement suggestions to be considered. In general, the suggestions aim to help students in making the best possible choice regarding their project topics by providing them with additional relevant information and overall try to start the process of thinking about that choice earlier by rather indirect low-threshold means. Importance was also placed on the suggestions being relatively easily implementable, not causing much additional effort to the affected stakeholders, and not being in conflict with current regulations and laws that are difficult to change.

Better Orientation and Planning by Students

The first, rather general suggestion is solely aimed at students. They should be encouraged and required to think more about their plans and goals respective to their studies - why they study what they actually study. It seems that especially BI and general, regular CS students, who did not choose a specialization, tap around rather aimlessly. This manifests itself in the difficulty of selecting a project topic as there appears to be no apparent area of interest and a kind of unhealthy indifference with a resulting focus on aspects such as whether the supervisor is likeable, perceived difficulty and very clear conception of the topic by the student.

Therefore, before especially CS Master's students start their studies, they should have a rough idea in which directions they want to take the opportunities presented to them by the practical courses, to truly start, specialize and gain skills in an area that is significant to them. This is ultimately something that students have to do by themselves, but they should be reminded of the importance of this action as well as the unique opportunity that they have.

Kickstarting the Student Search Process

As three of the interviewed students expressed to have a "late" start to the overall topic search process, only starting it essentially after the kick-off meeting and publication of the deadline for topic registration, there appears to be an inherent need to remind students

to start earlier and that they should already have a general idea about what they want to do before attending the kick-off meeting.

Especially, the three European Credit Transfer and Accumulation System (ECTS) credits that are allocated to the Master's thesis in the third semester for both BI and CS students, according to the official recommended semester schedule, as mentioned in Section 5.2.2, should actually be used by students to specifically give thought to the next semester and the upcoming Master's thesis. However, besides these three credits being scheduled for the semester, there is no kind of reminder or calling for students to actually do something. This unsurprisingly leads to the students starting the actual search for a topic after this semester, as there are seemingly more urgent affairs. In the worst case, students start their search only after the kick-off meeting for the Master seminar, after which they only have two weeks to settle on a topic and supervisors. This is partially described in more detail in Subsection 6.3.3.

Currently, it seems to be expected of students to start their search earlier on their own. In the shared kick-off meeting for PR1, PR2 and the Master seminar, the presentation slides state for the practical courses that *"it is best to find a topic before the start of the semester (but not necessary)"* . For the Master seminar, they express that students should already have a topic and supervisors for their Master's thesis[9]. This is a quite unuseful and not helpful remark, considering that this meeting takes place during the first weeks of the semester, in which the students should conduct their practical course projects and theses.

Reminding and calling students to think about possible project topics could be done in a variety of ways. Naturally, the online course information, where students register for the practical courses, Master's thesis, and Bachelor's thesis seminar should contain the call to already start the search for a topic and contact supervisors. As the students have to visit the web page containing this information when registering for the respective courses, there is a high chance that they will read this information. Additionally, courses that are likely to be attended by students in the semester directly before starting the practical courses and theses can also serve to remind students about the upcoming task of finding a topic and supervisor. For example, this can be done by sending out an e-mail to the course attendants at the end of the semester or by the instructor announcing it to the students at the end of a later course unit. Lastly, official information pages on the internet about, e.g., Bachelor's and Master's theses, should similarly highlight the importance of starting early and provide a starting point for the topic search process of students.

Increased Transparency - Student and Supervisor Aspects

Following the need for more transparency between supervisors and students and in the issued topics, described in the next Subsection, for students to be able to make the most informed and best decisions they deserve and need information that helps them to make

[9]Taken from the presentation slides available at: `https://ufind.univie.ac.at/en/course.html?lv=053049&semester=2021W`, accessed: 05/01/2022

them as well as enables them to overall plan ahead.

Instead of simply relying on very broad definitions by the curriculum and brief descriptions from the kick-off meeting, painting a very simplistic picture, students and their respective supervisors should openly talk about whether a continuation of a topic in a following level is planned and wanted as well as general prospects beforehand. Should the student wish to continue on the topic and desire a linear path to their Master's thesis, this aspect needs to be considered from the beginning. Identically, if the project is somewhat standalone, without direct continuation possibilities, this should be communicated from the beginning on instead of ensuing towards the end of the respective term.

Expectations regarding scientificity should also be disclosed and specified initially, especially in practical course projects, instead of crystallizing only later in projects. A more practically oriented student should know how much a potential supervisor focuses on the scientific aspect, as it is emphasized in very differing amounts by the interviewed professors/supervisors (as described in Subsection 6.3.2).

Increased Transparency - General Expectations and Regulations

In addition to more transparency in aspects found between students and their respective supervisors, more transparency could help and be needed in more general areas as well. To quote one of the interviewed students:

> "I think on all aspects the transparency is missing ... the overview about what exists, what is allowed and what should be done." - S7

Generally, information about what a Master's thesis is and can be, appears to be somewhat lacking. Especially in CS and BI, where theses can take various very distinct forms, requiring very diverse approaches, students should be able to obtain a broad idea of what directions are possible and what is actually allowed, to be able to make decisions in a more meaningful manner. This should not, in any case, mean to impose stricter regulations on supervisors, but simply to give students ideas earlier on and rough frameworks with which they can imagine potential topics and research questions better.

For example, one of the other university-level institutions, examined in Section 5.4, provides students with the information of very generic thesis types, e.g., in the form of "experimental and evaluation work" or "theoretic work". This effectively communicates what is possible and can be done in the scope of a thesis in an easy, generic and rather non-restricting manner. Furthermore, which was also addressed by the quoted student above, rules and regulations regarding, e.g., supervision by professors/supervisors from other faculties of the University of Vienna and conducting a Master's thesis as group work with another student should be openly communicated and easily obtainable.

Another way to achieve more transparency would be to provide students with past Master's theses that roughly match the previously mentioned archetypes, without having to ever formally collect or describe them. As stated in Chapter 5 a subset of the research groups already provides past exemplary theses and student projects to possibly interested students. This is definitely a healthy and beneficial practice that should be considered to be done more often.

Taking this even further but also requiring more maintenance and effort would be visualizing topics currently being worked on in the scope of student projects across the research groups and providing at least the titles of already finished projects, e.g., in the form of a Trello-Board. This idea was also directly proposed by the quoted student above.

Specific Inclusion of Possible Topics in Regular Courses

As one of the interviewed professors/supervisors said, courses are essentially the best way to find interested students, as students who chose to attend a particular course most likely display some kind of interest in the course's respective thematic area. Additionally, students then already know the supervisor, which has been perceived as an essential part when it comes to choosing a topic or supervisor in Subsection 6.3.3. Based on the interviews, it sometimes occurs that supervisors advertise the possibility of supervision at the end of the course or that students, who now gained a broad perception of the topic and supervisor, actively contact them based on that experience.

However, courses can and should be utilized even more to improve the overall topic search and decision process of students. Instead of just redirecting students to currently open topics at the end of the semester, the research group's current work focus should, if possible, be connected to the taught topics of the course. This allows students to gain a conception about what a research group is currently interested in based on the knowledge they have and put in terms they already understand. Additionally, it makes the course contents more relevant to students, as they now also get to know an actual current application of the taught contents.

Furthermore, opportunities should be actively created and advertised to do a project based on the contents and specifically the assignments of university courses. Topics arising this way are pretty optimal in terms of student search preferences, as not only do they now automatically know the respective supervisor, but they also have a clear conception of what working on that topic might be like and additionally are somewhat familiar with at least the basics, which as described in 6.3.3 is an important factor for students in their personal search for topics and supervision.

Lastly, by including possible topic opportunities and general areas where students could conduct a project in all throughout courses and therefore the respective semester, students are more stimulated to think about possible directions earlier on during their studies, making their final choices possibly more thought through and optimal.

This suggestion is heavily inspired by the experience of one of the interviewed students. They found their practical course topic through a course where the respective instructor offered the possibility of working on a topic closely related to the done course assignments, which they perceived very positively.

Improving the Kick-Off Meeting for Theses and Practical courses

Another common theme expressed by five students and even two of the professors/-supervisors was that the current style of the kick-off meeting for practical courses and

theses, which is described in more detail in Chapter 5, is currently not optimal in the sense that it is rather impersonal as well as not really aiding in finding a topic.

Therefore, it is suggested that its format and contents are changed in a way such that it provides value instead of repetitively presenting the same links and information, which could also be obtained by simply going through the presentation slides and instead provide valuable input and impressions that help in settling for a topic.

Talking to supervisors/professors and students alike, two possible general approaches crystallised themselves:

The first approach would be to motivate research groups to have their own smaller kick-off meetings, possibly in addition to the general one, should that still be formally required and maybe needed to convey the more general information. Ideally, all supervisors of the respective group would attend this meeting and initially briefly present themselves, their issued topics, as well as general areas of interest. Afterwards, interested students should have the possibility to directly approach the supervisors and ask further questions in a smaller circle. This is already practised by some research groups and has proven to be perceived positively by interviewed students who attended them or at least knew about them. Due to recent developments of the Coronavirus pandemic, which led to more regular use of online conference tools, these smaller group-specific meetings could also be conducted online and remotely and provide students with an easy and comfortable access. Maybe enabling these meetings to be easily attended virtually would further motivate students to participate in the sessions of multiple research groups.

The other approach actively includes the individual research groups in the general presentation by giving them a set timeslot after the general part, where they can present themselves and their topics as well as convey what should be done by students in case of interest. Similarly to the previous approach, representatives of the research groups should be available for direct follow-up questions and inquiries after their presentations. As the kick-off meetings are often scheduled for two and a half hours and most of the time after the actual presentation is used for questions of students regarding specific organizational aspects, such as them fulfilling the requirements for the course, which could be addressed elsewhere, all groups should get enough presentation time. In case of time constraints, the direct follow-up possibility could also be offered during the timeslots of other groups.

The benefits of both approaches are that students not only get a more precise conception about the topics and possible directions but also gain the ability to directly form impressions about the supervisors, which in term helps supervisors who do not teach many courses, to acquire student interest. Furthermore, it gives students a direct opportunity to "catch" their desired supervisors directly at a date long enough before the deadline for topic registration. Students can use this valuable opportunity to, if not already acquired, get acceptance for being supervised, propose ideas and ask questions, instead of primarily having to rely on e-mail communication, where they possibly have to wait a long time for replies or might not even receive them in the first place.

Of course, these suggestions have some drawbacks. The first, with individual meetings for research groups, would be somewhat of a challenge to schedule, as every student should have the possibility to attend all of them. Additionally, both suggestions would initially

mean more effort for the individual research groups and supervisors. Still, this effort might very well balance itself out afterwards by saving tedious e-mailing, and possible discussion meetings with interested students afterwards or at least reduce the time they take. Regarding effort, it should also not be overlooked that the current form of the shared kick-off has some effort associated with it, most notably in creating the presentation that needs to be partially okayed and updated by 14 research groups.

What additionally should not be forgotten is that these kick-off meetings should not serve as the entry point to the topic search. Instead, students should be stimulated to think about this process much earlier, which was already touched upon in Subsection *"Kickstarting the Student Search Process"* above.

(Digital) "Bulletin Board" for current topics

An additional improvement possibility is presented by and executed at one of the other institutions (No. 3) enquired in the international comparison described in Section 5.4. There open topics are not solely displayed on the internet but also physically visible in the university building itself that is regularly visited by students.

The way this other institution handles this is by essentially having a large "bulletin board" in the main hall of the building, where the research groups can pin topics or areas they currently search students for. The board is placed so that students pass it fairly regularly, leading to the fact that students absorb its contents implicitly. This is great because it once more rather passively and indirectly reminds students to think about future projects as well as informs them about what can be done and at which groups. Furthermore, it is an excellent way for research groups to reach students and build interest for their topics and them without having to teach courses. The ability to do so inherently solves the visibility problem that some professors/supervisors perceive to have, as briefly described in Section 6.3.2.

The manifestation of the described board does not have to be singular in nature or physical in terms of being an actual board with pinned sheets of paper on it. Instead, for example, the information monitors spread throughout the building of the Faculty of Computer Science of the University of Vienna could also be used for that purpose by regularly displaying some currently open topics.

Connecting Students Working on their Master's thesis

If students plan their studies according to the official recommendation[10] they probably face the unique situation during the conduction of their Master's thesis of being quite on their own concerning their work. In contrast to earlier semesters, where they visit courses with regular dates and deadlines as well as meet their peers regularly, they now have to manage their time independently without any fixed dates and lose the implicit opportunity for exchange with other students.

[10] Available at: `https://informatik.univie.ac.at/en/study/courses-of-study/master/master-computer-science/advanced-courses/timetable-informatik-in-general/`, accessed: 31/12/2021

Ways to facilitate this connection between students currently working on their Master's thesis could be setting up a specific online discourse tool that allows students to ask questions and generally enables participation with a low-treshold. For example, Tuhkala and Kärkkäinen [TK18] explored how they can include *Slack*, a software most commonly used as an instant communication platform for work teams, during the Master's thesis seminar to support the peer interactions of students. Their findings were, amongst others, an increase in bidirectional communication, a majority of students preferring it over alternatives such as *Moodle* and e-mails, as well as a large majority of students also recommending it for use in future seminars. Such a tool does not necessarily have to be directly managed and offered by the university itself and cause effort. If, e.g., the student representatives provide an informal platform enabling students to exchange with each other, this platform could well be used for that purpose. The existence of such an informal platform is given for the Faculty of Computer Science of the University of Vienna, as there is an unofficial *Discord* server, which is even officially advertised by the faculty[11], that students could be encouraged to utilize for that purpose.

Another more formal way of facilitating such a connection could be setting up a regular physical meeting opportunity for students currently writing their thesis and providing light and inexpensive incentives for attending, such as drinks and cake. Though in the author's and an interviewed professor's/supervisor's experience, the motivation of students to participate in such meetings, whose sole purpose lies in exchange with other students, is possibly limited.

The facilitation of connection gives students the important opportunity to relate to each other in terms of progress and provide orientation. Additionally, they have the valuable opportunity to share tips about common problems as well as learned lessons and, as brought up by one of the interviewed students, the possibility to find other students to proofread each other's written works.

Furthermore, it surely is comforting for students to know that they are not alone in their struggles and that others face certain problems and challenges as well. Lastly, there are indeed aspects, such as formal registration of a topic, shared modalities, and questions regarding formatting where students can additionally help each other instead of having to ask their respective supervisors, which could effectively reduce supervisor load.

This connection between students could also be facilitated in the scope of the obligatory Master seminar, currently planned for the same term as the writing of the Master's thesis itself. One of the interviewed students specifically stated that they would like more regular exchange possibilities with other students in the seminar and get to know more about the current topics of others. However, they also saw the inherent trade-off of additional effort caused by more dates and events.

[11] See `https://informatik.univie.ac.at/news-events/beitrag/news/inoffizieller-discord-server-von-studierenden-fuer-studierende-der-informatik/`, accessed 03/01/2022

Providing and Facilitating Cooperation Opportunities

In addition to attempting to connect students who may work in very distinct domains on very different topics and set out to facilitate relation and connection between them, it would also be an idea to design and issue topics so that opportunities for cooperation arise without compromising the necessary individuality and independence.

This can be done on various levels, most easily by using a similar technology stack across student projects or having the same "base task" as in, e.g., implementation of a web application. Cooperation opportunities could also arise when trying the same idea but in very distinct domains.

In light of a recent increased emphasis and appreciation for multidisciplinarity, a more utopian idea is that topics for projects could be designed in a way that connects students from different degrees. Consider, for example, the task of creating some kind of e-learning application where an educational sciences student and CS student could tackle different aspects of the task at hand.

Of course, besides just providing the opportunity for cooperation, it needs to be facilitated in some kind of way as well. Regular shared meetings with students, present or online or more indirect connection of the students via software such as Slack or Microsoft-Teams would be a possibility.

One of the interviewed professors/supervisors specifically stated that they had very positive experiences connecting their supervised students with each other.

Such topics, as well as opportunities, were specifically wished for by and brought up by one of the interviewed students. This student also considered writing their thesis about a project shared with another student but did not know whether that was possible.

This direction could possibly motivate students to take topics perceived to be "riskier" by them, as they are not alone and have a more informal partner available than the respective supervisor. With this informal partner, they could, for example, specifically discuss low-level implementation-related aspects of their work. In any way, it should at least make such projects or topics appear less unknown to students, as they are used to doing group-based work when it comes to bigger assignments.

Feedback from Supervised Students

Unlike regular courses, students cannot really know what it is like to conduct a Master's thesis project, as students that finished a Master's thesis most likely already left the university having no chance to share their experiences. Supervisors of theses actually face a similar situation with finished students being effectively gone. Whereas feedback for courses is often collected, either voluntarily directly by the course instructors or obligatory in regular intervals, feedback on the supervision of a Master's thesis is often missing. This specific lack of feedback regarding supervision was also perceived by one of the professors/supervisors in the interviews.

Therefore, possibilities should be explored for supervised students to give their supervisor feedback regarding how they perceived the supervision to enable supervisors to refine their supervision skills. The current feedback system in place at the University of Vienna

could be used rudimentary for practical courses, the Bachelor's thesis seminar and Master seminar. However, it is somewhat problematic, as anonymity cannot be guaranteed if, e.g., only one student is supervised by a supervisor and the fixed questionnaire with Likert scale answer possibilities is not designed for and therefore not well suited for this particular use case.

Feedback could, however, also be obtained by the respective supervisor by simply directly asking the student. At least, after students finish their Master's thesis and have their grade officially registered, there is no direct need for anonymity anymore. Naturally, after Bachelor's theses, PR1 and PR2 it is more problematic, as the student might still depend on the respective supervisor in their future.

In any case, supervisors should be encouraged to gather feedback as not only the experiences students made in these larger academic projects significantly shape the overall perception of the degree programme and the university overall significantly but also because they have the potential to be to most valuable and path-breaking task students do and as such should be performed in the best possible way.

Adaptation of Practical Course Topics

The last suggestion concerns the way topics for the practical courses (PR1 and PR2) are issued and designed. As more thoroughly described in Chapter 5, they are advertised as a possibility to get one's feet wet, as well as aid in the finding of a Master's thesis topic, and their official definition states their aim to be the conduction an IT-oriented project.

The official definition, however, somehow serves as a sort of entry barrier and makes it difficult for students to consider getting "their feet wet" in a specific area, as to conduct a concrete IT-oriented project, a student arguably and figuratively should already be in said water at least a bit to have the confidence to tackle this task.

Therefore, it should be considered to enable PR1 topics to be more general or ordinary in their nature. Instead of expecting something already rather unique and concrete, more ordinary tasks genuinely serving as a low entry point to the respective area and as evidence that the basic skills needed to work in that area were obtained could be considered. This essentially allows, enables and empowers students to start out in areas where they have little to no previous knowledge by giving them the opportunity to catch up on and specialize that knowledge. This, in turn, provides students with the needed skills and confidence to tackle more unique and innovative projects in that specific thematic area later on.

Additionally, as also touched upon in Subsection 6.3.4, it could also simply help to "disarm" concrete specific-task oriented PR1 topics by clarifying that the supervisor's expectation is a serious and honest effort by the student instead of the delivery of a fully functional artefact that might scare students who are initially lacking confidence.

6.4 Study Summary

In essence, this study showed the wide range of different views and perceptions about various aspects of the topic search, topic issuing and overall Master's thesis process. Especially, there was a large variety in the views and perceptions of professors/supervisors.

From professors/supervisors, views and perceptions regarding the following aspects were explored:

- Role in the supervision process
- Goals and requirements of a thesis
- Motivations and incentives for supervising - especially the relationship between student theses and published papers
- Issued topics, their target and how students seek topics
- Project ideas from students
- Common student difficulties
- Current faculty situation - especially the practical course system

From the perspectives of students, the following aspects were described:

- Practical course experiences
- How topics are searched, picked and finally obtained
- Beneficial and hindering factors in the search for a topic
- Wishes and expectations regarding supervisors
- Stances on own project ideas
- Generally how project-based work is perceived

The first noteworthy observation was that there appeared to be an overall lack of transparency, as the different perceptions and views of professors/supervisors and therefore implications on how they supervise or plan their projects with students are not sufficiently communicated to them.

Additionally, it was observed that a seeming lack of direct incentives for the supervision of students appeared to lead professors/supervisors to create their own incentives and motivations. This manifests itself in the form of including PhD students and aiding them in their dissertation or the focus on topics that could possibly be published at a conference or in a journal.

Furthermore, the students' interest appeared to be the deciding factor in determining how students feel about their projects and how difficult they deem it to settle on a topic. Therefore, in order to help students, they should be supported and enabled to develop a serious interest.

Based on the gained insights, suggestions for improvement were developed, focusing on being relatively easily implementable regarding the current circumstances and not causing much additional effort. The presented improvement suggestions were:

- **Kickstarting the search process of students** — usage of appropriate channels such as specific courses and online course descriptions, to remind students to start their search processes early.

- **Increased transparency - student and supervisor aspects** — openly disclosing expectations and plans of both supervisors and students alike in order to enable students to make the most informed decisions.
- **Increased transparency - general expectations and regulations** — provision of more information of what a Master's thesis is like and related regulations and rules to further inform students.
- **Specific inclusion of possible topics in regular courses** — create practical course and thesis topics based on regular courses and overall relate these topics more to courses to give students an ideal and natural access to topics and make them start the topic search process earlier.
- **Improvement of the kick-off meeting for theses and practical courses** — changing the meeting in a way that it actually provides additional value that helps students in their topic search processes and accelerates them.
- **A (digital) "Bulletin Board" for current topics** — displaying currently open topics in the faculty building to kickstart the search process of students and indirectly provide them with orientation on what can be done and where.
- **Connecting students working on their Master's thesis** — creation of channels where students currently writing their Master's thesis can exchange themselves with each other to provide them with an opportunity to exchange. Therefore, allowing them to share tips about common problems, learned lessons and overall struggles.
- **Providing and facilitating cooperation opportunities** — Enable cooperation between students without mitigating the independent aspect of theses.
- **Collection of feedback regarding supervision** — encouraging the collection of feedback to enable supervisors to refine their supervision skills.
- **Adaptation of practical course topics** — making topics for practical courses more general to allow students to start in a potentially new area and truly firstly "get their feet wet" instead of focusing on the creation of specific sophisticated artefacts.

7 Requirements & Feature Analysis

This chapter describes the process of determining the requirements for the web application, as well as collecting ideas and wishes of the interviewed stakeholders.

The requirements were determined by a detailed analysis of the as-is state, as described in Chapter 5 as well as by interviewing and talking with the relevant stakeholders within the scope of the qualitative study, which is the focus of Chapter 6. In the interviews, the participants were always also directly asked about their individual requirements and wishes.

In the first two Sections 7.1 and 7.2 the directly stated requirements and desired features for both students, as well as supervisors, are described and properly justified. Whenever possible, direct quotes from the interviews were incorporated to enable an authentic expression of ideas and requirements by the relevant stakeholders.

Section 7.3 then summarizes the stated requirements and wishes and incorporates the requirements that arose not through stakeholder statements directly but instead by the circumstances given by the overall goal of creating a truly usable application improving the current situation, the more open general parts of the interviews, and the analysis of the current state performed in Chapter 5.

The actual design and explanation of how these requirements and features were included in the final design of the web application can be found in Chapter 8.

7.1 Professor/Supervisor Perspective

This section describes the wishes and requirements directly stated by the professors/supervisor during the interviews regarding their perspective on the web application. As some functionalities and requirements suggested by professors/supervisors were related to the perspective of students, they are described in the following subsection dedicated to the student perspective.

Overall, professors and supervisors had a broad set of wishes and suggestions regarding functionality that was far bigger and more extensive than initially expected.

7.1.1 Thematic Area Presentation

As described in 5.2.3, there are professors/supervisors not issuing specific topics containing a description of what is supposed to be done, but rather only advertise general thematic areas they are currently active in.

Therefore naturally, the wish was stated that the application should also allow for the presentation of such areas and not just focus on specific topics:

> "What would be helpful, ... are somewhat higher-order topics, ..., kind of like saying: 'Okay, what are the higher-order topics we *[research group]* are interested in?'. Because students can also propose topics on their own right? Not only that we have such concise topic titles but also those. That means, if someone has a title and wants to work in a field, they could just take a look there ... so one *[student]* can make a directed suggestion of a topic." - P5

Additionally, further building on and supporting this wish, professors/supervisors who publish and issue more specific task-oriented topics also expressed the desire to assign them to thematic areas that can be presented and described independently. This effectively provides the possibility to present thematic areas to students who may not be initially knowledgeable about them, which also gives professors/supervisors not intensively involved in teaching courses the opportunity to present their areas of interest:

> "Thematic-Areas should be describable and conceivable to enable students to gain an idea about the *[specific]* topic, for example by means of including a picture or the availability of relevant information about the thematic area." - P6

Furthermore, it was expressed by one professor/supervisor that giving an overview about which research group currently works on what, by specifying broad thematic areas, is perceived to be important for students.

7.1.2 Automatic Assignment of Students & Load Balancing Facilitation

A subset of professors/supervisors requested that the application should be able to automatically assign students to supervisors, based on students submitting ranked preferences for topics. This would result in automating and greatly accelerating the often time-consuming process to form student-supervisor relationships, which otherwise frequently involves sending and reading many e-mails.

Additionally, by automating the assignment of students, it would be automatically assured that students are fairly and effectively distributed to supervisors and across research groups, therefore balancing their load and preventing the over- and underutilization of supervisors.

Inherently, this would make the application provide value to the supervisors and motivate its use. It would give them functionality that truly goes beyond the listing and presenting of topics, which can already be achieved with the current personal research group web pages. Ideally, this assignment would also consider student qualifications and prefer students who are a better fit for the specific topic.

7.1.3 Stimulate Personal Contact

Somewhat contrasting to the previously stated wish of automatically assigning students to topics was a subset of professors/supervisors stating that they want the application

to be able to increase and facilitate personal contact between interested students and supervisors instead of simply listing topics.

> "It is just genuinely difficult to get in personal contact and that[finding students to supervise] needs much more personal contact... Maybe this is my requirement for your *[author]* platform, everything that promotes personal contact would be extremely helpful. So that one, as a student, is also allowed to be simply interested in what a research group is doing. This just goes beyond slides that one as a research group puts on there."

7.1.4 Ease of Use & Usability

An important point mentioned by all professors/supervisors was usability or ease of use. In order to be used and accepted by professors/supervisors, the web application must not complicate the process of issuing topics and managing them in any way. Ideally, the application would even facilitate this task. This requirement is even more important to fulfil as professors/supervisors already use many different systems during their daily work routines, with several ones requiring a separate login. Therefore, there appears to be a general sense of tiredness and scepticism when it comes to adding another one. One supervisor was especially keen on this aspect:

> "I am going to say it like this, I have exactly three *[requirements]*: usability, usability, usability. I have a fear of yet another system. We *[professors/-supervisors]* use so many thousand systems at the university. It's just a cramp. I certainly log myself into different systems ten times a day just to work. That's a cramp ... therefore usability should be easy ... Yes, but if it is easy to use and not an additional effort, I have little against it. " - P7

Another important aspect of this requirement is that some professors/supervisors want topic issuing and management to be something that can be done quickly and effortlessly by themselves, instead of relying on and bothering technical staff or secretaries to input the desired changes into the *Typo3 CMS*. Ensuring that professors/supervisors can easily manage topics themselves would effectively eliminate the main argument for issuing them on external web pages, for example, Wiki pages.

7.1.5 Data Currentness

Mentioned explicitly by one of the interviewed professors/supervisors was the need for the contents of the web application to be kept current and not be outdated and obsolete. This professor/supervisor felt that many of the research group web pages are currently not adequately cared for. This results in topics staying there for many years, irrespective of whether or not they are still offered and not already taken or finished.

This is a valuable point, as outdated and obsolete topics that never disappear make browsing through topics feel frustrating and demotivating for students. Additionally, being able to see which topics are most current is also very beneficial. For example,

currently, students can see the same (older) topics over the course of many semesters and specifically need to search for new additions.

In order to ensure the currentness of the issued topics in the application, the respective professor/supervisor proposed that having to check topics regularly should be enforced and that professors/supervisors should be actively reminded and/or triggered to do so.

7.1.6 Meeting Facilitation & Announcement

Very much in line with criticism on the current kick-off meeting and the general desire of some supervisors for the application to not lose sight of the personal aspect of the problem at hand, a couple of supervisors brought up the idea that the web application could be used to facilitate meetings. Within such meetings, interested students would have the opportunity to further inform themselves about possible directions and meet potential supervisors. These meetings could either be held in person or through online conference tools, making their planning and actual conduction much easier.

This was deemed necessary by the respective professors/supervisors because currently, there does not seem to be a suitable place where such events could be announced. Since such meetings would also form a significant part of the students' topic search process, it would only make sense to advertise them along with issued topics in the web application.

7.1.7 Visibility Balancing

Highly related to the request for the application being able to present thematic areas and connect these areas to research groups and topics, some supervisors wish the application to be generally able to make them more visible to students. This aspect was mainly brought up by professors/supervisors currently not teaching many courses at the Master's level. Courses are deemed as one of the most important vehicles for finding students to supervise by professors/supervisors, and likewise for finding supervisors and topics by students. Therefore, it can be difficult for professors/supervisors to find students or generate interest in their topics or areas without being exposed and visible to students in courses.

7.1.8 Better Accessibility to Previous Works

Including the possibility to make previous works of former students easily accessible to currently searching students within the application was requested by two professors/-supervisors. These professors/supervisors deem past works to be a very useful and informative tool for giving students a good example and conception about topics or types of work. Furthermore, past works could also aid students during the writing of their theses and act as a rough point of orientation.

7.1.9 Dedicated Space for Presenting Oneself to Students

Due to the official research group web pages being more focused on external audiences, there is seemingly no space for a research group and professors/supervisors to advertise and

present themselves specifically to students currently searching for a topic and supervisor.

Therefore, one of the professors/supervisors expressed that they would like the web application to enable this decoupling from the official public internet representation of the research group web pages, as it would allow them to present their research group very differently and much more target-oriented to students without having to worry about university IPRs and other strict guidelines:

> "Currently, I would not even know where, I mean, okay, we *[research group]* could put it on our homepage naturally. But then it is simply access to all kinds of things, and you need to watch if it is in accordance to the Uni IPRs and other things, but if one said: 'Okay, this is an app, that is simply dedicated to students interested in theses', then it would allow me to represent a group much differently and much, much more target-oriented there. That would be great, yes." - P11

7.1.10 Transparency of Metrics & Feedback

One professor/supervisor wished for the application to disclose specific metrics for both supervisors and students. Students should be able to see how many theses a potential supervisor recently supervised and how many of them were finished successfully. Supervisors should see visited courses and grades of students wishing to be supervised.

> "I, personally, would find it nice, although probably difficult to implement politically, if such a system disclosed some metrics for the student of the potential supervisor: 'How many theses did they supervise in the last five years?', 'How many of them were finished successfully, how many not?'. For the supervisors, I would find it nice if they could view the student's transcript: 'What did they do already?', 'With which grades?'. ... I think it would be great if there was a little more transparency in both directions." - P6

A somewhat similar desire for more transparency was also expressed by a professor/-supervisor and a student, who would like the possibility to issue honest feedback to supervisors so that they can refine their supervision abilities.

7.2 Student Perspective

This section explains the wishes and requirements expressed directly by the students during the interviews regarding their perspective on the application.

7.2.1 More Detailed and Better Described Topics

A prevalent statement from students was that they would appreciate topics to be described in a more specific or detailed manner. This is very unsurprising and very much confirms the general preference of students to opt for topics having the least amount of ambiguity and about which they have the clearest conception, which was described in Section 6.3.3.

Generally, students would additionally like more topics to choose from and perceived it negatively that some research groups offer little or even none of them.

Information requested by students includes keywords/tags, further literature, abstracts, thematic areas, base courses and used technologies. Notably, more information regarding the current status and recentness of the topic was also wished for. This aspect was also expressed by a professor/supervisor in the previous Section.

However, some students recognize and understand why this is currently not done, as they know about the circumstances that topic ideas could be stolen. Additionally, providing more information cannot be forced, as some professors/supervisors dislike the issuing of specific topics and rather want to develop them together with the respective student.

7.2.2 Compilation/Unifying of Topics & Relevant Materials/Information

Another very common requirement expressed by students was that the web application should serve to compile topics and bring together all relevant information in one central place.

This compiling function was mainly requested regarding currently issued topics of different research groups, as they are currently scattered throughout various research group web pages in differing ways (as described in Section 5.2.3). In addition, this request was also made concerning other highly relevant materials, such as, information about how to formally register a topic and available templates, as these materials presently are, much like the topics, spread throughout various pages on the university website. Compiling other relevant materials on the platform was also proposed by one of the interviewed professors/supervisors, who added the possibility that the platform could advertise optional offers of the university for, e.g., workshops that help in scientific English writing.

Additionally, to having all the topics in one place, students wish them to be in a unified format, preferably with lots of required additional information (see subsection above). This would make browsing through topics more comfortable and easy for students, and improve their ability to form conceptions about topics and compare them to each other.

7.2.3 Research Group Presentation/Introduction

Related to one professor's/supervisor's wish for a space dedicated to representing their research group to students looking for supervision, students also desire the web application to provide overviews and presentations about research groups, their areas of interest and possibly supervisors.

These introductions and presentations should ideally help inform students about what a research group is currently working and focusing on, as well as what type of projects they are currently doing or interested in doing.

Additionally, it would help students to form a first impression of research groups, especially should it be a group they are currently not too familiar with. This ability to

gain a first impression would hopefully encourage students to contact groups with an interesting focus that are less known to the student or rather new.

7.2.4 More Supervisor Related Information

Very much in line with the students' request for more information about the specific research groups and their focuses, students also expressed that they would like the web application to provide them with further information about supervisors.

This supervisor information should convey what specifically the supervisor is interested in and where their expertise lies in. This, along with the supervisor's contact information, should enable students to more easily find and contact the supervisor they are actually looking for, to, for example, propose a project idea or ask them about specific topics.

Currently, this type of information can mainly only be indirectly acquired by, e.g., searching for recent publications and taught courses of a specific supervisor or looking at what kind of issued topics the respective supervisor currently offers.

7.2.5 Filter & Search Functionality

Another highly required and requested functionality by students was filtering and searching for topics. This wish goes hand in hand with the request of bringing all issued topics together in one place, as the current situation, where each research group issues their topics on their individual web pages, makes it impossible to search for topics properly since to do so, they inherently need to be in the same place.

One of the students especially stressed the importance of being able to search or sort based on information regarding the currentness of the topic, specifically being able to see the newest topics first. This was mentioned and emphasized by one of the interviewed professors/supervisors in the previous section as well.

This wish for filter and search functionalities is somewhat related to the already described wish of students for more information about topics. Especially, the specification of a thematic area for topics and keywords or tags would actually enable search based on specific criteria between topics of multiple research groups. Currently, topics are mostly, through the individual web pages, inherently searched and grouped solely based on research groups. This can become suboptimal for students, especially when the thematic areas of research groups start overlapping. Therefore, it would be a very useful and appreciated addition to be able to group and filter topics based on other common factors. By enabling this grouping and filtering on other criteria, it would be possible for students to search primarily based on interest and, based on that interest, be directed to the appropriate topics instead of inherently having to decide on a research group first.

> "... in any case, that one can search, so clearly, a search bar and that one can also filter. So, I'm assuming that it is listed tabularly, then that one can filter based on the columns or just sort, for example, by date, to search or filter for the newest topics. This way, one can limit the displayed topics or be able to only display all topics of a specific research group or of multiple selected research groups." - S6

Some students even took this idea further and expressed the idea of a search agent. This agent would, based on the input of specific information, for example, keywords and visited courses, suggest research groups, thematic areas or even specific topics to students to support and even direct their search process significantly.

7.2.6 Similar Ideas to the Ones Suggested by Professors/Supervisors

In line with many of the interviewed professors/supervisors, students emphasized the importance of the application to be overall convenient and straightforward, as well as easy to use.

Having better access to previous works of other students was mentioned by some interviewed students as well. Ideally, these previous works would be available on a per-supervisor or a per-area basis. Supported access to past works would primarily enable students to get a feeling about what is to be done. Additionally, students could also gain a feeling for the overall scope and know what kind of topics they could propose to a supervisor based on what they already supervised. However, past works were also requested to help during the writing of the students' theses to aid in, e.g., structuring the work.

One student also stressed the importance of being able to see what topics are recent and which ones are older and possibly outdated or taken, as well as the ability to filter and search based on this aspect.

Already discussed in thorough detail in their own respective sections were the wishes for the collection of other relevant materials and information, such as the process of submitting a Master's thesis topic in the web application, clustering issued topics by assigning them to thematic areas, and research group presentations as well as descriptions.

7.2.7 Other Ideas

In this section, ideas and wishes are documented that were stated by students but were deemed to be not easily realizable or problematic for some reason in the author's view. Nonetheless, these ideas might be considered and at least lead to the generation of other great ideas, making them noteworthy. The importance of such ideas is explicitly stressed in Design Thinking [Pre18], as they might lead to very innovative ideas even though not seeming very profitable initially.

Research Group Introduction Videos

One student wished to have short, about three to five minute long, introduction videos for each research group. In these videos, the relevant professors/supervisors briefly present themselves and show around the group's premises, also stating concisely what their research is about and what topic areas they cover.

Such introduction videos were perceived as a great way to show off the general working environment within the research group and be better than any textual information that could be provided. By actually seeing the possible supervisors speak, students could gain

an important first impression, and, e.g., decide whether a particular professor/supervisor seems like a good fit. These videos could be used for research groups to present their topics of interest as well.

Additionally, the videos could be great content to be shown in the kick-off meetings for theses and practical courses.

This idea was not further followed, as in the author's view, the realization of such videos sadly seems like a bit of a stretch, as (professionally) producing them is not in any area of responsibility of any current employee. Furthermore, they might need to be updated frequently, as personnel changes can happen relatively often and render these videos outdated quickly.

Ratings for Degree of Difficulty

This idea, stated by one student, is related and part of the already described wish for *"More Detailed and Better Described Topics"* (7.2.1). The respective student brought up the idea of a rating regarding the perceived difficulty, as determined by the issuing professor/supervisor, for each topic.

This idea was seen as problematic by the author. While this information about difficulty could be helpful for students, the danger that arises would be that it could lead to a large group of students preferring the "easy" topics while discouraging them from taking on the ones with higher difficulty ratings. This seems very counterproductive, as students seem to heavily focus on and consider the feasibility and difficulty of a topic already, instead of their interest (as determined in the qualitative study and described in Section 6.3.3).

Communication Platform

Another idea brought up by students was that the web application could be used to communicate with supervisors during the process of searching for a topic and even for communicating during the conduction of the project. This would further merge an additional aspect of the whole process in the application.

The idea of a communication platform was, however, discarded by the author. The reason being that it would not only be rather difficult to implement properly but also only offer little to no benefit, since the other communication channels and platforms, such as e-mails or *Microsoft Teams*, would still have to be used for other purposes. Therefore, it would not eliminate these other channels and platforms, but instead simply move the communication from them to another new channel that needs to be monitored and used regularly. Inherently, this would not be desirable, but the general idea of possibly simplifying some part of the needed communication process with the new web application could have merit.

Enabling Students to be Actively Picked by Supervisors

Brought up by one student and a supervisor was the idea, that instead of students having to contact supervisors, students could present themselves on the platform, by, e.g.,

specifying their skills and interest areas, and be actively picked by supervisors looking for students.

This would allow supervisors to directly contact students whose description they deem fitting for projects they want to conduct. Additionally, it could also enable students to present their topic ideas and supervisors interested in these ideas could directly come forward, instead of the student possibly having to contact multiple supervisors and present the idea to each one respectively.

While this general idea could offer much merit, especially as it would allow professors/-supervisors who are less visible and exposed to students to acquire students to conduct projects with directly, it is seen as somewhat problematic by the author. Firstly, it would be difficult to manage since such student presentations must be kept current, ensuring only still active ones are displayed. Furthermore, their validity would need to be assured to guarantee that they are genuine in the sense that the respective student fulfils the prerequisites for the level they are advertising themselves for.

Lastly, based on the interviews, it does not seem like most professors/supervisors would actually be interested in such a feature, as it would require some additional effort checking the students' presentations and contacting them. It would also offer many professors/supervisors little to no benefit to supervise the respective student project instead of students contacting them regarding their already issued topics.

7.3 Determined Requirements

After collecting and analysing the various wishes regarding functionality and requirements from the interviewees, the final set of requirements is summarized and motivated in this section. These final requirements incorporate deductions from the interviews, insights gained from analysing the faculty's current situation, and the circumstances given by the overall goal of creating an actually usable application that aims to improve the current situation.

These requirements, which sometimes conflict with each other, require well-thought-out trade-offs and form the foundation upon which the final design of the application is built on.

The final design and specifically the implications of the determined requirements on it are described in Chapter 8.

7.3.1 Usability

As directly expressed by multiple participants and also a very obvious self-explanatory requirement is that the application should be overall easy and convenient to use. The web application lives by being used by the stakeholders, professors/supervisors filling it with information and content, as well as students searching their topics through it and informing themselves with it. Therefore, all measures should be taken to ensure that it is actually used as much as possible. To achieve this, the experience of using it should be overall pleasant, non-frustrating, and nice.

Especially for the involved professors/supervisors, its utilization should not in any case cause more effort than the current ways of issuing topics. Otherwise, professors/supervisors will simply not use it and stick to the older and more established practices.

Ideally, the application would even make the overall topic issuing and management process easier, further motivating its usage for professors/supervisors.

7.3.2 Ease of Maintenance

The application must be implemented and delivered in a way that makes it easily adaptable and maintainable. The past attempt at creating a system for the topic issuing process, further described in Section 5.3 has shown the inherent drawback caused by the code and application being challenging to be taken over by another maintainer who was not part of the development process. Its source code was not documented, there was no description of the code structure, and it was implemented with a more advanced front-end framework. This made it very difficult to use afterwards. For example, the format of the CSV file, required to import student data, based on which accounts could be created, was not described anywhere, thus rendering its testing very frustrating. It then additionally proved to be a hassle investigating where in the code this import process was done to deduct the correct format for the import.

Therefore, to ensure the longevity of the web application, it is crucial to ensure that maintenance and potential adaptation can be conducted by people besides its original creator with the least amount of effort possible.

This aspect is rendered even more important by the fact described in Section 5.1. Since this project is not officially supported, there will most likely not be any kind of employee who formally will have the application's maintenance in their area of responsibility.

7.3.3 Benefiting all Involved Stakeholders

Another important aspect, with a similar notion as *"Usability"* that only really became apparent at the beginning of the qualitative study and the conduction of the interviews, is that the functionalities of the web application cannot be solely focused on students. The focus should not just be on students and how they can be supported and benefit from it the most. Instead, professors/supervisors need to be at least equally considered as well.

Professors/supervisors need to experience significant benefits too. Without their input and continuous motivated use, the platform cannot reach its goals, survive and even be considered to be used in actual production. As one professor/supervisor nicely stated, the web application can only really work and achieve its goals if it properly considers all involved stakeholders and their respective views.

Therefore, it must be ensured that the web application provides functionalities to professors/supervisors as well. Such functionalities should be overall beneficial and ideally go way beyond current possibilities provided by issuing topics on the individual research group web pages.

7.3.4 Acceptance & Flexibility

Since the usefulness and benefits of the web application inherently scale significantly with the number of professors/supervisors and research groups utilizing it, it is of the utmost importance to design the application in a way that allows every research group to accept and use it. Ideally, professors/supervisors can utilize the application to handle the topic issuing and management processes without significantly changing their individual ways and methods. As Chapter 5 and 6 have shown, research groups and the professors/supervisors therein are rather individualistic in the sense that they have their own views and methods of handling the topic issuing and management processes. Some of them have also shown a general aversion to too strict guidelines and formats.

The importance of the aspect of being accepted by all and flexible enough to be so was nicely demonstrated by the previous attempt of creating such an application, described in Section 5.3. The previous application ultimately enforced a style and method by focusing only on the needs of a specific research group and, therefore, possibly ended up only being used by this group, as it neglected the other perspectives.

As a consequence, it needs to be ensured that the web application is flexible enough to ideally cover all current styles of issuing topics to enable all groups actually to use it.

7.3.5 Embracing of Personal Channels

The requirement that the application should embrace and foster more personal channels for students to acquire topics for projects rather than just listing topics was expressed by some interviewed professors/supervisors. It was also motivated by the students' general preference of only considering topics of supervisors they already know.

This requirement for supporting personal channels also stems from the preference of some professors/supervisors to only issue topics based on talking and discussing students beforehand, as well as the general dislike for the idea of issuing concrete, specific topics stated by some professors/supervisors. Additionally, students wanting to propose and develop their own project ideas for theses and practical courses should benefit from its use and be supported as well. This cannot entirely be done within the application itself, as it inherently requires personal meetings and discussions.

Subsequently, the new web application should aid students and professors/supervisors alike in establishing face-to-face contact, if that is wished.

7.3.6 Access Control & Authentication

There is a general requirement for many parts of the application being only available to students and university personnel. This requirement primarily stems from the fact that some professors/supervisors do not like to publicly display their issued topics, as they worry about the ideas being possibly stolen.

Most obviously, it must be ensured that not everyone can issue topics and edit the information contained in the application. These permissions need to be exclusively granted and available to professors/supervisors.

Additionally, there is an inherent need in separating the managed contents and topics of the research groups, in the sense that professors/supervisors should only be able to edit and issue topics for their respective research groups. Ideally, the overall use of the application would require no coordination between the different research groups and clearly separate between them. This enables the research groups to do things in their way without having to coordinate with others and deal with their contents as well.

Furthermore, supporting personal channels, as described in the previous requirement, also poses a need for the web application contents to be only visible to eligible students and university personnel. For example, links to online meetings, where topics could be discussed, should not be visible to the public to prevent abuse.

Lastly, the resources of the web application should always be primarily dedicated to the people who actually need to use it and not be wasted by outsiders.

7.3.7 Independence of the Web Application

As mentioned in Section 5.1, the web application does not have access to the IT system of the university. Therefore, it cannot utilize student-related data such as visited courses, the student ID, and grades. This fact inherently implies that it needs to be implemented to act and be used independently of this data.

Sadly, this obviously greatly restricts possible functionalities and poses unique challenges. For example, the authentication and authorization of users, as specified in the previously described requirement, is made much more challenging by the lack of access to official data.

7.3.8 Centralization & Compilation

One of the biggest current hindrances for students is the issued topics being scattered across different research group web pages, as described in more detail in Section 5.2.3. This fact leads to an inherent need to bring the issued topics together in one central place and, therefore, hugely streamline the topic search process of students.

Furthermore, besides the topics not being located in a singular space, additional highly important information/material is also not available in a central place. Such information and materials comprise, for example, templates or information about how a Master's thesis topic is formally registered. The application should also compile this information in order to serve as a central hub regarding all aspects of project-based work, be it in the scope of a thesis or practical course. This compiling function enables students to find relevant material and information more easily. It possibly even reduces the load of supervisors, who may have to answer fewer questions covered by the now compiled material and information.

7.3.9 Unification of Issued Topics

The issued topics being spread across different web pages, as addressed above, is only one significant part of the problem. The other part is the issued topics being presented in very

varying formats and styles, making it more difficult for students to browse through and compare them to each other. The varying formats of issued topic are further explained in Section 5.2.3.

Therefore, highly related to the requirement of *Centralization & Compilation* regarding topics above, the issued topics should be unified as well as possible. However, their unification should not restrict professors/supervisors too much and thus disregard the requirement of *Acceptance & Flexibility*.

7.3.10 Search & Sort Capabilities

Based on the previous two requirements is the requirement that the issued topics can be searched through and sorted according to student preference and priority. Enabling this should greatly facilitate the search process of students and make it way more targeted in general. The relation between these requirements arises from the fact that in order for students to search through topics meaningfully, these topics firstly need to be present and compiled in the web application *(centralization/compilation)*. Secondly, in order for topics to be sorted and searched for uniformly, they require having some common format or attributes to enable these actions *(unification)*.

Overall, students should be enabled to directly search for and find topics that are possibly interesting to them, without having to naively browse through all the research group web pages individually and repeatedly.

7.3.11 Provision of Additional Information for Students

Students additionally commonly expressed the wish for more information they deem relevant for making their final choice regarding topic and supervision, to enable them to make the best decision they can. Such additional information was expressed to be related to supervisors, research groups, as well as topics. It included, for example, more information regarding research groups, access to previous works of other students, and generally more details about topics.

Consequently, the web application should attempt to provide this additional information. While providing it, the application, however, needs to ensure that the requirements of *Usability*, and *Acceptance & Flexibility*, are not negatively affected.

8 Design

In this chapter, all aspects regarding the design of the web application are described and justified.

In the first section, the design process is briefly explained, the second section deals with the naming of the web application.

Subsequently, the third section goes into detail regarding the design objectives of the web application by delineating and motivating all of them in their respective subsections.

Lastly, the most extensive section of this chapter thoroughly explains and depicts the final features of the web application. It also provides insight into the thought process behind their respective design.

8.1 Design Process

The design process can be seen as the continuous development and refinement of a mental model, supported by notes and roughly drawn models describing the coarse design and structure of the web application, as well as the planned features and how they are going to be implemented. Especially after every stakeholder interview, this model was adapted and refined according to the gained insights arising from the discussion. However, also when there was no additional external input for some time, the design process was never quite at a stop as ideas and insights were constantly critically reflected.

Due to utilizing a pipeline to deploy the web application directly, as described in more detail in Section 9.3, the application was already accessible on the internet from a very early stage. This advantage was used to actively invite the involved stakeholders to follow its implementation, test it and give feedback at any time. Therefore, the design process was still ongoing during the implementation of the web application, as the design was not yet entirely set in stone. Instead, the feedback was continuously considered, and therefore adaptations based on it were constantly made.

A special emphasis was put on the notion of *"Idea Quantity"* taking precedence over *"Idea Quality"* in order to generate and come up with novel non-obvious features. These features aim to enrich the process and possibly support all concerned people in various ways. This process was demonstrated in the previous Chapter 7, where the interviewed stakeholders' wishes and requirements were described. The notion of *"Idea Quantity"* is a fundamental aspect of the Design Thinking methodology, as described by A. Pressman [Pre18] and T. Brown [Bro08].

Ideas brought forward from the stakeholders in the interviews were also discussed with consecutive participants or, if possible, reviewed in follow-ups. Therefore, ideas were continuously refined, adapted, and discarded if needed.

Attention was also given to designing the application in such a way so that it already considers the improvement suggestions to the current process made in Section 6.3.5 and enables their support and implementation.

8.2 Naming

The web application was chosen to be named **"TheHub"**. It is a partial acronym for "Thesis Hub". This naming playfully aims to stress its aim to be the central (and only) hub for all information necessary regarding the search for topics for project-based work and the conduction of such projects. Another reason for settling on this name and specifically including the word "hub" is because it nicely summarizes its purpose and role in just a few characters.

Therefore, from this point on, the developed web application is sometimes referred to directly by its name: **TheHub**.

8.3 Design Objectives

This section explains the overall objectives of the design. These objectives are highly related to and derived from the final summarized requirements in Section 7.3, that were followed in the design of the web application. These objectives form the principal guidelines that were followed while making the decisions for and designing and developing the final manifestation of the features described in the next Section 8.5.

8.3.1 Ease of Use & Usability

Directly matching the related and highly significant requirement, usability, and ease of use was always the first aspect considered when designing a feature of the web application. The reasoning for this significant emphasis was that it is paramount for the web application to fulfil its goals and truly bring about improvements.

This aspect is especially crucial for professors/supervisors, as solely adding a new system to be used already inherently increases the effort needed from them. Therefore, as already mentioned in the respective requirement in Section 7.3, it is crucial to make the use of the application and especially the input of new data as comfortable and easy as possible and require the least amount of effort possible.

Specifically learned from the past attempt of creating such a system, described in Section 5.3, was the importance of making the application intuitive and eliminating ambiguities regarding its use that could lead to frustration later on.

To ensure excellent usability, a huge emphasis was placed on following the ten famous usability heuristics defined by J. Nielsen [Nie20] as much as and wherever possible. Since a detailed and significant evaluation regarding usability was determined to be out of this project's scope, this aspect should be mainly ensured by following and using already well-established patterns and methods, for example, breadcrumb navigation. Wherever

possible, help or additional information should be provided in case some aspects turn out to be not as intuitive.

Regarding ease of use, the current way of issuing topics is used for comparison and acts as a threshold. The newly developed application should be designed so that the effort required is overall smaller compared to the current method.

8.3.2 "Implicit" Addition of Information

An emphasis was placed on providing as much information as possible to students with the least required effort needed from professors/supervisors. This is done in an attempt to carefully harmonize the requirements of students wanting more information at their disposal and supervisors wishing the overall process of issuing topics and working with the application to require as little effort as possible.

This aspect somewhat complements the objective of the application having high usability and being easy to use, as it aims to make the most out of as little time and effort required from professors/supervisors.

8.3.3 Voluntariness & Complementation

Overall, the web application builds on voluntariness and complementation rather than compulsion and replacement.

It is unrealistic to expect all research groups to migrate their topic issuing to *TheHub*. Therefore, the current method of handling this process with the individual research group web pages is most likely here to stay. As already discussed in 5.1, the research groups and supervisors cannot be forced to use it, but they also should not have to be. Instead, the application itself should be designed so that they want to use it voluntarily.

Additionally, there are parts of the process that the application, even if all research groups would like to use it, cannot replace or support sufficiently without contradicting its requirements and goals. On a lower level, there is just too much variety and too many differences in preference between the various research groups and supervisors.

Therefore, one of the primary objectives of *TheHub* is to encompass the topic issuing and search process for students on a very high level that all research groups and supervisors can actually share without them having to compromise much, while simplifying the process and generating significant benefits for all. This encompassing on a higher level also provides much-needed flexibility, as organizational changes do not directly affect the application and necessitate crucial adaptations. Such necessary adaptations were one of the downfalls of the previous system made to support this process, described in Section 5.3. The previous system was simply too specific and not flexible enough to support the process on a higher level. Since *TheHub* gets significantly more useful with more of the 14 research groups using it, designing it so that it could and also be liked to be used by each group is of topmost importance.

Establishing a common basis should be seen as a huge priority of the system and definitely takes precedence over very specific features that might benefit a subset of the research groups or even just a single one. The addition of such specific features

can generally be done later on, especially if the web application is implemented and designed so that this is generally possible. This is the case for *TheHub* as described in the requirement for "Ease of maintenance" in Section 7.3. In contrast to feature addition being generally possible, ideally easy in the future, the changing and adapting of a basis, that is not designed to be used and shared by all the research groups is a far more difficult, potentially impossible, challenge.

Because of the high importance laid on enabling all research groups to use it and establishing a common basis, as many features as possible should only have to be used on a purely voluntary basis. The features and functionalities of the application should not by any means be a reason why research groups choose not to utilize *TheHub*.

TheHub should also be somewhat able to generically include groups that do not wish to partake in its use at all. There would be dwindling benefits if students, instead of visiting a certain number of different research group web pages, would only visit a smaller number of them and *TheHub*. Therefore, *TheHub* should be able to live up to its name and serve as a hub, even if not actively used by all the research groups and supervisors.

8.3.4 Bringing all Ways of Issuing Topics Together

As the research groups should not be forced to issue their topics in a specific format or level of detail, there is an inherent need for *TheHub* to attempt to bring all the different ways of issuing topics for project-based work together meaningfully.

In essence, this means that the application needs to allow for rather high individuality and freedom of the research groups when it comes to deciding how to issue their topics, while still serving its purpose as a hub. Subsequently, this requires a generic format for topics, flexible enough to cover all the research groups' ways, while still enabling uniform display as well as search and other features with the best possible quality.

This aspect is especially motivated by the previous attempt on creating a web application for the topic search/assignment process described in Section 5.3. It most likely simply imposed too significant changes in the respective workflows of the research groups, discouraging them from utilizing it.

Therefore, a focus needs to be placed on meaningfully combining all the various ways of issuing and displaying topics. However, this needs to be done without expecting the research groups to change their respective workflows and ways.

8.3.5 Supporting Students' Different Search Approaches

One insight gained by the qualitative study of Chapter 6 is that students exhibit different ways of searching for topics and set different priorities.

For example, some students browse through topics and if one sparks their interest, they pursue it further. Other students generally want to start with an idea about which group or supervisors they would like to be supervised by, and based on this idea then choose one of the group's topics. This demonstrates, that these students have different approaches. While the first student is perfectly happy with a listing of topics that can be filtered and sorted, the other one, assuming that they do not already start with a preference,

would need ways of informing themselves about groups and supervisors to make an initial selection. With this initial selection in mind, that student can then approach the research group's listed topics.

These two demonstrated types are however by far not the only ones. Some students generally do not care about specific topics at all. Instead, such students base their search on broader thematic areas. Another type of students would be ones preferring to propose own ideas to professors/supervisors.

Therefore, much like with research groups and professors/supervisors, *TheHub* must not be designed to only perfectly match and support the particular workflow of one type of student when it comes to searching for and deciding on a topic. Rather, to be truly effective and appreciated by all, *TheHub* needs to consider and be designed to support all the ways of students to get to a topic at least in some way.

8.3.6 Being Part of Students' Earlier Started Search Process

Much in line with the improvement suggestion mentioned in Subsection 6.3.5, dealing with the need of motivating students to start thinking about their future choices regarding topics earlier, *TheHub* should be usable before a defining decision regarding a topic must be made.

TheHub should not just be a simple tool to quickly find a topic within a narrow deadline. Instead, it should be a platform that can be used beforehand to generally realize what can be done. In addition, it should be able to foster interest in the research groups and their current activities, as well as other students' activities. Ultimately, this should enable students to make better, more informed, and not rushed choices about their topics and supervisors.

Ideally, visiting it and briefly glancing over newly added information is something students do voluntarily and regularly out of interest. Besides being interesting, it possibly can also lead to discovering new areas of interest and potentially influence the students' individual study paths.

8.4 Structure & Style

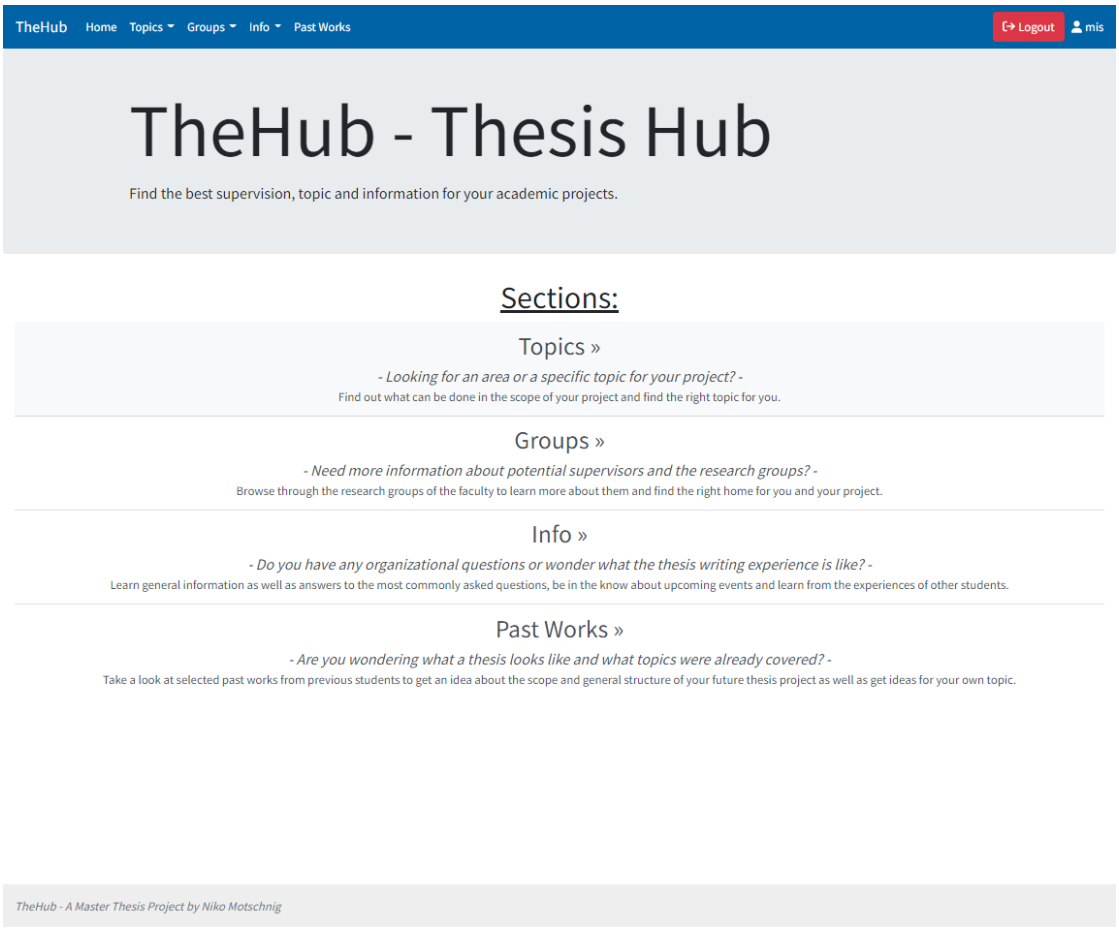
Overall, *TheHub* is split into three main sections:

- The **Topic-Section** contains the functionalities that help the students to find topics for their projects. It provides lists and search interfaces for areas and specific topics. It also allows performing a keyword-based search to receive recommendations for groups, areas and specific topics. In addition, it allows the users to manage their bookmarks for areas and specific topics.
- The **Group-Section** is dedicated to giving students an overview and information about the research groups and their supervisors.
- The **Info-Section** focuses on answering all kinds of questions regarding performing a project-based work as a student. It has an event calendar and information pages

compiling relevant information and materials. Additionally, it contains reflections written by former students about their thesis experiences.

These sections are accessible from any part of the application by a navigation bar placed at the top. Furthermore, there is a dedicated home page listing all sections, their purpose, and the functionalities contained within. This home page is depicted in Figure 8.1.

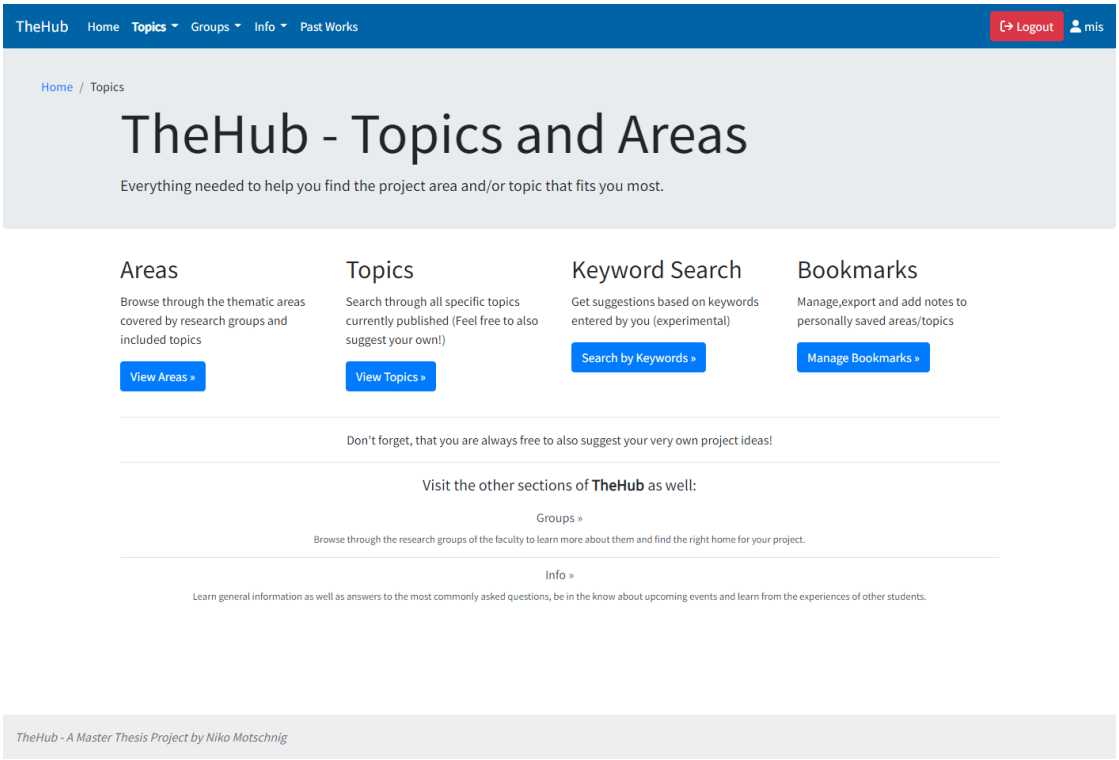
Figure 8.1: Home page of TheHub



Each section has a main page. These main pages further split the section into dedicated parts corresponding to their functionality. For example, the topic-section is split into parts for areas, topics, keyword search and bookmark-management. The main page for the topic-section can be seen in Figure 8.2. Additionally, these main pages contain links to the other sections to ease user navigation.

For the navigation within a section and as a secondary navigation aid, breadcrumbs are utilized. The breadcrumb-navigation gives users orientation, shows them exactly

Figure 8.2: Main page of the topic-section



where they are within a section and enables them to navigate it by a well established and common practice.

Additionally, *past works* from former students are also available in their dedicated space, not directly assigned to the three main sections described above. The past work functionality is described further in Subsection 8.5.12.

Regarding optical appearance, *TheHub* is heavily inspired and guided by the design and appearance of other websites from the University of Vienna. This intends to make *TheHub* appear similar to the other university websites and familiar to the users. It was achieved by following the official corporate design manual of the University of Vienna[1]. For example, the same characteristic blue ("University Blue") was used as a colour for the main navigation elements.

Lastly, the *TheHub* website is fully responsive, therefore adapting its layout to the specific user's screen size or used device. This means that it can be utilized on mobile devices as well. Being usable on smartphones was specifically pursued since it enables students to check topics or other contents of the application quickly. Consequently, students can easily access and use *TheHub* while being on the go, for example, in public transport or downtimes between lectures. This further increases the application's accessibility and motivates students to visit it more regularly.

8.5 Design Decisions & Features

This section addresses and motivates the main design decisions and the features that were developed and implemented.

These decisions and features are based on the design objectives specified and justified above in Section 8.3 and also aim to fulfil the requirements described in Section 7.3 of the previous chapter.

8.5.1 Required Login & Registration for Access

As already motivated by the requirements determined in Section 7.3, access to the application needs to be restricted, and authorization of specific users must be possible.

There was no support from the university to enable *TheHub* to authenticate users based on their credentials and accounts for the system of the University of Vienna. This was already further described in Section 5.1 and motivated the requirement of *Independence*. Consequently, a way had to be found to firstly ensure that only actual students and professors/supervisors can access most parts of the web application through registered accounts. Secondly, the permissions of professors/supervisors and their research group allocation had to be handled securely.

This is handled for students and professors/supervisors in different ways:

Students have to register their account by specifying an e-mail address and password. They then have to follow the established process of confirming their account by visiting

[1] Available at: `https://www.univie.ac.at/iggerm/archive/files/queerreading/CorporateDesign_Manual.pdf`, accessed: 17/01/2022

a unique link sent to that specified e-mail address. Assurance of only actual students performing this registration is achieved by requiring the specified e-mail address to be a standardized student e-mail address from the University of Vienna, containing their student ID and always having the same domain. Since obviously, only the actual students should be able to check the e-mails sent to their respective student e-mail addresses, the access restriction for students is achieved. Furthermore, using this method, the student ID is obtained, which is currently not used but could be useful in the future. Should the password be leaked or forgotten by the student, *TheHub* allows resetting and changing it as long as access to the student e-mail address is possible. Access to the e-mail address is necessary, as students have to visit a unique one-time-use link to choose a new password.

For professors/supervisors, this method could not be used. It cannot be sufficiently determined if they should be authorized to manage the contents of *TheHub* solely based on their e-mail address. Additionally, the e-mail address contains no information about which research group the professor/supervisor belongs to. Therefore, professor/supervisor accounts must be created more centrally, using a superuser that should be secured with a strong password and given to a managing entity such as the study director or the research group leads. Using this superuser, a lower-level administration application can be accessed. This application enables the creation and management of professor/supervisor accounts and, specifically, their research group allocation. Access to the lower-level administration application can be restricted to be only possible within the university network to eliminate external abuse possibilities further.

8.5.2 Topics and Thematic Areas

Topics in *TheHub* are essentially split into two levels of granularity:

- **Specific topics** — Are more detailed and represent a specific mission or task that a student is supposed to do in the scope of their project.

  An example for the concept of a specific topic would be *"Clustering of spatio-temporal climatological data"*.

- **Thematic areas** — Represent a broader type and more abstract level of topics. They do not contain a more or less specific task and mission to be done by a student. Rather, they describe a general area that can contain and encompass multiple specific topics.

  An example for a thematic area, considering the previous example for a specific topic, would be *"Data Mining/Clustering"*.

Thematic areas only consist of a name. Therefore, they are not very useful by themselves. Thematic areas have to be related to a **group area**. The group area adds the possibility for a group to specify further detail about their conception of this area by a description, technologies, related courses, supervisors, and tags.

Group areas are separated from thematic areas. This separation allows research groups to share thematic areas between them without communicating and settling on a shared

specific definition for them. Not requiring any coordination in this aspect is highly significant, as it would inherently cause effort and diminish the individuality desired by the research groups.

(Specific) topics consist mostly of the same properties as group areas. Instead of a thematic area, topics must be associated with a group area. The properties themselves, with their purpose and motivation, are described more thoroughly in the following Subsection 8.5.3 dedicated to them.

The overall data model used by the application is visualized and summarized as an Entity-Relationship-Modell (ERM) in Figure 8.3. This model is slightly abstracted. The entity types needed for the authentication and authorization of users are simplified.

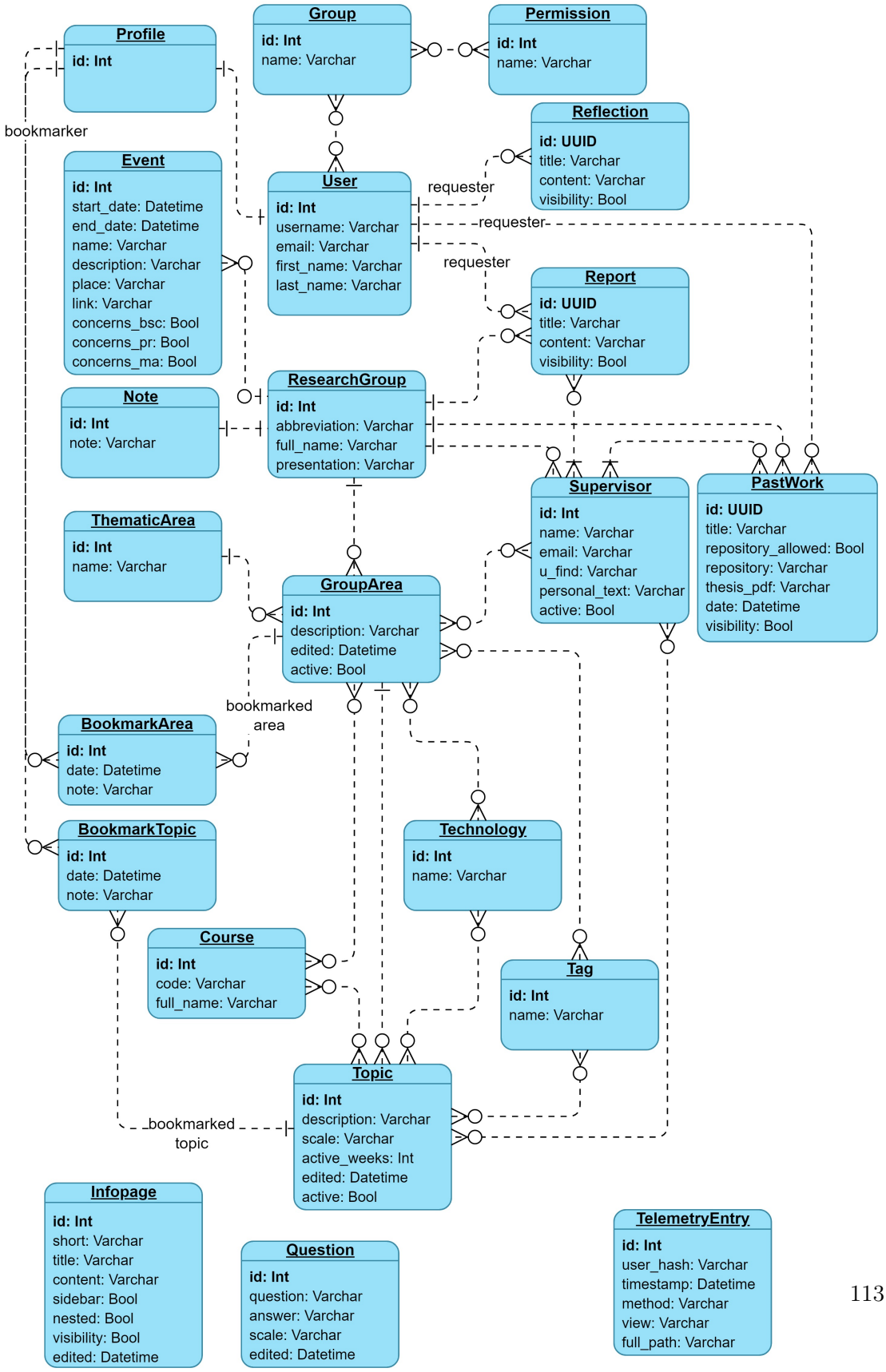
The required association of specific topics to group areas is the only property that *TheHub* additionally, compared to the minimal way of issuing topics currently, requires for topics. In this case, it was deemed as necessary to insist on some additional effort by professors/supervisors, as this connection between topics and thematic areas is crucial and of uttermost importance, as it:

- Enables students to search and inform themselves about broad areas, instead of just specific topics.
- Implicitly gives students an overview about what areas a research group is active in.
- Groups the specific topics in a meaningful and important way across research groups. In essence, this replaces the issuing research group with the thematic area a topic is settled in as the broadest categorization. The thematic area is inherently a more important and meaningful feature shared between specific topics, especially when a group is active in multiple areas and areas are shared between multiple research groups.
- Most notably, provides the basis upon which all ways of issuing topics can be combined. It eliminates the gap between research groups only issuing rather specific topics and ones specifying their general areas of interest, and effectively requires the groups preferring specific topics to assign them to a broader area. Subsequently, this broader area encompassing specific topics is then comparable to the other groups' higher-level topics and areas.

Requiring all issuers of specific topics to assign their topics to thematic areas consequently requires them to specify thematic areas. As this inherently represents an increase in the needed effort, it had to be ensured that this additional effort is kept as low as possible. This is accomplished by only requiring a name for defining a group area.

Of course, a name alone is seldom enough to represent such a group area. This is where the design guideline of *"Implicit" addition of Information* comes into play by effectively making the area inherit the information contained in its subordinated topics. This allows the specific topics to describe their encompassing group area by accumulating the information contained within them. In essence, this enables thematic areas to be sufficiently presented and described without actively entering information for them.

Figure 8.3: Entity-Relationship-Modell of TheHub (Crow's Foot notation)



Instead, areas are described automatically by issuing specific topics. Therefore, forced group areas themselves cause very little required additional effort to professors/supervisors. The only additional effort is due to professors/supervisors having to initially enter an appropriate name for an area and associating it with specific topics.

As already noted, group areas can also be actively described without relying on specific topics to do so. However, this is purely optional. The approach can be mixed as well, and, e.g., a description for a group area be provided manually while the rest of the information is added automatically by the specific topics associated with the group area.

Group areas, therefore, aggregate their associated topics. The aggregated and manually added information about group areas is visible in specific group area detail pages. These group area detail pages inform about other groups offering the area, supervisors, associated topics, relevant technologies, related courses and tags. In addition, research groups can also freely describe their group areas with a description entered with a WYSIWYG editor. This description is then presented on the respective group area detail page. An example of such a group area detail page can be seen in Figure 8.4.

A further implication of this required two-level separation is that the definition of additional levels, e.g., subareas, is not directly supported. However, if desired, it can be achieved by using the tagging system further explained in the next subsection. The reasoning for no direct support of defining multiple levels is that it would inherently make the topic issuing and management process more complicated and cause more effort to all research groups. Besides an inherent effort increase, it would also be unclear if any of the research groups used this feature.

8.5.3 Topic and Thematic Area Properties

As already briefly touched upon in Subsection 8.5.2 above, group areas and thematic areas have additional optional properties.

A **description** can be used to specify further detail to topics and areas and explain them further. The description has a flexible format. It can contain anything from plain text to links or even images.

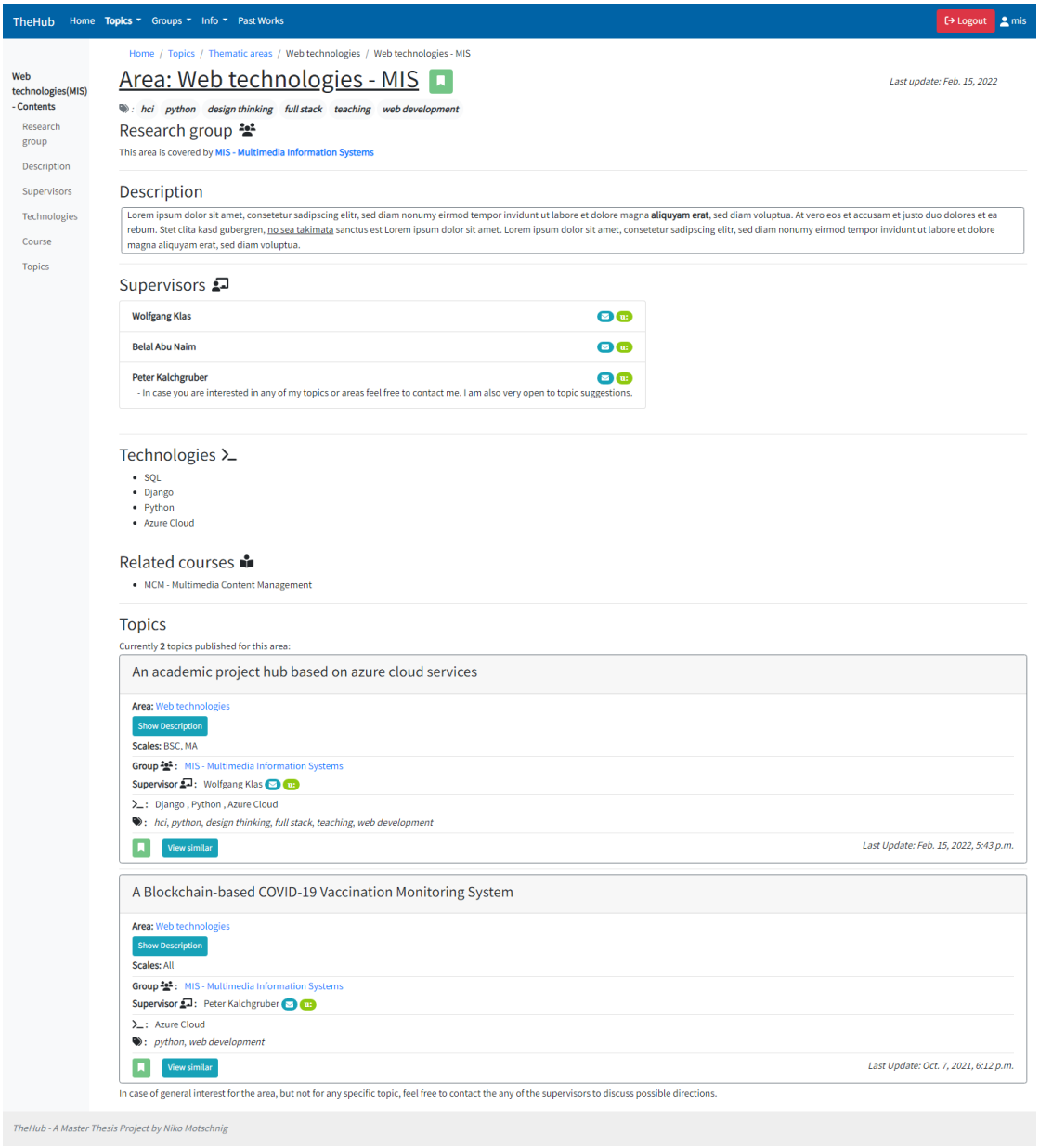
Technologies are used to express what technologies are planned to be used in the scope of the specific topic or are typical for the area. Such technologies can, for example, be programming languages or frameworks.

Related courses are specifiable to describe on what courses the specific topic or area builds upon. This connection to courses was specifically wished for by students. It allows students to quickly search for topics they deem to be qualified for and gives them a logical base to start their search.

In accordance with the focus on voluntariness and establishment of a common shared basis motivated in Section 8.3.3 adding and managing all these predefined properties is completely optional. In its most minimal form, a topic can consist of a title and supervisor only.

In addition to these fixed optional properties, professors/supervisors can also optionally add **tags** to their group areas and topics. Tags can be any text and can categorize and flag areas as well as topics in any imaginable way not captured by the other properties.

Figure 8.4: Group area detail page example



Technologies, related courses, and tags were separated as distinct properties from the topic and area descriptions that could contain them in the text. This was done to enable *TheHub* to offer students the possibility to perform searches and filter topics based on those properties. Additionally, it enables searching based on selectable values rather than just free-form text-based search. The search capabilities and how topics are listed is further explained in Subsection 8.5.4.

The tagging functionality makes the overall approach to categorization very flexible and allows supervisors to categorize their material based on anything they want. In addition, it implicitly invites other groups to use already created tags as well. The added flexibility was deemed necessary, as otherwise, the categorization into different subareas would feel very constraining with one topic having only one core thematic area. The freedom in how to use the tags also aims to provide a slight positive feeling of being in control to professors/supervisors. Rather than them feeling obliged to adapt to a new way of describing their topics and areas.

The approach of only having the smallest amount of required properties, with the other ones being purely optional, makes the overall approach to topic issuing very flexible. It allows professors/supervisors to categorize and describe their topics or areas how they want and not how the system forces them to.

Tags, as well as the more fixed properties explained before, can also, once added, be used by other research groups as well. This is even especially facilitated by suggesting already existing values to professors/supervisors. They can even search for existing values while editing and creating topics and thematic areas through a more advanced dropdown menu that supports the input of new values as well.

Emphasizing and specifically facilitating as well as supporting the reuse of values of the described properties is especially beneficial for two main reasons:

- It allows the research groups to form cross-connections between their topics and allows for much more meaningful search possibilities and results.
- Additionally, it inherently reduces the effort needed to add and adapt topics and thematic areas. Obviously, the reuse and selection of values is much simpler than entering new ones. Subsequently, this motivates professors/supervisors to specify these properties, leading to more available information and search possibilities for students.

Lastly, a property denotes when the specific topic or group area was updated last. However, this property is never directly edited but managed automatically by the system. This last-edited property is of high importance. It enables *TheHub* to enforce data currentness somewhat and enables students to filter for newly added or updated information. How the data currentness is achieved is discussed explicitly in Subsection 8.5.5.

8.5.4 Topic Search and Listing

One of the core functionalities of *TheHub* is the listing of topics and the ability to filter and sort this list based on personal preferences and priorities.

To provide this functionality, a search interface was designed and implemented. It is designed with the primary goal that students can quickly glance over topics to capture the most relevant information by initially hiding the more detailed and possibly long topic descriptions. Another reason for initially hiding the description is that it is the property where the most deviation is possible across research groups. Therefore, by initially hiding it, the listed topics appear way more uniform and consistent. However, should a topic capture a student's interest, the description can be quickly and easily shown by clicking a button. Additionally, there are buttons available within each topic allowing to quickly access the *u:find* profiles[2] of the topic's supervisors, send an e-mail to the supervisors, bookmark the topic and find similar topics to the currently viewed one. The last two of the functionalities, bookmarking and finding similar topics, are further described in their dedicated Subsections (8.5.7 and 8.5.6).

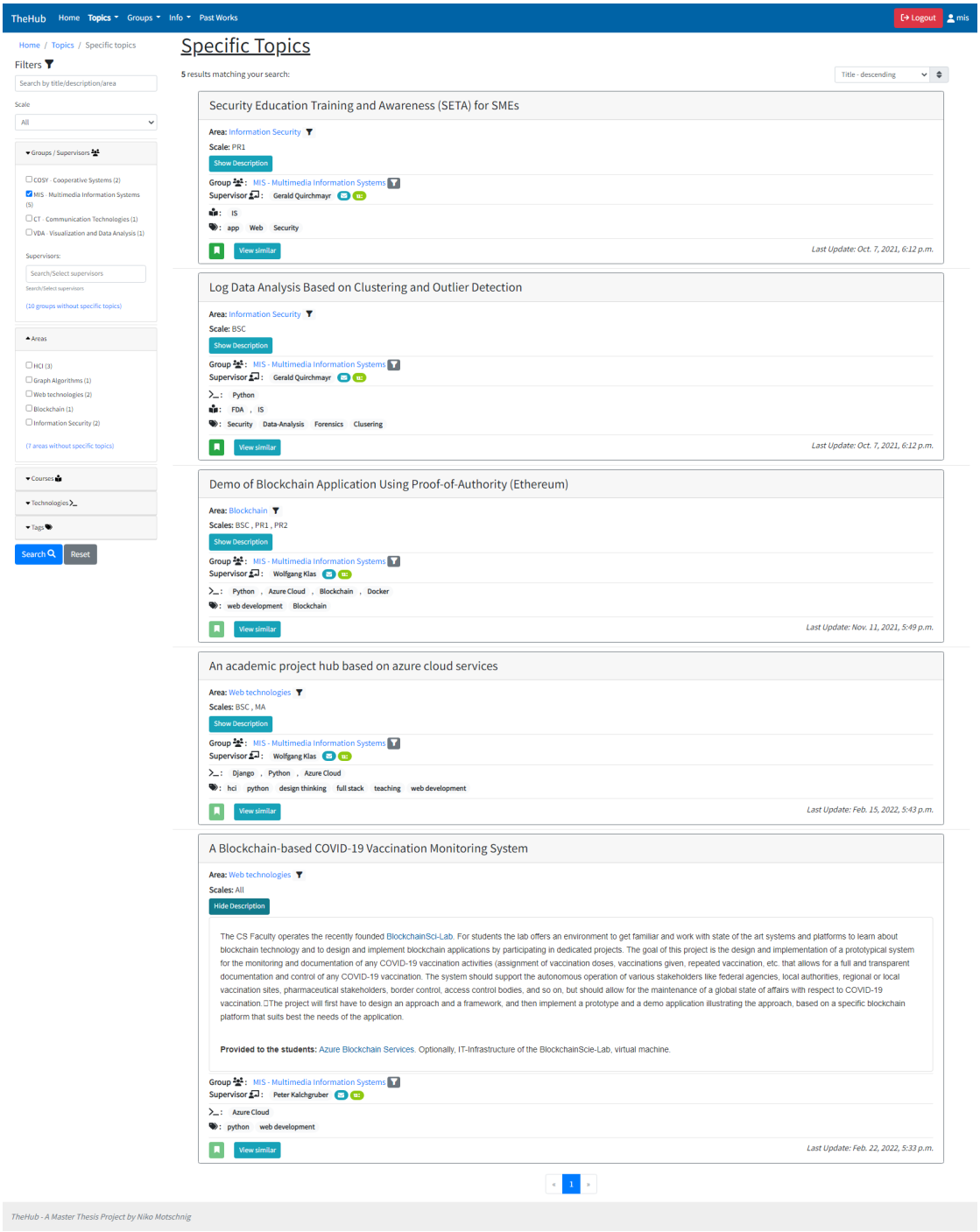
Furthermore, the search interface allows for a more explorative search process by making the searchable criteria such as tags and technologies clickable. When clicked, this criterion is automatically added to the current filter mask, limiting the currently displayed topics. This makes it possible for students to browse through topics and filter on relevant criteria on the go, instead of having to specify it beforehand and going through all filterable values to decide which ones to filter by.

Besides supporting various ways of filtering topics, the search interface, as already mentioned, enables sorting of the listed topics. Especially relevant, as emphasized by students and supervisors alike, was sorting based on the date of the last update performed on the topic. The search interface for specific topics is depicted in Figure 8.5.

The interface for thematic areas mirrors the one for specific topics. However, it aggregates the information from multiple group areas, should multiple research groups offer projects in the particular thematic area. An example of this aggregation would be that supervisors from different groups are displayed if the respective thematic area is shared between different group areas. The display of thematic areas in the search interface is likewise limited. Directly displaying all available information was not possible while still providing a clear, searchable list with appropriately sized elements. Therefore, to view the full details of a group area, a button has to be clicked. This button then redirects to a specific detail page, instantly displaying the details of the group area if only one single group area exists for the specific thematic area. Should multiple group areas for a thematic area exist, a page is displayed listing all research groups offering the respective thematic area and allowing for selection of which details want to be seen. The detail pages of group areas, sharing a thematic area with others, also directly display the other research groups active in the area and provide links to these detail pages. This connects group areas from different research groups with the same thematic area.

[2] In essence the official supervisor profile in the official university calendar, listing the contact information and taught courses of the supervisor.

Figure 8.5: Search interface for specific topics



8.5.5 Currentness of Topics & Data

As emphasized explicitly by one of the interviewed professors/supervisors, it is of high importance that the data within *TheHub* is kept somewhat current to, for example, prevent already finished or no longer offered topics to be present in the system forever. Currentness was also, but in a different manner, wished for by students, who wanted to see what is new or updated and thus most recent directly. To enable this, information about currentness does not only have to be available and visible. Rather, it must be possible to sort and filter based on this data as well.

However, keeping data current inherently means regularly managing and attending to it, inevitably requiring additional effort. This is directly in conflict with the design guideline and requirement of *Ease of Use*. Therefore, a way had to be found that leads to current data and requires the least amount of effort to do so.

The best method of achieving this was determined to be that specific topics have an additional property denoting for how many weeks this topic is active for. Attending to entering a value for this property is entirely optional, as it has a default value of 52 weeks, roughly corresponding to a year. After this time has elapsed, the topic is automatically inactive. To make it active again, it has to be updated (this update request does not need to contain actual changes). Additionally, topics are also set as inactive if they have no (active) supervisors assigned to them or if their group area is set as inactive. In contrast to topics, group areas and supervisors do not automatically become inactive. Their active-property can be toggled manually.

In addition to lightly enforcing currentness, *TheHub* also makes the recentness of data transparent wherever possible. This is achieved by displaying the date of the last update. Besides simply displaying this date, it is always possible for students to sort based on this data as well.

8.5.6 NLP-Based Search & Finding Similar Topics

Mainly inspired by the suggestions of students regarding a sort of search agent for topics, *TheHub* has Natural Language Processing (NLP) functionalities. Concretely, there are two ways in which *TheHub* uses NLP.

Firstly, *TheHub* allows students to find similar topics to a particular topic. This can be done by pressing a button located under each listed topic.

Similar topics are determined in two distinct ways. The first way is simply by finding topics sharing the most tags with the topic for which similar topics want to be found. The second way is more advanced than the first one. It does not require professors/supervisors to provide tags for their topics. Instead, it directly calculates the similarity between topics as a score based on the content of the titles, descriptions and additionally provided information.

Secondly, there is a dedicated functionality to enter keywords corresponding to a student's interests. Based on this user input, the application suggests research groups to contact, the most fitting topics, as well as thematic areas to pursue and investigate further. Should the entered keywords be directly contained in descriptions of topics, their

occurrences are also highlighted. This keyword-based search functionality is supposed to act as a search agent, providing students with a first recommendation and starting point for their search process.

An explanation of how exactly similarity scores are calculated and how this is implemented is provided in Section 9.5.

8.5.7 Bookmarks

Another way in which *TheHub* hopes to improve and organize the search process of students is by providing a low-threshold bookmarking functionality. The bookmarking functionality allows students to save specific topics and group areas. This enables students to get a persistent quick overview about interesting topics and areas. Specifically, bookmarks for group areas give students quick access to these areas and enable them to catch up on newly issued topics quickly.

Bookmarks additionally allow for the attachment of notes by students. In these notes, students can write anything they want about a bookmarked topic, such as open questions, topic ideas and priorities. The bookmarks, with all relevant information about the associated specific topic or area and their attached notes, can be exported from *TheHub* as text files. The exported text files can then be further used and manipulated, as well as saved locally by students.

Besides benefiting students, bookmarks also aid professors/supervisors in the background. *TheHub* displays information about students who bookmarked a group area or specific topic to professors/supervisors. This can be utilized to somewhat predict the expected load on a specific topic, area, or supervisor. Additionally, this feature can be used to contact interested students actively. While *TheHub* cannot display or access student-related information, e.g., visited courses, which was wished for by professors/supervisors, this can be achieved indirectly through displaying the students' e-mail addresses to professors/supervisors. Since the e-mail addresses of students contain their student ID, professors/supervisors can potentially use it to find out further details about the student on their own, despite this not being directly supported by *TheHub*. Furthermore, the number of students interested in a topic or area can indicate what kind of topics and areas are perceived as interesting to refine the topics offered further.

To keep the information about interested students recent, the bookmarks, much like topics, are not active indefinitely. Instead, they need to be renewed regularly by students. To somewhat motivate students to renew inactive bookmarks, they are shown to them in a greyed out manner with much of the information missing. In addition, the note functionality is disabled for inactive bookmarks as well. Renewal of a bookmark is straightforward. It can easily be done by pressing a button directly above the respective bookmark.

8.5.8 Research Group Representation & Information

Another set of wishes, emerging from the interviews, came from students, who wished to obtain more relevant information about the research groups as well as professors/-

supervisors, who wanted a presentation of their group aimed and exclusively dedicated to students looking for supervision. Therefore, motivated by these wishes, *TheHub* dedicates a whole section to presenting the research groups.

In this section, *TheHub* firstly lists all currently active research groups and provides links to their *TheHub* exclusive representations. Research groups not using the web application are listed in this section too but with a different style to be distinguishable. For groups not utilizing *TheHub*, users are redirected to the official groups' web pages. This enables *TheHub* to also connect students to research groups choosing not to partake in its use. Ultimately, by including groups not using it, *TheHub* provides students with a central place from which all relevant research group representations can be reached, no matter if they are in *TheHub* or outside it.

For research groups using it, *TheHub* provides a dedicated detail page. On this page, research groups have the optional opportunity to define a presentation without any fixed format. In this presentation, the research groups can portray themselves as they want to interested students. This presentation could, for example, contain information about what the research group offers, how to obtain a topic and what it currently works on. Since this presentation is only accessible for logged-in users, it does not lead to a non-uniform or unprofessional image of the university to the general public.

As already mentioned, providing this manually created presentation, as motivated by the design guideline of *Voluntariness*, is entirely optional. It is the only part of a research group representation within the application needing to be manually created and managed. The entire other content of the group's representation is automatically generated by *TheHub*.

These automatically generated parts of the representation follow the design guideline of *Implicit Addition of Information*. They are dynamically generated based on which parts of *TheHub* the respective research group uses. For example, if a research group does not gather reports and past works from former students, these dedicated subsections are not generated. Consequently, these subsections are also not visible to students in the sidebar, acting as a navigation tool for the research group's representation.

The central part of the automatically generated representation is the research group's profile. In the profile, all information from a group's issued specific topics and group areas is aggregated. Therefore, the profile clearly depicts, what areas a group is working on, what tags are associated with it, what courses are related to its work, what kind of technologies get utilized in its projects and lastly, its supervisors.

Additionally, there is a supervisor section, which is automatically generated as well. The supervisor section also aggregates all available information, but this time based on the respective supervisors of the group. It provides students with a clear overview of what a supervisor is doing by directly displaying supervised areas and topics, along with past works and reports of them (if available). Professors/Supervisors can also optionally add a personal message that is also displayed in this section. The supervisor section is one example of how *TheHub* supports various students' search methods. It could, for example, be greatly utilized by a student looking to propose their own topic idea to find out whom to contact for their proposal specifically.

The other automatically generated parts are dedicated to listing all currently issued topics of a research group, submitted reports, submitted past works and events. For the reports and past works, search and filter utilities are provided, allowing, for example, searching and filtering based on the year and the responsible supervisors, rather than just a plain list.

An exemplary automatically generated profile of a research group is depicted in Figure 8.6. In the sidebar, the other automatically generated parts of a research group's representation are listed. The supervisor section, another example of an automatically generated page, can be seen in Figure 8.7.

8.5.9 Infopages

The core functionality of *TheHub's* info-section are infopages. They serve the purpose of compiling and providing relevant information and material regarding project-based work currently scattered across different (university) web pages in a simple and flexible yet powerful manner.

Much like the optional research group presentations, the content and format of an infopage are primarily not fixed. The only fixed content is an infopage's title. This title is always displayed at the top as a heading. In addition, it serves to identify the infopage in the navigation elements.

The infopage subsystem works like a small and light CMS as it allows to dynamically add or delete infopages to *TheHub* that have a dedicated URL. These dedicated URLs and the option to define nested infopages that are not visible in the main navigation elements allow infopages to be nested hierarchically within each other should that be required.

Additionally, a working sidebar with the subheadings of an infopage can be automatically generated. This is especially useful for larger infopages to facilitate the navigation within.

Infopages are made available through the main page of the info-section or the main navigation bar, always located at the top of the application interface.

8.5.10 FAQ Functionality

Further complementing the goal of the infopages, and also part of the info-section, is a Frequently Asked Questions (FAQ) functionality. The FAQ can specifically be utilized to answer very commonly stated questions that are currently not directly answered and hopefully reduce the need of students to ask them.

The questions and corresponding answers contained in the FAQ have levels (Bachelor's thesis, Practical Course, Master's thesis) assigned to them. The levels enable the users to filter questions relevant to them. Additionally, specific questions and answers can be searched for by a text field.

To provide students with a clear overview, the answers to questions are initially hidden. This is done to prevent detailed answers from obscuring the page and making it very long. They can be made visible by simply clicking on the corresponding question. The answers are also directly displayed, should the user enter a search text contained in it. To further

Figure 8.6: Group profile page example

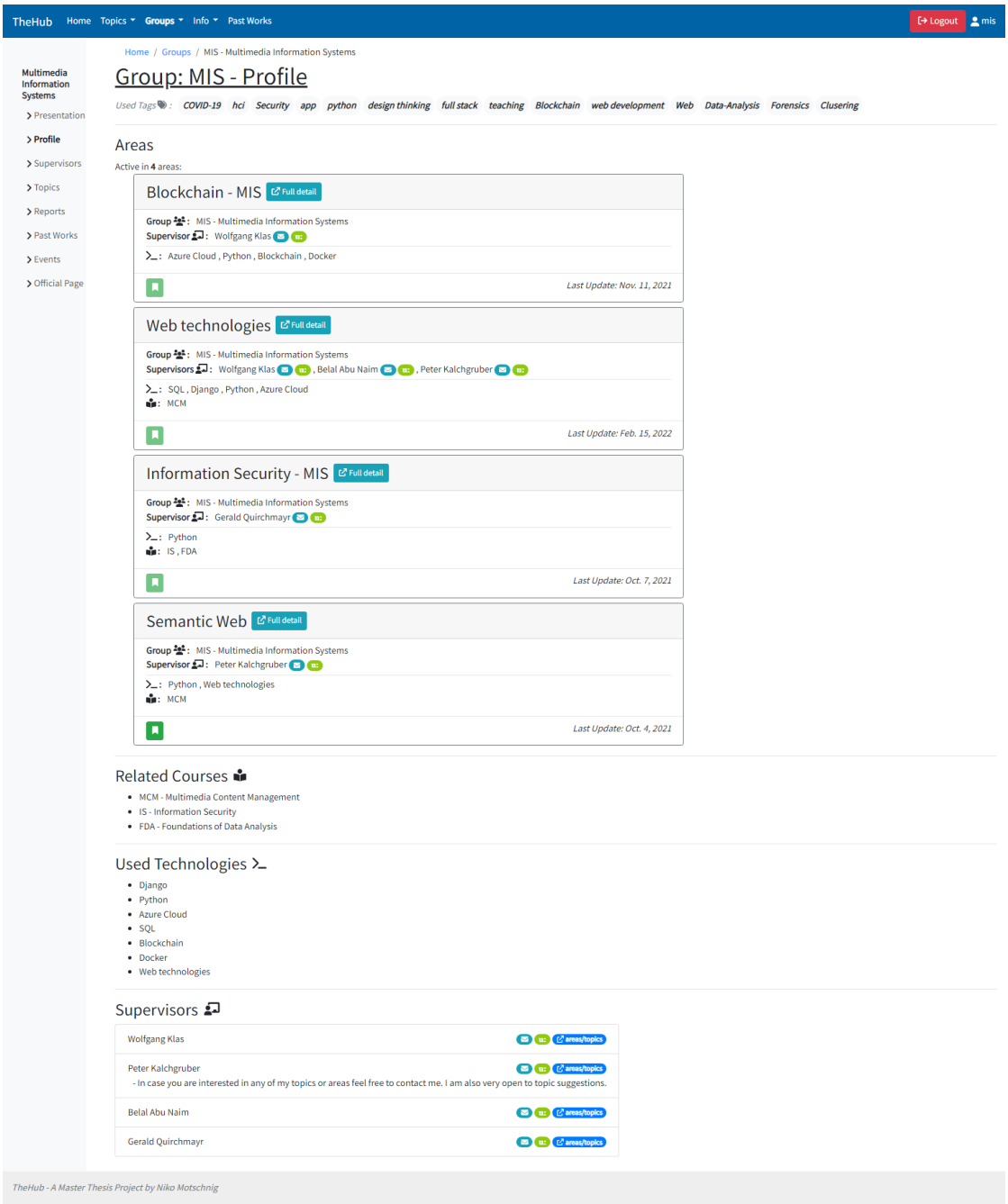
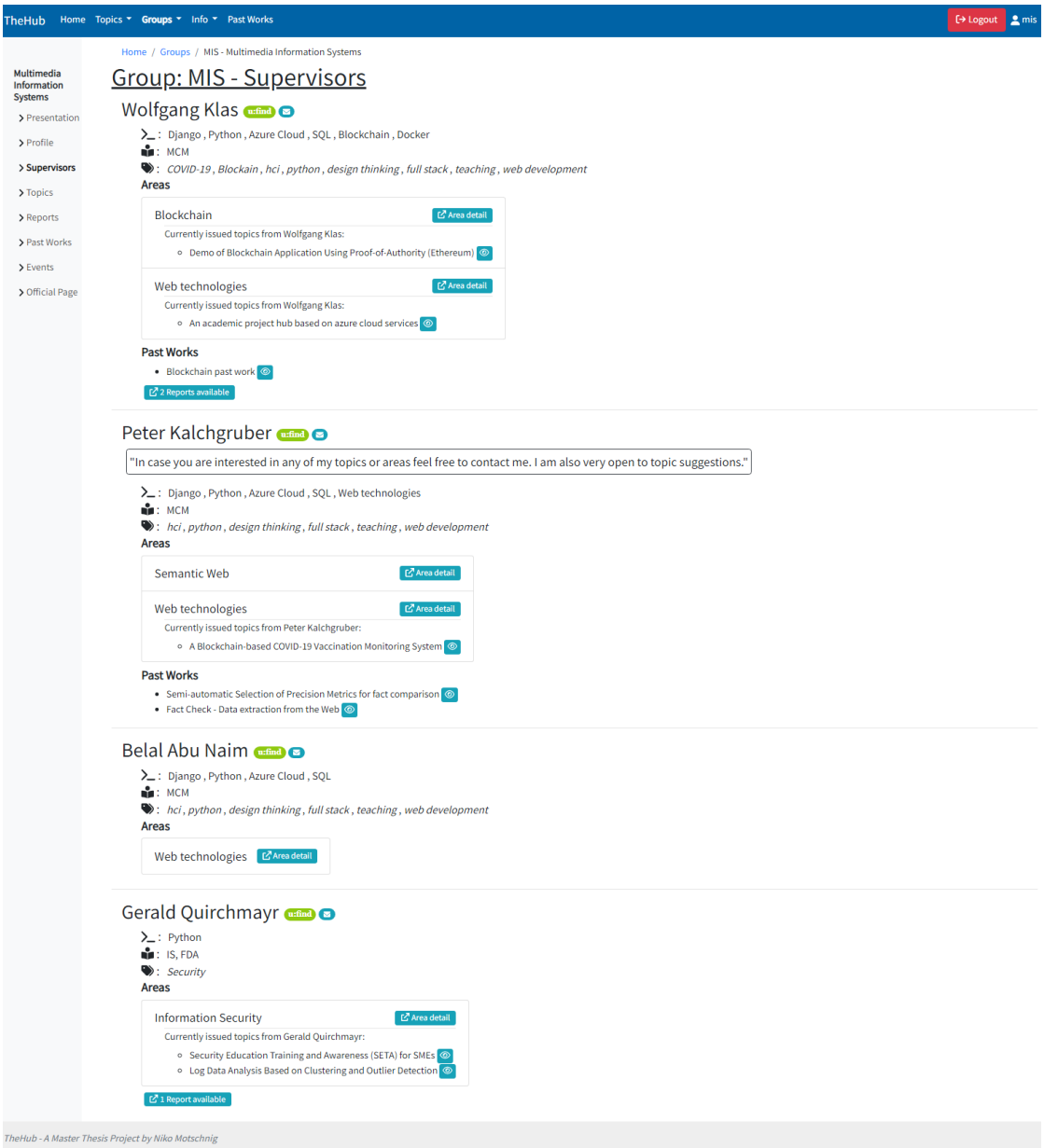


Figure 8.7: Group supervisor page example



improve the search functionality for questions, *TheHub* also highlights text matching with the search input. The level of a question/answer pair is always clearly displayed next to the respective question.

The format and contents of an answer are not fixed and can, for example, contain links, lists, and even images. The FAQ is visible in Figure 8.8

8.5.11 Event Support

Besides providing the infopages mentioned above, *TheHub* additionally provides dedicated support to publish events.

Events can be either research-group-specific or general and be assigned to specific levels (Bachelor's thesis, practical courses, Master's thesis). Additional information about events is a description, time, and place. Events can have a link too. The link is for virtual events, held over an online conferencing tool instead of in-person at a specific location.

The main use-cases for the events would be group-specific preliminary meetings for project-based work, or generally, events where students can inform themselves and connect with potential supervisors as motivated and suggested in 6.3.5. However, the possibilities are rather endless. For example, events could also be used to inform students about deadlines and optional offers provided by the university, e.g., courses that help in scientific English writing. The ability to advertise such additional optional offers was specifically suggested and wished for by one of the interviewed professors/supervisors.

To inform students about upcoming and past events, *TheHub* displays all of them in a uniform colour-coded manner in a clear calendar equipped with filter functionalities. This effectively gives students a singular place to inform themselves about all upcoming events that previously would be announced across various web pages in different ways. Group-specific events are also displayed in the respective research group representations.

8.5.12 Provision of Additional Information by Students

Another way in which *TheHub* aims to provide additional valuable information to students without causing much effort for professors/supervisors is by distributing this task to the students. This is effectively done in three different ways and contexts: past works, reflections, and reports.

Past works, as their name suggests, are finished projects by former students. They are included and used in many ways for a variety of purposes in *TheHub*. Most obviously, there is a dedicated section to filter and search for past works. The interface to browse and search through past works is designed very similarly to the one for topics and thematic areas. It is depicted in Figure 8.9. Past works are also used in the research group and supervisor descriptions to provide students with more relevant information.

Past works are especially beneficial. Students can profit from them in multiple ways. They can serve as concrete examples of what a research group is focusing on and give insights into how this is typically done in the scope of student projects. Students can use this information to better decide on a topic or supervisor and gain additional ideas and directions for the proposal of their own topic ideas. Additionally, past theses can be

Figure 8.8: FAQ page

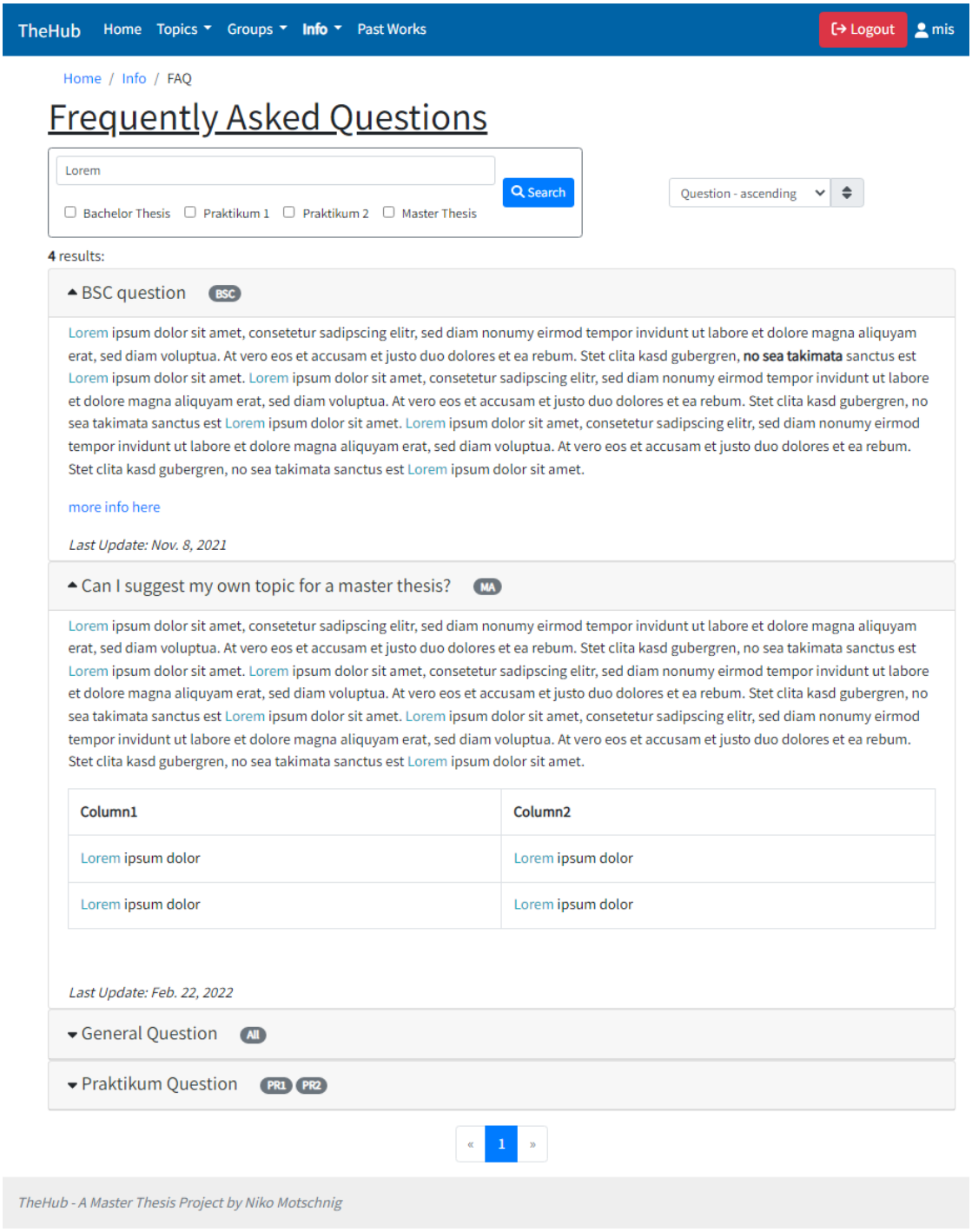
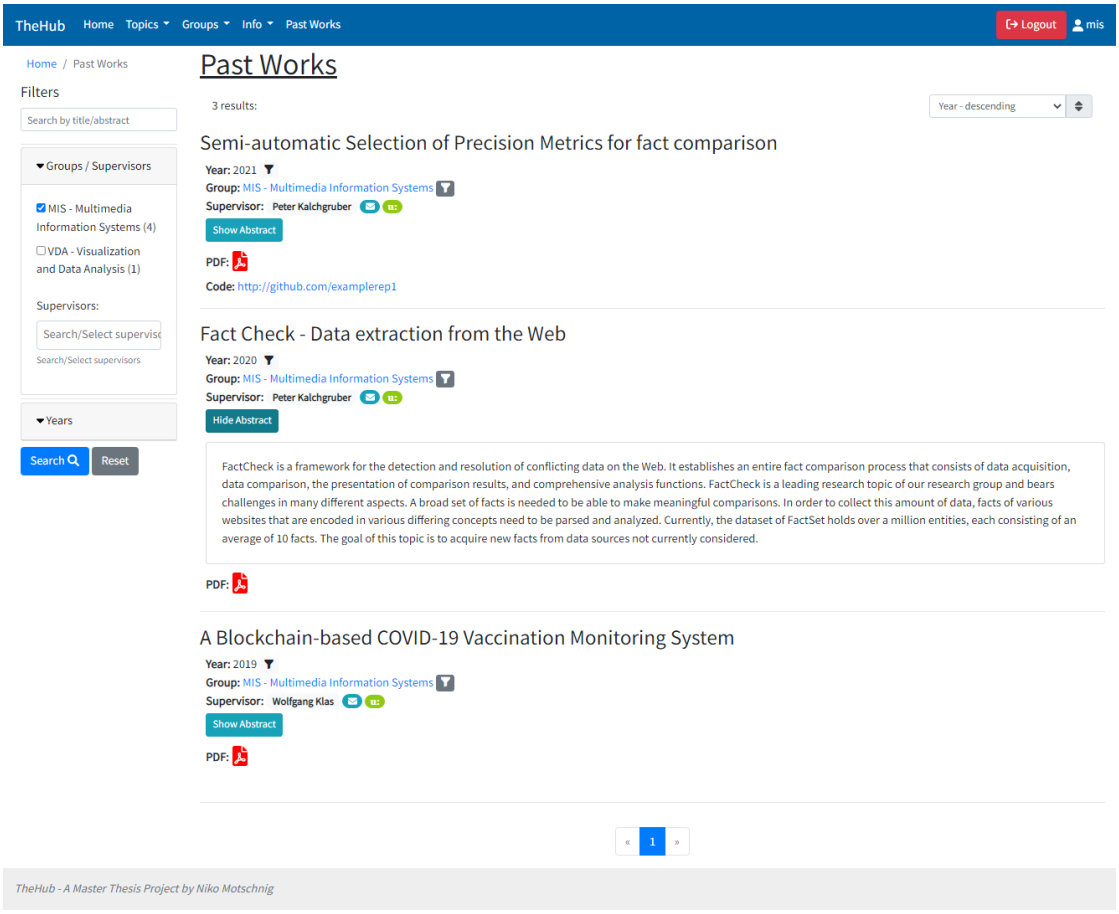


Figure 8.9: Interface to browse and search through past works



used later on by students currently writing their theses, as they can analyse the structure and orientate themselves on them. Additionally, abstracts of past works are used to create research group recommendations in the keyword-based search functionality and generally aid in making the similarity score calculation more accurate by increasing the data available. A hoped-for effect is also that students are interested in what others are doing, and therefore during their studies, regularly check what has been done recently. This, in turn, could make them think about their topic search process earlier on as well.

Reflections are the most general kind of information provided by students. With them, students are supposed to generally describe their thesis writing process, possibly even their path on how they arrived at their topic, briefly delineating the practical course experiences. Students should also describe perceived difficulties and how they dealt with them.

Reflections aim to inform future students about the general process and enable them to gain a conception of the possibly very unfamiliar task of having to write a Master's thesis. Furthermore, it could prove beneficial and supportive for students to read about other students' difficulties and know that they are not alone in their struggles and that others successfully overcame them.

Students can access the reports through a dedicated section in the info-section of *TheHub*.

Reports are directed and assigned to a research group and specifically the supervisors responsible for the respective student. In reports, students should briefly and honestly explain how they experienced the supervision of their project. This serves two purposes. Firstly, it gives important insights and information about the supervisors to other students. This, as time goes on, generates great descriptions of supervisors and their supervision style, without supervisors having to provide this information. Secondly, it allows supervisors to gain important feedback from students. Supervisors can then potentially use this feedback to refine their supervision skills.

The reports are made available to students through a section in the research group detail pages. They can be accessed through an interface with search, filter, and sort capabilities. This interface is designed very similarly to the one for past works.

Furthermore, the reports could somewhat lead to a healthy competition between the research groups. Many good reports are likely to significantly improve the image of a research group and supervisor to students, and good reports can only be made by students happy with their supervision.

Requesting reflections, reports, and past works can be done by professor/supervisors easily. They have to fill out a short form in the admin interface of *TheHub*. In this form, professors/supervisors can explicitly choose what they want to request. A student is always asked to submit a reflection. Whether a past work (with or without a link to a code repository and the document) and/or report is requested is entirely up to the professor/supervisor. The professor/supervisor then has to enter the supervised student's e-mail address and can customize the message sent. After submitting the form, the web application sends an e-mail to the specified address. The e-mail contains links to feedback submission forms, where students can enter their feedback. These links are similar to

password-reset links. They only work once and have a unique URL.

To prevent the misuse by students, submitted reflections, reports, and past works have to be explicitly made visible after their submission by professors/supervisors. Apart from editing them, except for past works (which can be edited), professors/supervisors have complete control and can make them invisible or even delete them at any time.

8.5.13 Full Compatibility to the Current Method

As motivated in Section 8.3, a massive focus in the design was placed on *Complementation* of the current methods instead of aiming to straight out replace them and make *TheHub* handle everything as well as *Usability & Ease of Use*.

For this reason, *TheHub* is fully compatible with the way topics are currently issued on the research group-specific web pages. It offers the functionality to manage and add specific topics with its administration interface and make them available to the research group-specific open topics pages using the Typo3 CMS.

Compatibility is achieved by providing an endpoint secured with a token. On this endpoint, the specific topics of a research group, identified by the token used, can be requested as a JSON array. A request to the endpoint can be made using JavaScript in the Typo3 CMS. The JSON array returned from the request can then be used to generate HTML displaying the contained topics.

This effectively, after a brief setup, allows to entirely circumvent the currently necessary editing of raw HTML in Typo3 to manage the groups' issued topics. Enabling *TheHub* to handle the issued topics on the web pages as well is of high importance. It eliminates the need to synchronize the official topic listing with the one in *TheHub*, and subsequently, most arguments for not utilizing it. Enabling *TheHub* to provide the topics to the official pages too actually reduces the effort currently needed and provides an easier and more accessible interface for managing the open topics. Furthermore, since the admin interface of *TheHub* is usable by anyone, the dependence on specific staff to perform changes is removed as well.

Additionally, this compatibility gives research groups a reason to start using *TheHub*, even if they do not appreciate the other benefits and features and would prefer their topics to be available on the official open topics pages.

8.5.14 Administration Interface

Since *TheHub* lives from the input of professors/supervisors, a huge priority was placed on the design of the admin interface. The interface should overall be easy, convenient, and practical to use. In addition, it should provide useful functionalities and benefits, incentivizing professors/supervisors to use the application.

An emphasis was placed on making the interface uniform across all sections. Generally, the system's data is displayed in tables showing the most important properties. One column of these tables always contains buttons for all available operations such as viewing all details, editing, deleting, and even copying for events since those are likely to repeat themselves. All tables are search-and sortable by various attributes.

An always-present sidebar enables navigation through the various sections of the administration interface. This sidebar interconnects all the sections with each other.

Learning from the previous attempt of creating a system for this purpose, there are always help buttons available for non-obvious parts. These buttons explain the purpose and possibilities of the respective section in detail.

Specifically, the larger, more versatile properties, such as descriptions or group presentations, can be created and edited by a WYSIWYG editor. This should be a massive improvement over the editing of raw HTML in the current Typo3 CMS.

The forms themselves are made so all the data can be inserted directly without leaving the form itself. For example, to add a topic, small pop-ups can be used to create required supervisors or group areas.

Regarding additional functionalities, there is a note functionality allowing the research groups to share notes about their activities in *TheHub*. These notes are only visible to professors/supervisors of the respective group. If the notes are updated, a notification is displayed to all users that have not looked at the updated version yet. Furthermore, a dashboard quickly informs the professors/supervisors about the current state of the topics and other data. This dashboard is located at the index page of the administration interface. Another additional functionality for professors/supervisors is the visibility of interested students in their topics and areas based on bookmarks. This was already further discussed in Subsection 8.5.7.

The research groups in *TheHub* are nearly fully separated and disconnected from each other to enable research groups to work independently and individually. Data and information specifically assigned to a specific research group can only be edited by users assigned to that research group.

The other not directly assigned data, such as infopages, general events, and reflections, are manipulatable by users of all groups. This enables the task of keeping this data and information relevant and up to date to be a shared effort, and emphasizes that *TheHub* is genuinely a shared system.

An exemplary section of the admin interface, the one with which currently issued topics are managed, is visible in Figure 8.10.

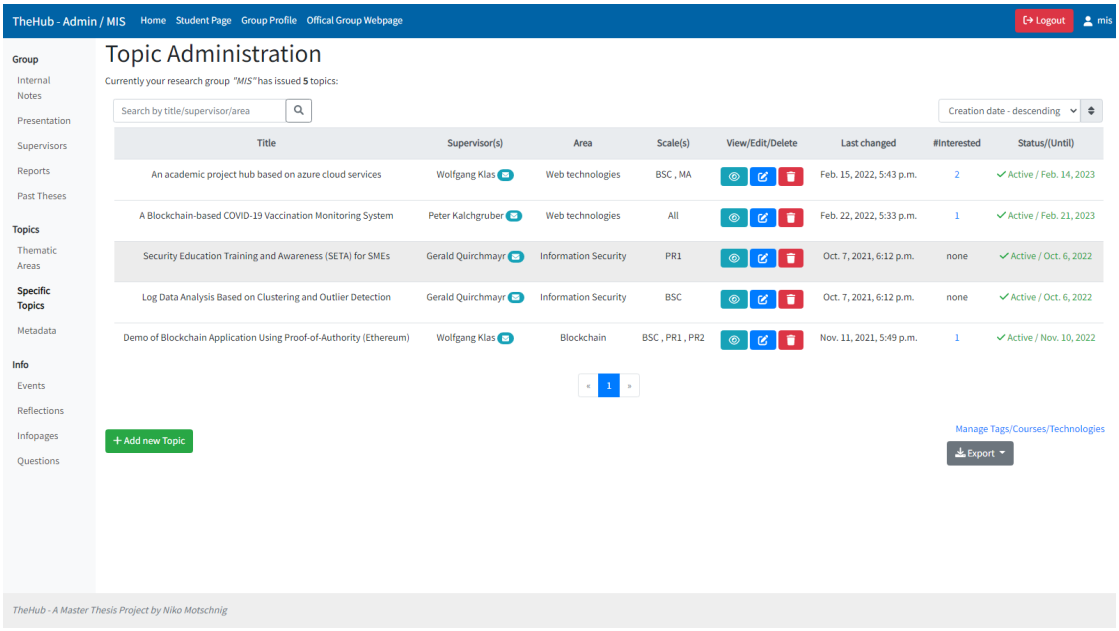
8.5.15 Built-in Telemetry

Primarily inspired by the work of D. Rao [Rao19], who developed an automatic testing and grading software system for a university course and then used the data automatically collected by the system, such as timestamps of student submissions or their amount, to gain valuable insights into the work habits of students and how and when the system was used, *TheHub* aims to also provide the ability to gain such insights.

The ability to gain these insights is achieved by a built-in and easily adapt- and customizable telemetry system. This telemetry system can automatically collect data about how *TheHub* is used. The data can then be quickly exported in different formats and evaluated.

The collected telemetry and the evaluation of it enable *TheHub* to gain further insights into how students search for topics and how they use the application. These collected

Figure 8.10: Admin interface for currently issued topics



data can be used later, for example, to evaluate how actively the application is utilized, investigate which features are most actively utilized and based on what criteria most searches are performed.

The gained insights can then be used to not only improve the actual application, but also to generally learn more about the search habits and preferences of students to possibly further meliorate the whole process. For example, it could be easily evaluated whether measures taken to motivate students to start searching for topics earlier are working based on checking when users first start using *TheHub*.

Since the telemetry data is made accessible in well-established formats, such as CSV or JSON and can be adapted easily within the web applications code, it can be evaluated and utilized by nearly all programming languages.

A detailed explanation on how the built-in telemetry is implemented, and specifically, how its flexibility is achieved, can be found in Section 9.6.

8.6 Functionality Overview

Whereas the previous section provided detailed descriptions and motivations behind the final features, this section summarizes all the implemented functionalities of *TheHub* concisely. The functionalities are grouped by the three sections (topics, groups, info), the administration interface of the application described at the beginning of Section 8.4, and the orthogonal authentication/registration functionalities. The functionalities for past

works are grouped in the topic-section, since they are not assigned to one of the other sections. For each functional part of the application, a listing is provided describing the contained functionalities.

Besides textual descriptions, Figures 8.11 and 8.12 contain UML diagrams with the use-cases for professors/supervisors and students respectively to additionally visualize the functionalities.

8.6.1 Topic Section

Area List

Lists all thematic areas for which at least one research group defined a (active) group area and provides additional functionalities.

- All currently active/visible thematic areas are displayed in a list. This list enables:
  - Sorting thematic areas by name, research group, or last update (determined by the most recent update of either assigned topics or a group area itself).
  - Searching for thematic areas based on their name/description, research group, supervisors, related courses, technologies, and tags – search can be performed by specifying the filtering criteria or more exploratory by clicking on data and including it into the current criteria.
- Thematic areas from the list can be bookmarked (bookmarks all group areas of that thematic area).
- Area detail of any thematic area listed can be viewed. The area detail functionality is described further below).

Specific Topic List

Lists all (currently active) specific topics and provides additional functionalities.

- All currently active/visible specific topics are displayed in a list. This list enables:
  - Sorting topics by title, thematic area, research group, supervisor, or last update.
  - Searching for topics based on their scale, title/description, thematic area, research group, supervisors, related courses, technologies, and tags – search can be performed by specifying the filtering criteria or more exploratory by clicking on data and including it into the current criteria.
- Specific topics from the list can be bookmarked.
- Similar topics to a specific topic can be identified and displayed. Two distinct measures determine the similarity: common tags and similarity score as determined by LSI (more implementation detail about this aspect can be found in Section 9.5).

Figure 8.11: Student Use-Case diagram

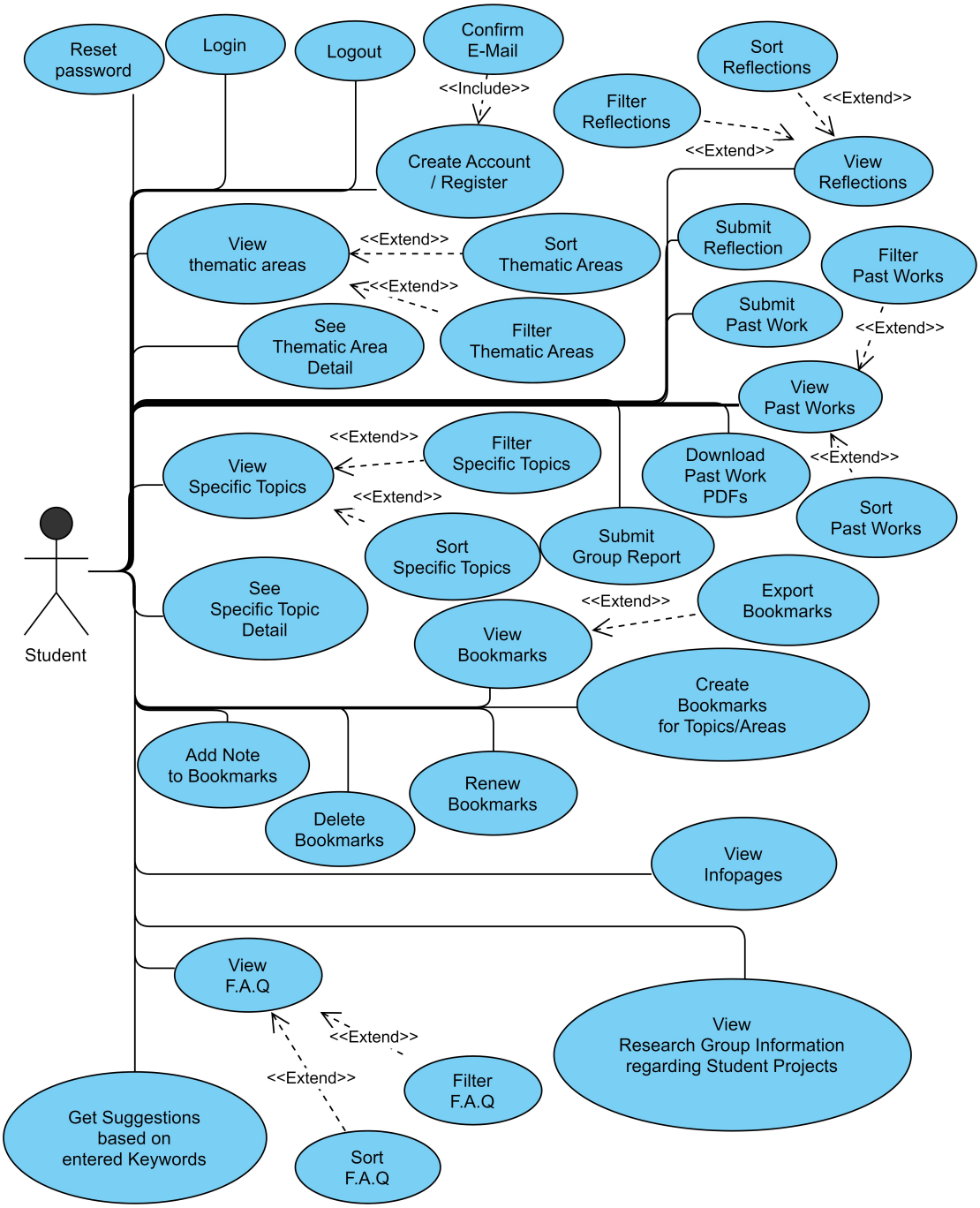
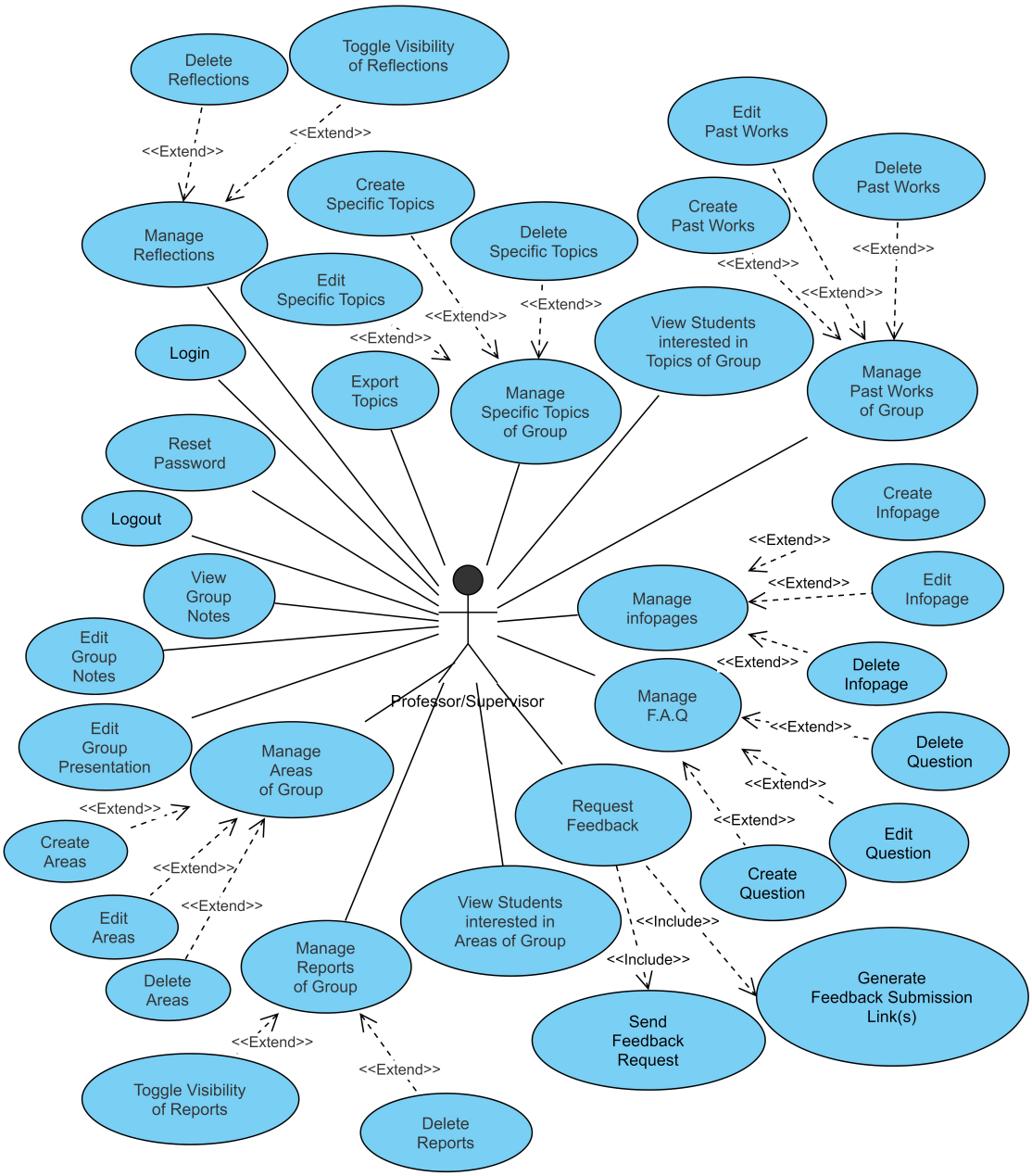


Figure 8.12: Professor/Supervisor Use-Case diagram



Area Detail

Generates an area detail page based on the information related to a group area itself and all its contained topics. If multiple research groups offer a thematic area, the user can select the research group they want to view the area detail of.

The area detail page provides the following:

- All research groups offering the thematic area (if multiple).
- Description of the group area (if specified by the research group).
- (Active) Supervisors, either directly assigned to group area or supervisors of contained (active) topics
- Technologies, related courses and tags – of the group area itself and all contained (active) topics.
- (Active) Topics of the group area as a list along with full information and bookmarking option.

Topic/Area Bookmarks

Allows users to manage their bookmarks. The rationale for letting users bookmark topics and areas can be found in Section 8.5.7.

- All topics/areas bookmarked by the user are displayed as a list.
- Bookmarks can be deleted.
- Inactive Bookmarks can be renewed.
  - For active bookmarks (more recent than a set duration), information of the topic/area is displayed and notes can be added/edited.
  - Inactive bookmarks are greyed out and need to be renewed. Notes cannot be added/edited.
- Bookmarked topics/areas and notes added to them can be exported as .txt files.

Word Search

Given a space-separated list of terms, the "Word Search" functionality provides the following for the user to further enquire:

- Suggested research groups – link to their profiles (further described in 8.6.2.
- Recommended (active) topics – full information, similarity score and option to bookmark.

- Suggested (active) areas – groups active in that area, supervisors, technologies, related courses and tags along with a link to the full area detail page and a bookmarking option.

This data is determined by LSI. How this functionality is implemented is further elaborated in Section 9.5. The reasoning for this feature is explained in Section 8.5.6.

Past Work List

Lists all (visible) past works of all the research groups.

- Enables searching of past works by title/abstract, research group, supervisor and/or year – The search can be performed by specifying the filtering criteria or more exploratory by clicking on data and including it into the current criteria.
- Past works can be sorted by title, research group supervisors or year.
- Allows downloading the PDF files of past works if uploaded.
- Automatically highlights the parts of the past works' abstracts if they match the text searched for and displays the respective abstracts .

Past Work Submission

Allows users (students) to submit their past work. Links for submission are unique and can only be used once.

Submissions links, and associated empty past work objects, need to be created beforehand (by supervisors). More details about this can be found in Section 8.5.12.

8.6.2 Groups Section

Group List

Lists all research groups and highlights the ones using *TheHub*. Redirects users to the respective group profiles if the respective research group uses *TheHub*, otherwise redirects the user to the official research group web page.

Group Detail

Represents research groups using *TheHub* within the application. The motivation behind this is explained in Section 8.5.8.

Generates the following web pages related to a specific research group that are interconnected with a navigation menu:

- **Presentation** – Displays the custom presentation of the group if the respective research group sets it.

- **Profile** – Aggregates all information (tags, related courses, technologies) of the (active) topics and group areas of the research group and lists all (active) areas of the research group.

- **Supervisors** – Lists the (active) supervisors of the research group and aggregates the available information by them:
  - Personal note of the supervisor if set by the supervisor.
  - Technologies, related courses, tags of (active) topics/areas of the supervisor.
  - Supervised areas of the supervisor, along with topics currently issued in that area by the supervisor. Details of areas are available as links, and topic details can be viewed as a modal.
  - Past supervised works of the supervisors. Details available in a modal.
  - Number of reports about the supervisor with a link to a page displaying them.

- **Topics** – Briefly lists (active) group areas of the research group by name and a link to the respective group area details, as well as fully displays (active) specific topics of the research group. Group areas and specific topics have a bookmark button.

- **Reports** – Lists (visible) reports of the research group.
  - Enables searching by title/content, supervisor, and year.
  - Allows sorting by title, supervisor, or year.
  - Automatically highlights the parts of report contents if they match the text searched for.

- **Past Works** – Lists (visible) past works of the research group:
  - Enables searching by title/abstract, supervisor, and year.
  - Allows sorting by title, supervisor, or year.
  - Makes the PDF file of the past work available if uploaded.
  - Automatically highlights the parts of the past works' abstracts if they match the text searched for and displays the respective abstracts.

- **Events** – Shows upcoming events of the research group as well as the most recent past events.

- Link to the official research group web page.

Certain pages, e.g., "events", are only made available if the respective research groups utilized the respective functionalities.

Report Submission

Allows users (students) to submit a report about a research group. Links for the submission are unique and can only be used once.

Submissions links, and associated empty report objects, need to be created beforehand (by supervisors). More details about this can be found in Section 8.5.12.

8.6.3 Info Section

Event Calendar

Provides an interactive calendar displaying all events. The rationale for the calendar functionality is described in Section 8.5.11

- Details about events can be viewed by clicking on events in the calendar.
- Events can be filtered by research groups and scope.

Infopage List

Displays the titles of all visible infopages and provides links to them. The motivation behind the infopages is explained in Section 8.5.9.

Infopage View

- Displays the contents of a specific (visible) infopage.
- Automatically generates a sidebar to navigate through the respective infopage. The sidebar is generated by utilizing the headers of the content of the infopage and allows users to jump to specific headings directly.

FAQ

Lists all available questions. The idea behind this is described in Section 8.5.10.

- Answers to questions are initially hidden and can be made visible by clicking the respective question.
- Questions can be sorted alphabetically, by scope or the last update.
- Questions can be searched by entering contained text and their scope.
- Automatically highlights specific parts of the answers if they match the text searched for.

Reflection List

Lists all (visible) submitted reflections.

- Enables searching by title/content and/or year.
- Allows to sort reflections by title or year.
- Automatically highlights the parts of the reflections' contents if they match the text searched for.

Reflection Submission

Allows users (students) to submit a reflection about their general Master's thesis experience. Links for the submission are unique and can only be used once.

Submission links, and associated empty reflection objects, need to be created beforehand (by supervisors). More details about this can be found in Section 8.5.12.

8.6.4 Administration Interface

The admin interface and its contained functionalities are only available to users with professor/supervisor permissions.

Information on the general design and motivation behind this interface is available in Section 8.5.14.

Admin Dashboard

- Provides a quick overview about relevant metrics:
  - Number of issued topics, active topics, and inactive topics of the user's research group.
  - Timestamp of the last edit to any topic of the research group.
  - Number of active student bookmarks to topics and areas of the user's research group.
  - Number of invisible submitted reports and past works of the research group.
  - Number of invisible submitted reflections.
- Displays group-internal notes and provides the possibility to edit them.

Internal Notes

- Users can edit initially empty group notes.
- The notes are displayed in their dedicated section or at the dashboard/index of the admin interface.

- If an update on notes is performed, users not having seen the most recent version have a visual indicator displayed to inform them about the update.
- Notes are formatted with HTML and edited with a WYSIWYG editor.

Group Presentation

- Users can edit their group's presentation displayed within *TheHub*.
- The group presentation is formatted with HTML and edited with a WYSIWYG editor.

Supervisors

- CRUD operations for the supervisors assigned to the user's research group.
- Specific search for supervisors of the user's research group by name.
- Sorting of supervisors of the research group by creation date, name, supervised topics, status, or number of students interested in topics.
- View students with active bookmarks for areas and topics of the supervisors and the number of inactive bookmarks.

Reports

- Limited CRUD operations for the reports of the user's research group:
  - Reports can always be deleted and viewed.
  - The visibility of reports can be toggled.
  - Reports cannot be directly created. Instead, submission links for them can be generated and sent to a specified e-mail address with a customizable text.
- Specific search for reports of the user's research group by title, supervisor, and requester.
- Sorting reports of the user's research group by date, visibility, title, supervisor, or requester.

Past Works

- CRUD operations for the past works assigned to the user's research group.
- Generation of submission links for past works assigned to the user's research group.
- Specific search for past works of the user's research group by title, supervisor, requester, abstract.

- Sorting of past works of the user's research group by date, visibility, title, supervisor, and requester.
- Download of PDF files of past works if submitted.

Reflections

- Limited CRUD operations for all reflections
  - Reflections can always be deleted and viewed.
  - The visibility of reflections can be toggled.
  - Reflections cannot be directly created. Instead, submission links for them can be generated and sent to a specified e-mail address with a customizable text.
- Specific search for reflections by title and requester.
- Sorting of reflections by date, visibility, title, or requester.

Group Areas

- CRUD operations for the group areas of the user's research group (the area description is formatted as HTML and edited with a WYSIWYG).
- Specific search for group areas of the user's research group by name, supervisors, and topic.
- Sorting of group areas of the research group by creation date, name, status, or the number of students interested (active bookmarks).
- View students with active bookmarks for the group area and topics of the group area, and the number of inactive bookmarks.

Specific Topics

- CRUD operations for the specific topics of the user's research group (The topic description is formatted as HTML and edited with a WYSIWYG editor).
- Search for specific topics of the user's research group by title, supervisor, and thematic area.
- Sorting specific topics of the research group by creation date, title, thematic area, status, last update, status, or the number of students interested (active bookmarks).
- View students with active bookmarks for specific topics and the number of inactive bookmarks.
- All specific topics of the research group can be exported as JSON or CSV file.

Specific Topic API

Specific topics of the user's research groups can be requested by accessing an endpoint providing the topics as JSON.

This is a distinct endpoint to the export available in the administration interface for topics as it is implemented with a specific extension of the used framework for REST and provides, e.g., authentication with tokens. The motivation behind this is described in Section 8.5.13.

Metadata

Metadata for specific topics and group areas in the form of courses, technologies, and tags are managed on a single page split into three parts, one for each type.

This interface is shared between the users of all research groups.

- CRUD operations for metadata. Metadata can only be deleted if it is not used at all or only on specific topics or group areas of the user's research group.
- Filtering for metadata based on all properties and whether it is used by the research group of the user.
- Sorting of metadata based on name or usage count.
- Access to additional information about metadata: total and research group internal use count for specific topics and areas.

Events

- CRUD operations for events (The event description is formatted as HTML and edited with a WYSIWYG editor).
  - Events not assigned to a research group can be managed by all professor/-supervisor users.
  - Events assigned to a research group can only be managed by users of the respective research group.
  - Events can be copied.
- Searching for events based on event name and description.
- Sorting of events based on date, name, or type/scale.

Infopages

- CRUD operations for all infopages (The infopage content is formatted as HTML and edited with a WYSIWYG editor) – this interface is shared between the users of all research groups.

- Searching for infopages based on URL short and name.
- Sorting of infopages based on title, URL short, or recent edit.

Questions

- CRUD operations for all questions (The answer to questions is formatted as HTML and edited with a WYSIWYG editor) – this interface is shared between the users of all research groups.
- Searching for questions based on question and answer contents.
- Sorting of questions based on last edit, question content, or scale.

8.6.5 Authentication & Registration

- Registering/Account Creation – Users can register and create accounts. The e-mail address used for the registration has to be a student e-mail address of the University of Vienna.
- Account Activation – Users confirm their registration and activate their accounts by visiting a unique generated link sent to the student e-mail address used for the registration.
- Passwords can be reset – Users can send requests to reset their password.
  - To reset the password, the application generates a unique link and sends it to the e-mail address of the user's account.
  - At the link, a form is provided with which a new password can be set.
  - The generated password reset link can only be used once.
- Users can log in by entering their username and password. To access nearly all parts of the application, users must be logged in.
- Users can log out.

The authentication, registration, and account creation for professors/supervisors is described in more detail in Section 8.5.1.

9 Implementation

Chapter 9 aims to explain key aspects of the web application's implementation and the overall implementation process.

It firstly portrays the used technologies and frameworks as well as establishes their use in Section 9.1. Afterwards, Section 9.2 is dedicated to explaining how the Azure Cloud was used.

In Section 9.3 an explanation and motivation for the used Agile Software Development practices are provided. This is followed by a description of the overall implementation process in Section 9.4.

Finally, Sections 9.5 and 9.6 describe the implementation details of the Natural Language Processing functionalities and the built-in telemetry system respectively.

9.1 Used Technologies and Frameworks

This section gives a brief overview and reasoning for the frameworks and technologies used in *TheHub's* implementation.

9.1.1 Python

The probably first decision which had to be made is the choice of programming language. Many programming languages can be used to implement a web application. The most prominent ones for this use case are JavaScript, Java, Python, PHP, and Ruby, and they all offer excellent and established frameworks for web development. Previous knowledge was not really a factor, as the author was not distinctly experienced in one language or the other, especially regarding web development. All the possibilities were considered and briefly probed. The final choice fell on Python, as it:

- Has a syntax that is easy to learn and understand.
- Has a design philosophy that emphasizes code readability.
- Does not have as many "quirks" as, e.g., JavaScript.
- Provides many very useful built-in data structures, e.g., dictionaries.

Since Python cannot be used directly on the front-end (client-side), as it is only a back-end (server-side) language, JavaScript was also used for small interactive parts of the web application to make some aspects more responsive.

Python was also specifically chosen, as all its features make it pretty easy to learn and get into, therefore supporting the requirement of *"Ease of maintenance"* which was described in Section 7.3.

9.1.2 Django Web-Framework

The choice of Python as the programming language described in Section 9.1 above logically limits the selectable web development frameworks. Such frameworks handle many, sometimes even all, aspects of developing a web application such as database access, database management, routing, and security.

In Python, the two most popular web frameworks are Django[1] and Flask[2]. Both of them are free to use and open source.

After briefly looking at the respective documentations and available material of both frameworks, the choice fell on Django. The reasoning for that choice was that it comes with many of the required features already built-in, as it is a very high-level framework that officially describes itself as *"The web framework for perfectionists with deadlines"*. It heavily focuses on the fast and effective development of websites by helping developers take applications from concept to completion as fast as possible, security, and scalability. Especially a very well included ORM that also offers an automatically generated and easily adjustable database management interface made it very appealing.

In contrast to that, Flask is defined as a micro-framework. By itself, it only handles fundamental features. Everything else needs to be added manually by installing extensions. Much of these extensions add functionalities that Django has already officially built in. This results in Django offering a very extensive official documentation covering many aspects. In contrast, Flask's documentation is inherently more sparse, as it does not cover the extensions (they have separate documentations).

In addition to the functionalities that Django already has built-in, it also offers extension possibilities through apps that are the counterpart to Flask's extensions. Many such extensions were used in the scope of this project. They were especially useful for the front-end since Django only provides a template engine which inherently by itself is not very suitable for the implementation of interactive and responsive elements, for example, WYSIWYG editors.

Another reason which made Django a good choice was that it structures its code in a very modular manner. Therefore, later extensions and adjustments to the web application are greatly facilitated.

9.1.3 Relational Database - MySQL

A web application containing dynamic and persistent data inherently requires a database in which it stores the data and can access it from. For this project specifically, MySQL[3] was used as the Database Management System (DBMS).

[1] `https://www.djangoproject.com/`, accessed: 17/02/2022
[2] `https://flask.palletsprojects.com`, accessed: 17/02/2022
[3] `https://www.mysql.com/`, accessed: 17/02/2022

MySQL is a popular relational Database Management System (DBMS) that is open source. It was chosen for a variety of reasons over its numerous competitors:

- Previous experience and knowledge of the author.
- Directly compatible with MariaDB, which is the DBMS included in Apache XAMPP, which was used for local development and testing.
- A database service with MySQL is included in the Azure subscription provided by the faculty.
- It is directly supported by Django.

A relational DBMS was chosen over a non-relational one, as Django does not directly support non-relational database systems. While Django can utilize non-relational database systems by installing specific third-party apps, it is way more error-prone as it is not officially covered. Additionally, knowledge about relational DBMS is way more frequent as they are the still more established type. Specifically, every student of the CS and BI degree programmes offered by the University of Vienna must attend a course teaching relational DBMS and SQL. Therefore, to enable the web application to be easily maintainable and adaptable, it was a very logical and easy choice to opt for a relational DBMS.

9.1.4 Bootstrap

The Bootstrap[4] framework was used to make the web application's front-end responsive and facilitate its overall design and creation. It already provides most of the necessary Cascading Style Sheets (CSS) classes and JavaScript functionalities for interactive and dynamic elements.

Bootstrap is the most popular front-end framework and was chosen over competitors mainly because of previous experience and knowledge of the author, its thorough documentation and its giant community, which already answered most questions that could arise.

More precisely, Bootstrap 4 was utilized over the more recent fifth version that was available. This is because the older (fourth) version is still more established and more commonly supported by external Django applications. Additionally, much more information, material, and learning resources are available about it.

9.1.5 Back-End Template Engine

To generate the actual HTML pages displayed by the web application to its users, the default template engine directly included in Django was used. While it generally is powerful and supports, e.g., inheritance of templates to facilitate the template writing process, it is only truly great for creating static pages that do not have to change between page reloads, as the creation of the HTML document is handled purely by the server

[4] `https://getbootstrap.com/`, accessed: 17/02/2022

in the back-end and then sent to the user. Template engines, in general, are rather suboptimal for the creation of more dynamic web applications, dynamically loading their contents without having to reload the whole page through a HTTP request. To create such dynamic web applications, more advanced frameworks and libraries such as React and Angular exist.

Django could work with such a framework. It can also be utilized to serve as an Application Programming Interface (API) to an external and independent JavaScript application utilizing, e.g., React, and completely bypass any template engine. In fact, this would definitely have benefits. It would fully decouple the front and back-end. This would, for example, allow a dedicated specialized mobile app to utilize the same back-end instead of having tight coupling between the display on the front-end and the back-end logic.

The reason a back-end template engine was still chosen over a front-end framework is once again simplicity and because the web application was not deemed to need and utilize such highly dynamic and interactive elements that would actually require a more sophisticated front-end framework. Furthermore, using a dedicated front-end framework and using Django only as an API has other negative side effects that would not only complicate the implementation process itself:

- Besides the front-end itself being more complex, it would also have a massive impact on the Django back-end. To utilize Django as an API, an external app has to be installed, greatly changing the way Django is used. This would mean forgoing many of the highly beneficial included functionalities as well as great extensive documentation and material available.

- Maintainability and adaptation of the web application would be more difficult. Dedicated front-end frameworks need some time to get acquainted to. In comparison, even without specific prior knowledge, templates are pretty intuitive and easy to adapt.

- Automated testing employing unit tests would not be possible for the front-end. If the Django template engine is used, unit tests can be used to directly check the contents of the generated HTML documents alongside other back-end aspects. This is not the case if Django only serves as an API for a dedicated front-end app.

9.2 Azure Cloud Deployment

The way deployment on the Azure Cloud is achieved is rather straightforward. In essence, it consists of only two resources.

The first resource is an App Service. This App Service runs the Django application and deploys the web application on the internet. Furthermore, the service enables very useful features such as Continuous Integration (CI)/Continuous Deployment (CD), which was also used in this project and is further described in the next section of this chapter. Azure handles many aspects that otherwise need to be configured manually. For example,

the deployed web application can be directly accessed by a URL and even automatically has a valid HTTPS certificate.

The other required resource is an Azure Database for MySQL server, which provides the relational database used by Django running in the App Service. A regular Virtual Machine (VM) resource can replace this database resource. In this case, however, much more manual configuration is required without offering many benefits, as the cost is almost the same for a comparable amount of computational resources.

Both the required resources can be hosted locally as well. Azure is by no means required, but it simplifies the whole process a lot, especially when it comes to aspects such as deployment. In the long term, it might be worth considering hosting the relational database locally and connecting it to an Azure App Service. The reasoning for this is that the database resource provided by Azure is pretty expensive compared to the app service.

To deploy the Django web application on Azure, one firstly needs to create a database within the Azure database resource, as it provides a full Database Management System and not a singular specific database. This step inherently requires the database resource to be created beforehand. Afterwards, the Django settings need to be correctly set to define that the web application utilizes the previously created database of the Azure database resource. This is achieved by putting in the correct engine driver and name of the database created within the database resource, along with the username, password, host, and port. These values are visible in Azure and defined by the respective Azure database resource. Additionally, the SSL certificate needs to be downloaded from Azure and referenced, as the web application will otherwise not be authorized to use the database.

After correctly configuring the Django settings, the app service can be created. For the app service, it is necessary to select the correct runtime environment (Python). The other necessary input is rather arbitrary, e.g., the name of the application. After creating the resource, the code of the web application has to be uploaded. Ideally, this is done by directly connecting a compatible Git-repository provided by, e.g., GitHub. However, it can be performed by uploading the code as a zip package or with FTP as well. Nonetheless, connecting it directly with a repository, should be preferred as it provides and enables the use of CI/CD. After the connection with the repository has been established, a file is automatically pushed to the repository. This file defines the pipeline tasks to be performed after each commit to deploy the application code on Azure. The file might need to be adapted before attempting to deploy the application code to ensure that it automatically installs all requirements. In this case, those requirements are mostly Python packages. Afterwards, if all pipeline stages are completed successfully, the application is automatically deployed after each commit, and the web application can be accessed through an URL on the internet.

9.3 Agile Software Development Practices

As already mentioned in Chapter 4 an emphasis was put on trying to follow modern Agile Software Development principles and practices as well as possible as a team consisting of only one person. This section is dedicated to explicitly explaining the used practices in

more detail.

9.3.1 Test-Driven Development (TDD)

Tests were written and performed regularly all throughout the implementation process. Generally, when wanting to add functionalities to the web application in development, tests they should pass were written beforehand or directly afterwards. If a bug or error was discovered at any point in the implementation process, a test was subsequently written deliberately causing and reproducing it. After fixing the bug/error later, this test was used to check whether the bug/error has been resolved.

The TDD approach was greatly supported by the Django framework. It includes a unit test suite specifically designed for it. It was even possible to test front-end related aspects directly within the unit tests due to sticking to the included template engine for the front-end and not resorting to a dedicated front-end application framework.

In the end, 1220 tests were written covering almost all parts of the web application. Some more interactive parts of the front-end are not automatically tested, as it would require the application of a more advanced test framework (e.g., Selenium) specifically designed to handle such interfaces. The use of such a framework was deemed out of this project's scope since it would require significant additional preparation. Furthermore, the used CI/CD pipeline, further described in the following Subsection, does not support such tests.

While indeed being very time-consuming initially, TDD resulted in the web application having a very extensive test suite, enabling thorough automatic testing at any point. The tests can be run as a stage of the CI/CD pipeline as well, which would further automate their execution. The considerable emphasis laid on automatic testing is further beneficial. It not only greatly increases the ability to maintain the system later on, but also ensures a high-quality result, since bugs and errors get eliminated very early on. Additionally, bugs and errors are almost guaranteed not to reoccur since the tests should adequately cover and detect them.

9.3.2 CI/CD

A Continuous Integration (CI)/Continuous Deployment (CD) pipeline was utilized all throughout the development process. This pipeline ensured that after every commit to the git-repository, which at the processes peak, was made at least every day, the most current source code was directly deployed on the used Azure App Service and the internet.

The pipeline itself was defined with a YAML file describing its workflow, performed with GitHub actions. These actions first set up the web application's runtime environment and install all the requirements, for example, the Django Python package. After setting up the environment for the web application, the code is downloaded from GitHub and consequently uploaded to the Azure App Service. Finally, the web application is started within the app service, completing the integration and deployment stage.

CI/CD allowed the most current version of the application to be accessible on the internet without additional effort after it was set up. This effectively enabled the practice

of incremental development described in the next Subsection. Furthermore, it was paramount for the inclusion of the users in the web application's development and later design process.

The CI/CD pipeline, as mentioned in the previous Subsection, can be greatly used in conjunction with TDD. The pipeline can include a stage during which the tests are run concurrently on many runtime environments (Python versions). Should any test of this suite fail, signalizing an error was detected, the pipeline is stopped, and the code not deployed. However, in the scope of this project, the pipeline did not include this additional stage. The tests take a long time, especially if executed multiple times, and thus consume many (limited) GitHub Action credits. To compensate for this, the test suite was manually executed locally before each commit.

9.3.3 Incremental Development

Development of the web application was rather incremental because each successive version was directly usable and accessible from anywhere on the internet. This was greatly facilitated by the CI/CD pipeline and the TDD approach. Furthermore, commits were made very frequently, leading to more vertical increments in functionality instead of horizontal ones where a new version adds complete components.

This iterative and incremental development process, which was directly visible from the outside, was used to gather feedback from stakeholders all throughout the implementation process. This feedback was responded to, and, if necessary, adaptations to the application's functionalities were performed.

9.4 Implementation Process

To prepare for the implementation process, Django and JavaScript for web development were initially studied by following tutorials and going over the Django documentation. This was done to gain the basic knowledge required for the upcoming implementation work. Afterwards, the basic setup for the implementation was done, meaning installation of the required dependencies, the correct configuration of an Integrated Development Environment (IDE) and a project within it as well as the creation of a git repository.

The used IDE was PyCharm by JetBrains. PyCharm is a Python IDE providing plugins with which the creation of Django web applications is greatly facilitated and supported. Azure DevOps initially provided the used git-repository. However, as Azure DevOps weirdly did not offer CI/CD support for the Azure App Service used later, the repository was transferred to GitHub. To not depend on Azure during development and to perform tests locally quickly, a local database (MariaDB) and management interface (phpMyAdmin) for it were used. The database and interface were part of XAMPP, a program package that is very quick and easy to install. It aided in locally testing and deploying the application.

Most of the implementation was done from early June to the start of December 2021. More minor, earlier parts were conducted in spring of the same year. The last finishing

touches were performed in late January 2022.

Once a base was established, the first fully implemented aspect was the administration interface. After creating the administration interface, dummy test data was inserted. This data was later on used during the implementation of the more student-oriented functionalities. There, the first implemented functionalities were the ones deemed most important, such as the lists for topics and areas.

During the whole implementation process, new knowledge was gained about Django and web development in general. This led to the fact that some parts had to be refactored or improved based on the newly acquired knowledge. As already mentioned in Subsection 9.3.1 the creation and execution of tests was done constantly throughout development. However, more knowledge and improvement ideas based thereon were not the only reason for going back and improving as well as refactoring previously created code, as stakeholder feedback also led to this action.

Generally, a huge emphasis was placed on clearly structuring the code, overall adhering to best practices and guidelines (e.g., for naming), providing a docstring based documentation and writing comments in the code to increase its readability wherever needed. The intention behind this was to allow others to easily get acquainted with the code to possibly take over the project and perform necessary maintenance later on.

9.5 Natural Language Processing & Search Agent

As the previous chapter mentioned, the web application allows students to find topics similar to a chosen one based on topic titles and descriptions. To calculate the similarity between a topic and all other currently active topics Latent Semantic Analysis (LSI) is used.

LSI, as established by Deerwester et al. [DDF+90], is an information retrieval technique used to analyse the relationships between documents in a set and their contained terms. It firstly creates a matrix, where each row represents a word contained in the set of documents and each column represents a document. The values within the matrix are then the number of occurrences of that word within the document. In order to reduce the number of rows/words while still preserving the similarity structure between the documents/columns SVD is used. The reduction of rows/words leads to its beneficial feature that it combines them to so-called concepts. These concepts can span multiple related words and detect similar documents even if they do not share any identical words. To calculate similarities, the cosine similarity between any two columns/documents is calculated.

Before LSI is performed, the web application combines the title, description, and other additional information of a topic into a string for each topic. This string serves as the document representing that topic for the LSI. Since topic descriptions are not just text but rather consists of HTML elements created by the WYSIWYG editors in the application, the data gets preprocessed. This preprocessing consists of removing the HTML tags and other non-useful content for the LSI, e.g., links.

In order to increase the size of the document set and increase the accuracy of the scores

calculated by the LSI, group area information and past work abstracts are also included in the document set. Much like the topics, they are also correspondingly preprocessed.

After preprocessing the documents, they get tokenized, meaning that out of the strings, corresponding arrays are constructed containing the words of the documents. Subsequently, the tokens get stemmed to identify words based on their word stem and cleaned from stopwords. The stemming and stopword removal is achieved using an external stemmer and stopword collection. Both of them are part of the open-source Natural Language Toolkit (NLTK) Python library collection.

Now the token arrays are ready to be used by the LSI, whose implementation is provided by the open-sourced Gensim Python library. The LSI returns a list of similarity scores between -1 and 1. This list is then enumerated by its indices, denoting the documents, and sorted descending to identify and retrieve the most similar documents quickly.

The search agent used for the keyword-based search utilizes the same LSI implementation and does the same preprocessing. However, it considers all types of documents to recommend research groups and ranks the groups based on points. These points are given to research groups by having a group area or specific topic within the top eight most similar (to the entered keywords) ones. Past works also give points if they are within the top ten per cent of most similar documents. Besides using the topics and group areas for determining which research groups to recommend, the keyword-based search argent also returns the four most similar topics and three most similar areas as recommendations to the user. However, to not make bad recommendations, topics and areas are only recommended if their similarity is above a certain threshold.

Generally, the LSI implementation and the keyword-based search argent are implemented rather naively and therefore not fully optimized. This is because it was not the actual focus of this project. There was also simply no adequate dataset of appropriate size that would enable thorough testing and fine-tuning.

9.6 Telemetry

The built-in telemetry system described in Section 8.5.15 is implemented employing a Django Mixin. A Mixin is basically a class adding functionality on top of any view related method of a Django class-based view, which is achieved by the inheritance of classes supported in Python.

Almost every functionality targeting students within the web application is, in essence, a Django class-based view, inheriting from this telemetry mixin. This easily adds the telemetry functionality to each one of them. Additionally, the mixin does not only allow to add it to any of the class-based views easily, but also enables that the way the data is logged and how can be quickly changed. These changes can be performed by modifying the code of just one class (the telemetry mixin). The inheriting class-based views then automatically receive these changes as well.

This mixin functionality is one great example of how Django simplifies creating web applications. Django by itself already provides many premade mixins. These mixins can, for example, be utilized to easily specify that a functionality (a class-based view) can

only be accessed by logged-in users. Additionally, the basic functionality, which is based on the inheritance of these mixins, is also used in Django to define view-classes. These view classes provide premade basic functionalities, solving common tasks such as form submission or listing of objects.

The telemetry is collected when calling a student targeted class-based view. This happens when a request for an URL is made, which is mapped to one of the views targeted to students. In its current form, the collected data is:

- The **user** who made the request. In order to not violate the privacy of students, the username is hashed.
- The **timestamp** of the request.
- The used **HTTP method** of the request.
- The **name of the called view**, to easily identify what functionality was used.
- The **full path** of the request, to fully capture used HTTP GET-parameters which are used when searching, filtering and sorting data. When exporting the data, the GET parameters are extracted from the path and made available as name and value pairs.

The collected telemetry data is stored in the relational database and can be exported as CSV or JSON file by authorized users (professors/supervisors). Should the telemetry collection not be desired, it can be disabled by changing a variable in the settings file.

9.7 Code Availability & Repository

The repository containing the source code for *TheHub*, dummy data, and a README-file with further explanation can be found on the GitLab server of the University of Vienna, Faculty of Computer Science at `https://git01lab.cs.univie.ac.at/thesis/2021ss/01621899-niko-motschnig`.

10 Quality Assurance

This chapter aims to provide an explanation of how the quality of the resulting design and implementation of the web application (*TheHub*) is ensured.

It is split into three sections. The first one focuses on the evaluation methods of Design Science [HMPR04]. Subsequently, the second section explains how critical evaluation as part of the Design Thinking [Pre18] methodology was performed. Lastly, the third section describes how telemetry data provides great evaluation possibilities of the web application later on.

10.1 Design Science Evaluation Methods & Guidelines

As already briefly mentioned in Chapter 3 and 4, Design Science evaluation methods and guidelines, as proposed by Hevner et al. [HMPR04], were utilized and followed to ensure the quality of the resulting web application.

Testing of the implemented web application was performed with unit tests that were constantly written all throughout the implementation process as part of a Test-Driven Development approach. The TDD approach was described in more detail in Section 9.3.1. The final test suite, consisting of 1220 unit tests, covers both functional (black box) aspects and structural (white box) ones. The test suite targets nearly all aspects of the implemented web application. The tests contained in the suite are also fully automated and can be performed at any time through a single command.

Experimental Evaluation Methods are partially covered, as *TheHub* was available online and functional with dummy data, thus fulfilling the evaluation method of Simulation. Controlled experiments, for example, a usability study, were not performed. They would require a significant amount of effort as well as participants to perform in a meaningful and proper way, which was deemed as out of the scope of this project.

Descriptive Evaluation Methods, such as informed arguments building a convincing argument for *TheHub's* utility and exemplary scenarios directly demonstrating it are provided and presented throughout Chapter 8, especially in Section 8.5, to justify the design decisions made and the implemented features.

Some Design Evaluation methods, as presented by Hevner et al. [HMPR04], were, however, not covered.

Specifically, **Analytical Evaluation Methods** were one of the not covered methods, as they were perceived to be not quite applicable in the context of this project. The reasoning for the analytical methods being deemed non-applicable was a lack of measurable qualities that could be interpreted meaningfully concerning reference values. However, an architectural analysis studying the fit of the web application into the technical architecture

is somewhat replaced by parts of Chapter 8, specifically Section 8.5.13. There a detailed explanation is provided for how *TheHub* is designed to be directly usable as well as complement and build on top of the current system for displaying currently issued topics.

Additionally, **Observational Evaluation Methods**, such as a thorough case study, were not performed. While a case study would definitely make sense and provide a very meaningful evaluation of *TheHub*, it was deemed as impossible to conduct in the scope of this Master's thesis project. Such a case study would need to be performed in a particular timeframe, the start of a semester. In addition, it would require much setup, as *TheHub* would need to be deployed in a production environment and, most importantly, be filled with real data. Additionally, the case study would only be effective if multiple research groups agree on using and therefore testing *TheHub*. This is something that cannot be achieved quickly, as it would furthermore initially require all the groups and involved professors/supervisors to become acquainted and familiar with *TheHub*. Inherently, such a case study would need to be conducted within an extended period as well in order for it to produce reliable insights.

In addition to using Design Science evaluation methods, a focus was laid on following the seven Design Science research guidelines also proposed by Hevner et al. [HMPR04] to create an artefact of high quality. The respective Guidelines are briefly described in Section 3.2.

10.2 Design Thinking

Since Design Thinking, as described by A. Pressman [Pre18] and T. Brown [Bro08], is a more general methodology, it does not specify concrete evaluation techniques and methods. Instead, it generally emphasizes critical evaluation. However, this critical evaluation should not just be performed at the end of the project, but throughout it, as the Design Thinking building blocks are not passed iteratively and linearly but rather repeatedly in a loop. The building blocks of Design Thinking, as proposed by A. Pressman [Pre18], were briefly introduced and explained in Section 3.1.

Furthermore, this critical evaluation is not achieved by any specific techniques or methods, but by actually constantly exposing the work to criticism and feedback given by people with various backgrounds, skill sets and especially points of views. This feedback and criticism should be used constantly to refine, eliminate or come up with ideas regarding the design and solution to be produced and overall be integrated in real time. Secondly, besides external feedback and criticism, Design Thinking highlights the importance of self-criticism, which should be conducted thoroughly throughout the design process as well.

This aspect of being able to receive and integrate feedback constantly was possible in the scope of this project thanks to *TheHub* being easily accessible on the internet from a very early stage on. The early accessibility was possible through the CI/CD pipeline, further described in Section 9.3.2, and the Azure Cloud hosting the application. The application being online was used to actively invite the involved stakeholders to give feedback at any time. Additionally, even earlier in the design process, at the stage of the qualitative

interviews, ideas for features were discussed and refined with the interview participants. An emphasis was also placed on self-criticism, which was constantly practised during the project. Therefore, many of the implemented aspects, features, and characteristics of *TheHub* are the actual result of and emerged from an evaluation process that was ongoing all throughout the project and ensured their respective quality.

To further ensure the quality of the developed solution and to offset the lack of well established and more concrete evaluation methods in Design Thinking, Design Science evaluation methods and guidelines, primarily focusing on IT artefacts, were additionally followed. Their utilization was described in the previous subsection.

10.3 Telemetry Data

As already mentioned in Subsection 8.5.15, *TheHub* has a built-in telemetry system which is very flexible. In its current form, this system collects data about how students use the application by logging their activities based on their requests. The collected can then be accessed easily by authorized users (professors/supervisors).

In the scope of this Master's thesis project, the telemetry data was not used for evaluation purposes since this would require the conduction of an extensive case study or an experimental deployment for at least a semester. This, as substantiated in the previous subsection, was not deemed feasible in the scope of this project.

However, even though not being directly usable in this project's scope, the built-in telemetry system was designed and implemented to significantly enable detailed and thorough evaluation possibilities later on.

For example, the collected and provided telemetry greatly lends itself to be used within a large case study. In such a study, the telemetry data could prove very useful for monitoring and evaluating the web application instead of relying solely on interviews and observations. However, besides being used in a case study, the telemetry data could also be used for evaluation at any time after the actual deployment of the web application.

Furthermore, in addition to the higher-level telemetry data provided by *TheHub*, the telemetry data automatically collected and provided by the Azure App Service on which *TheHub* can be run could also be used for a more detailed analysis of how the application performs regarding, e.g., performance. In some aspects, the Azure data could be used for the same purposes as the earlier mentioned one provided by *TheHub*, to, for example, find out when students start using it or when peak loads are. However, in this case, this can only be achieved if the web application is hosted on Azure, which is not necessarily the most reasonable solution, as it generates constant monthly costs and is not really necessary. The University can provide a Virtual Machine with enough computing power to host the application as well. Therefore, the built-in telemetry system enables these evaluation possibilities independently of the hosting platform used. This explicitly removes any dependency regarding evaluation on Azure.

11 Discussion

In this chapter, the potential impacts of this project, its limitations, as well as possibilities for future work are briefly described and discussed.

11.1 Impact

Whether this project will have an actual significant impact cannot be said, as it is unsure if *TheHub* is actually going to be used. If *TheHub* ends up being used by multiple research groups, ideally and hopefully even all of them, this already is a tremendous and significant result. This significance stems from the most considerable difficulty of this project being the creation of a shared basis that is acceptable and usable by all the research groups by respecting their individual views and ways of handling the topic issuing process, all the while creating a better and more uniform representation of topics for students. In addition, this shared basis and better representation should not cause any additional effort for any of the research groups and professors/supervisors.

Assuming the application does get utilized, it can be expected to greatly improve the students' experiences of searching for a topic to pursue in the scope of an academic project. The application could also enable students to make more meaningful, well-informed and better decisions. Overall, both aspects should lead to better outcomes for professors/supervisors and students alike.

Besides aiding students in their decision-making process, *TheHub* additionally aims to support them subsequently while performing the academic projects by additional functionalities, such as further compiling relevant information.

Professors/Supervisors would also profit from using *TheHub*. It facilitates the process of issuing and managing topics significantly by reducing the effort needed to do so, and provides further useful functionalities.

Additionally, the improvement suggestions proposed in Section 6.3.5 should also improve the overall process of academic projects by generally aiding students in their decision-making process. *TheHub* is designed to support the implementation of these suggestions wherever possible by, for example, explicitly providing the functionality to advertise group-specific meetings. By following the improvement suggestions, students should start their topic search process way earlier and be supported throughout this meaningful process in *TheHub*.

Furthermore, while *TheHub* was developed purely with the situation at the Faculty of Computer Science of the University of Vienna in mind, it might also be useful to other faculties or possibly even universities. There are some CS specific aspects in the design, such as technologies to describe topics or the possibility of attaching code repositories to

past works. However, these aspects can easily be removed or changed to fit a variety of other contexts, since they are in no way essential for the application's core functionality. Even if the provided implementation in the scope of this work is not directly usable, the general design and the ideas behind it should, at the very least, prove themselves beneficial.

Lastly, the methodologies used in the scope of this work, especially the overall Design Thinking approach, including some aspects of Design Science and the inclusion of qualitative and agile methods, to firstly truly gain an understanding of the problem and then develop a fitting solution for it, proved to be very appropriate for tackling the complex problem at hand and arriving at a hopefully truly usable solution in the shape of *TheHub*. Therefore, this work may demonstrate their usefulness and ideally motivate their use for other projects.

11.2 Limitations

As already primarily described in the previous chapters, this project has inherent limitations.

Firstly, the qualitative study, topic of Chapter 6, had its own limitations discussed in Section 6.3.4. Briefly summarized, they lie in the study's explorative nature, the fact that the interviewed students emerged in hindsight to all be quite well-performing, therefore leading to the not proper representation of less well-performing students, and lastly its resource, especially time, limitations as it was only one more minor aspect of this project that definitely proved to be worthy of being an independent work on its own.

Additionally, limitations were also faced due to the lack of official support and approval mentioned in Section 5.1. Due to student data not being accessible, some features could not be implemented. For example, it was not possible but definitely would have been beneficial if *TheHub* could retrieve finished courses of students and filter topics based on this information.

Another feature that also partially fell victim to this limitation was the ability to automatically suggest assignments of topics to students, as requested by some professors/-supervisors. Without access to student data, there is no way, not causing great additional effort, to limit only students actually qualified for topics of a specific scope to register for them. Subsequently, ways to make this assignment more meaningful, such as taking into consideration courses visited by students, were heavily limited by not having access to official student data.

Furthermore, the lack of official support leads to other limitations besides the student data not being accessible. This lack of support means that *TheHub's* proper use cannot be centrally recommended, and that there are no resources officially dedicated to its maintenance and adaptation later on. This implied that the web application had to focus intensely on voluntariness and optionality[1] to enable it to be acceptable by all groups and make it act on a rather high-level independent of organizational details, which, if

[1] As motivated by the design objective of *"Voluntariness & Complementation"* described in Section 8.3.3.

changed, would necessitate an adaptation. The last point, especially, inherently limits feature possibilities, such as the aforementioned automatic assignment of students.

Lastly, as described in Chapter 10, the evaluation of the web application was somewhat limited as well. There was no case study or controlled experiments conducted because of time limitations of this project. This additionally means that the telemetry data collectable by the built-in telemetry system was also not utilized, since there was no actual real-world data collected about *TheHub's* use.

11.3 Future Work

Regarding future work, many directions are conceivable.

The explorative qualitative study described in Chapter 6 opens up many possibilities. Examples of possibilities would be follow-up studies with a more focused research question, possibly with a different quantitative approach, or simply an extended version of the study with a higher number of more diverse participants. The future work possibilities emerging from the study are described further in Section 6.3.4.

TheHub lends itself greatly for future work as well. It could be extended by more specific functionalities, especially if at some point it received official support and consequently access to student and professor/supervisor data. One of such possible features, currently not implemented, mainly due to being difficult to achieve without student/supervisor data and not aiding the goal of creating a shared basis for all research groups, is the possibility of automatically performing the student to topic/supervisor assignment if desired. Another direction in which *TheHub* could be extended when official support is achieved is supporting the actual process of submitting a Master's thesis topic. This submission process is currently a rather manual process that lends itself to being streamlined too. Experimentally, some of the other ideas that emerged could also be explored further or even tried out, for example, enabling students to issue their topic ideas and be actively contacted by professors/supervisors.

Another potential improvement for *TheHub* would be to allow it to be connected to the Moodle learning platform, and, e.g., directly read data for future events from Moodle courses. This way, professors/supervisors do not have to enter these events manually.

Additionally, *TheHub's* purpose, which currently partially lies in connecting students to potential supervisors and topics in the scope of academic projects, could be moved into a more general direction. As one of the professors/supervisors suggested, it could act as a tool to generally connect supervisors/professors and students outside of courses. An example of how this connection could be made and utilized is to provide functionalities to find potential tutors for courses.

Furthermore, the Natural Language Processing functionalities of *TheHub* could not only be extended, but be refined greatly as well. In their current shape, they are implemented rather naively and rudimentary. This most likely opens possibilities to increase their performance and efficiency as well as effectivity significantly.

Inspired by the considerable emphasis that most students put on supervisors in their search process, a further extension possibility of *TheHub* would be to expand on the current

personal text for professors/supervisors and generally expand the way they are portrayed in the application. This can, for example, be done by enabling professors/supervisors to optionally create profiles, similar to the optional individual presentations of research groups, and adding photos.

Lastly, as already stated in the previous Chapter 10, a more detailed and thorough evaluation employing observational and experimental evaluation methods is outstanding. Therefore, a field study supported by the telemetry system of the application to observe and investigate how *TheHub* is used in a real-world context or extensive controlled experiments to perfect the usability of the application could be very valuable. Both of these activities would provide valuable insights that could be used to improve *TheHub* further. Conduction of a field study would inherently also mean that *TheHub* would need to be deployed in production within the university, rather than only being experimentally available on Azure. This in itself forms a substantial future effort.

12 Conclusion

This chapter concludes this work by providing a summary in the first subsection and subsequently containing a personal reflection of the author in the second subsection.

12.1 Summary

Deciding on a topic to pursue in academic projects, such as practical courses or theses, is probably one of the hardest decisions students have to make during their studies. Especially for larger projects, such as the Master's thesis, making the best and most informed decision is highly important to students as they have to invest a significant amount of time and effort into them.

At the Faculty of Computer Science of the University of Vienna, the processes of searching for and issuing topics are handled rather suboptimally for professors/supervisors and students alike. Each research group issues topics differently and uniquely on their individual web page. Likewise, updating the issued topics in these web pages is made rather difficult as doing so is based purely on the editing of text.

To face these difficulties and challenges, the core research question of this Master's thesis project was *"How can students be supported in finishing their theses successfully, especially how can a software solution help them find a suitable topic and supervisor?"*. The software solution aiming to address this question is an innovative web application named *TheHub* that was designed and implemented in the scope of this project.

TheHub aims overall to improve the process for students and professors/supervisors alike. This is achieved in many ways, firstly by providing a shared basis between the research groups and supporting the topic search and issuing process on a relatively high level in a way that is compatible and a valuable addition to the current process. A high emphasis was put on creating a solution that can truly be utilized and accepted by all the research groups, supporting and respecting their different individual approaches while still combining them meaningfully. Through this combination, *TheHub* provides students with an interface to search, filter, and sort topics as well as gives them much additional information about, for example, research groups and supervisors. *TheHub* aims to aid students in their search process, all without generating required additional effort by professors/supervisors.

Professors/supervisors also profit from *TheHub's* use to motivate its actual utilization. This is primarily achieved through an accessible admin interface that allows managing and adding topics easily. In addition, this interface sets out to provide additional beneficial functionalities.

The overall project employed a Design Thinking [Pre18, Bro08] methodology supported

by well-established guidelines and evaluation methods from Design Science [HMPR04] to ensure further the quality of the IT artefact produced in the form of a web application. The implementation itself was conducted with a focus on modern technologies and practices, mainly inspired by agile software development [CLC03, TH19]. In the implementation, a focus was also placed on ease-of-maintenance. This was done to enable *TheHub* to be easily adaptable as well as extendable, and therefore as future-proof as possible.

To inform the design and development of *TheHub* an explorative qualitative study [Yin15] was conducted. The interviews conducted as part of this study were also used to gather requirements and wishes for the web application, discuss already emerged ideas as part of the Design Thinking process, and overall gain a better understanding of the current processes of topic search and topic issuing.

Additionally, participants with relevant experiences at other universities were asked about how the process of topic issuing and searching was handled there. This part of the interviews, combined with additional separate interviews with professors/supervisors from other universities, was used to conduct a small international comparison. The goal of this comparison was to understand how this process is handled elsewhere to additionally inform the overall design process and generate ideas.

The qualitative study revealed many interesting aspects that could form a starting point of further inquiry. It especially showed how differently the practical courses and Master's thesis, as well as related aspects, are perceived by the different professors/supervisors. Furthermore, the study provided significant insights about the search processes and preferences regarding project topics of different students.

Lastly, to further answer the core research question, the aforementioned qualitative study and international comparison were used to propose improvement suggestions regarding the overall Master's thesis process at the University of Vienna, Faculty of Computer Science.

12.2 Reflection & Lessons Learned

Looking back at this project, it was definitely long-lasting. I must admit that I definitely underestimated the required effort to conduct a proper qualitative study. One aspect of this I especially underestimated was the difficulty of being a good interviewer and evaluating the interview transcripts as unbiased as possible. As such, I definitely gained more respect towards these aspects of research and disciplines commonly utilizing them. Another underestimated aspect was the difficulty of putting ideas and thoughts into a well-understandable and structured written form.

However, while being long-lasting and pretty strenuous, I would confidently say that it was an overall very valuable experience. I still fully support my topic choice, even though it might have taken way more time to finish this project than I initially had planned. During this project, I learned a lot about web development, feel very confident in utilizing the technologies and frameworks that I used to implement *TheHub* and overall feel like my programming skills improved. In addition, I believe that my English writing skills improved dramatically during the writing of this thesis. Overall, I had much autonomy

in this project, was able to work on a problem I care for and even provide a potential solution to it. This especially was really motivating.

The qualitative study also was an interesting experience. It enabled me to delve into and become knowledgeable about a type of research very unknown to me. Despite it being way more time-consuming than I initially thought, I still feel that it was instrumental and probably even necessary for this project. It truly allowed me to understand the respective stakeholders and the current situation and enabled me to develop a solution that I deem to be very appropriate.

Additionally, through the aforementioned conducted interviews, I think I greatly refined my skills of being a good and confident talk partner and listener. It was really motivating as I noticed my improvements in that regard after each interview, especially after transcribing them later on.

The aspect that surprised and impressed me the most was how valuable it was to discuss and generate ideas with all the interview participants openly. I feel like each one of them was able to contribute something, and the accumulation of all these contributions is something I would never have been able to come up with on my own, leading to a truly special result.

Regarding aspects I would have done differently in retrospect, I think I firstly could have done a better job at personal time management. Additionally, I probably should have worked more on the written part of the thesis during the qualitative study and the implementation phase, which I wanted to do but somehow still ended up mostly doing it separately. I had many ideas and thoughts during the overall process, and I cannot help but feel that a significant part of them was somewhat lost, as it was difficult to recall them afterwards. I was also not as diligent in writing notes as I would have liked to be.

Overall, I genuinely like and am proud of the results of this Master's thesis project. I hope that it can help future students by improving the current situation and actually have an impact.

Bibliography

[ABCP18] Carmen Aina, Eliana Baici, Giorgia Casalone, and Francesco Pastore. The economics of university dropouts and delayed graduation: A survey. *Labor: Human Capital eJournal*, 2018.

[ABM17] Ishrat Ahmad, H Bakht, and U Mohan. Cloud computing–a comprehensive definition. *Journal of computing and management studies*, 1(1):8, 2017.

[ABRK15] Rouhollah Askari Bigdeli, Ali Rahimi, and Ali Kazemi. Master's thesis writing: Cinderella of Iranian ELT education. *Journal of Research in Applied Linguistics*, 6(1):28–39, 2015.

[ÅSEKN16] Eva Svärdemo Åberg, Ylva Ståhle, Ingrid Engdahl, and Helen Knutes-Nyqvist. Designing a website to support students' academic writing process. *TOJET the Turkish online journal of educational technology*, 15(1), 2016.

[ASRW17] Pekka Abrahamsson, Outi Salo, Jussi Ronkainen, and Juhani Warsta. Agile software development methods: Review and analysis. *arXiv preprint arXiv:1709.08439*, 2017.

[ATH06] Nicholas Abercrombie, Bryan Turner, and Stephen Hill. *The Penguin Dictionary of Sociology*. Penguin Books, Jan 2006.

[BB06] John Bitchener and Helen Basturkmen. Perceptions of the difficulties of postgraduate L2 thesis students writing the discussion section. *Journal of English for academic purposes*, 5(1):4–18, 2006.

[BB20] Bakhou Boufeldja and Bachir Bouhania. A qualitative inquiry into the difficulties experienced by Algerian EFL master students in thesis writing: 'language is not the only problem'. *Arab world English journal*, 11(2):243–257, 2020.

[BBVB+01] Kent Beck, Mike Beedle, Arie Van Bennekum, Alistair Cockburn, Ward Cunningham, Martin Fowler, James Grenning, Jim Highsmith, Andrew Hunt, Ron Jeffries, et al. Manifesto for agile software development. 2001.

[Bro08] Tim Brown. Design thinking. *Harvard business review*, 86:84–92, 141, Jul 2008.

[CLC03] David Cohen, Mikael Lindvall, and Patricia Costa. Agile software development. *DACS SOAR Report*, 11, 2003.

[DDF+90] Scott Deerwester, Susan T Dumais, George W Furnas, Thomas K Landauer, and Richard Harshman. Indexing by latent semantic analysis. *Journal of the American society for information science*, 41(6):391–407, 1990.

[DR08] Edward L Deci and Richard M Ryan. Self-determination theory: A macrotheory of human motivation, development, and health. *Canadian psychology/Psychologie canadienne*, 49(3):182, 2008.

[GLH] Leo Gürtler Günter L. Huber. AQUAD8. `http://www.aquad.de/en`. Accessed 06/07/2021, Version 8.2.2.

[Hac20] Claudia Hackl. *Studienstillstandsbefragung Informatik-Master-Studierender der Universität Wien als Grundlage für die Entwicklung von hochschuldidaktischen Maßnahmen zur Studierendenaktivierung*. Wien, 2020.

[Hat19] Red Hat. What are cloud services? `https://www.redhat.com/en/topics/cloud-computing/what-are-cloud-services`, Dec 2019. Accessed 10/12/21.

[Heu14] Ulrich Heublein. Student drop-out from German higher education institutions. *European journal of education*, 49(4):497–513, 2014.

[HMPR04] Alan R Hevner, Salvatore T March, Jinsoo Park, and Sudha Ram. Design science in information systems research. *MIS quarterly*, pages 75–105, 2004.

[HSSS05] Ulrich Heublein, Robert Schmelzer, Dieter Sommer, and Heike Spangenberg. Studienabbruchstudie 2005. *Die Studienabbrecherquoten in den Fächergruppen und Studienbereichen der Universitäten und Fachhochschulen. HIS–Kurzinformation Nr. A*, 1, 2005.

[Hug01] Peter Hughes. Developing independent learning skills. *Implementing Skills Development in HE: Reviewing the Territory, University of Hertfordshire*, pages 11–12, 2001.

[Iva21] Sarah Ivan. Qualitative data analysis: 7 things you need to know to get it right. `https://www.nichq.org/insight/qualitative-data-analysis-7-things-researchers-need-know-get-it-right`, Nov 2021. Accessed 10/12/21.

[Jon05] Kathrin Jonkmann. Studienabbruch, studiendauer und studienerleben. *Analyse der Studierendenumfrage des Instituts für Informatik der Humboldt-Universität zu Berlin*, 10:16, 2005.

[Kai19] Sebastian Kaiser. The difference between design thinking & design science. `https://medium.com/@sebastian_kaiser/the-difference-between-design-thinking-design-science-482244cfb327#`, Jan 2019. Accessed 13/05/21.

[Kom15] Sotco Claudius Komba. Challenges of writing theses and dissertations among postgraduate students in Tanzanian higher learning institutions. *International journal of research studies in education*, 5(3), 2015.

[Lei09] Simon A Lei. Strategies for finding and selecting an ideal thesis or dissertation topic: A review of literature. *College Student Journal*, 43(4):1324–1333, 2009.

[Lum19] Matthias Lumpe. Studienabbruch in den mint-fächern: Fallstudien an der universität potsdam und mögliche folgerungen. *Alles auf Anfang! Befunde und Perspektiven zum Studieneingang*, pages 177–192, 2019.

[Max12] Joseph A Maxwell. *Qualitative research design: An interactive approach*. Sage publications, 2012.

[May04] Philipp Mayring. Qualitative content analysis. *A companion to qualitative research*, 1(2):159–176, 2004.

[Nie20] Jakob Nielsen. Ten usability heuristics. `http://www.nngroup.com/articles/ten-usability-heuristics/`, Nov 2020. Accessed 23/03/22.

[OAA06] Jeanne Ellis Ormrod, Eric M Anderman, and Lynley Hicks Anderman. *Educational psychology: Developing learners*. Pearson/Merrill Prentice Hall Upper Saddle River, NJ, 2006.

[OD04] Jeanne Ellis Ormrod and Kevin M Davis. *Human learning*. Merrill London, 2004.

[PL01] Michael C Poock and Patrick G Love. Factors influencing the program choice of doctoral students in higher education administration. *NASPA journal*, 38(2):203–223, 2001.

[Pre18] Andrew Pressman. *Design thinking: A guide to creative problem solving for everyone*. Routledge, 2018.

[R+69] Carl R Rogers et al. *Freedom to learn: A view of what education might become*. Merrill,, 1969.

[R+02] Johnmarshall Reeve et al. Self-determination theory applied to educational settings. *Handbook of self-determination research*, 2:183–204, 2002.

[Ra'20] Mayyada Mahdi Ra'uf. Scientific academic writing: The difficulties of writing abstracts of theses and dissertations in biological disciplines. *International journal of psychosocial rehabilitation*, 24(2):2078–2087, 2020.

[Rao19] Dhananjai M Rao. Experiences with auto-grading in a systems course. In *2019 IEEE Frontiers in Education Conference (FIE)*, pages 1–8. IEEE, 2019.

[Res17] Provalis Research. QDA miner lite. `https://provalisresearch.com/products/qualitative-data-analysis-software/freeware/`, 2017. Accessed 06/07/2021, Version 2.0.8.

[RRD21] Rémi Rampin, Vicky Rampin, and Sarah DeMott. Taguette. `https://www.taguette.org`, 2021. Accessed 06/07/2021, Version 0.10.1.

[Sac02] John Sachs. A path model for students' attitude to writing a thesis. *Scandinavian Journal of Educational Research*, 46(1):99–108, 2002.

[SEM19] Frode Eika Sandnes, Evelyn Eika, and Fausto Orsi Medola. Improving the usability of interactive systems by incorporating design thinking into the engineering process: raising computer science students' awareness of quality versus quantity in ideation. In *2019 5th Experiment International Conference (exp. at'19)*, pages 172–176. IEEE, 2019.

[SK20] Zahra Shahsavar and Haniyeh Kourepaz. Postgraduate students' difficulties in writing their theses literature review. *Cogent education*, 7(1):1784620, 2020.

[SSK15] Karim Sadeghi and Arash Shirzad Khajepasha. Thesis writing challenges for non-native MA students. *Research in post-compulsory education*, 20(3):357–373, 2015.

[TE96] H. Tait and N. Entwistle. Identifying students at risk through ineffective study strategies. *Higher Education*, 31(1):97–116, 1996.

[TH19] David Thomas and Andrew Hunt. *The Pragmatic Programmer: your journey to mastery*. Addison-Wesley Professional, 2019.

[TK18] Ari Tuhkala and Tommi Kärkkäinen. Using Slack for computer-mediated communication to support higher education students' peer interactions during master's thesis seminar. *Education and Information Technologies*, 23(6):2379–2397, 2018.

[TSB06] Malcolm J Todd, Karen Smith, and Phil Bannister. Supervising a social science undergraduate dissertation: staff experiences and perceptions. *Teaching in higher education*, 11(2):161–173, 2006.

[Yin15] Robert K Yin. *Qualitative research from start to finish*. Guilford publications, 2015.

[Zim08] Stephan Zimmermann. Gründe für den studienabbruch an der ETH Zürich. Master's thesis, Eidgenössische Technische Hochschule Zürich, 2008.