

INTEGRATIVE WORKPLACE
EMPLOYING REALITY-BASED INTERACTION TO JOIN
DIGITAL AND ANALOG MEDIA AT A
WORKPLACE

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ABSTRACT

This thesis presents the development and the evaluation of an interactive workplace which supports knowledge workers by integrating printed media. The major benefit of the workplace is the possibility to use features of digital devices within paper documents. Features of this thesis' prototype that demonstrate this benefit are digital full-text search as well as the simple excerpting of contents. Furthermore, digital content and its analog sources can be related to each other. To process digital and printed texts in the same manner, the same stylus and the same interaction techniques are used. The unique characteristic of this system is the combination of aforementioned features and their application in a real working environment.

A case study with participants solving a legal record showed that this system is actually facilitating knowledge work. The study revealed that it is necessary to picture the linear evaluation order of legal issues to support the juristic working methodology. In addition it proofed that users appreciate the way paper was integrated into the prototype and enjoy the experience of using features known from digital devices on paper documents. Most of all, the evaluation discovered that users having problems with the distinction between pen and finger for context-switching in pen and touch user interfaces.

ZUSAMMENFASSUNG

Diese Thesis befasst sich mit der Entwicklung und Evaluation eines interaktiven Arbeitsplatzes, der durch die Integration von Printmedien Wissensarbeiter unterstützt. Der grösste Vorteil dieses Arbeitsplatzes ist die Möglichkeit, Funktionen digitaler Geräte mit Printmedien zu verwenden. Funktionen des Prototypen dieser Thesis, die diesen Vorteil aufzeigen, sind die digitale Volltextsuche in analogen Quellen sowie das einfache Exzerpieren daraus. Des Weiteren können digitale Inhalte und deren analoge Quellen in Beziehung zueinander gesetzt werden. Um digitale und gedruckte Texte auf die gleiche Art und Weise bearbeiten zu können, werden für beide Textarten der gleiche Eingabestift und die gleichen Interaktionstechniken verwendet. Das Alleinstellungsmerkmal der Arbeit ist die Kombination der vorgestellten Eigenschaften und deren Verwendung in einer echten Arbeitsumgebung.

Anhand von Versuchspersonen, die einen juristischen Sachverhalt lösen mussten, hat eine Fallstudie gezeigt, dass dieses System tatsächlich Wissensarbeit ermöglicht. Die Studie hat festgestellt, dass eine Anwendung die lineare Prüfungsreihenfolge von Rechtsfragen widerspiegeln muss, um juristisches Arbeiten zu unterstützen. Des Weiteren hat sie bewiesen, dass Nutzern die Art und Weise gefällt, wie Papier in das System eingebunden wurde und sie von der Möglichkeit fasziniert sind Funktionen digitaler Geräte auf Papier Dokumenten verwenden zu können. Vor allem aber hat die Auswertung der Studie ergeben, dass Nutzer Probleme mit der unterschiedlichen Anwendung von Stift und Finger haben, wenn es darum geht, zwischen dem Bewegen und dem Zeichnen von Objekten zu unterscheiden.

ACKNOWLEDGMENTS

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ERKLÄRUNG

Ich versichere hiermit, dass ich die anliegende Arbeit mit dem Thema:

*Integrative Workplace - Employing Reality-based Interaction to
join Digital and Analog Media at a Workplace*

selbständig verfasst und keine anderen Hilfsmittel als die angegebenen benutzt habe. Die Stellen, die anderen Werken dem Wortlaut oder dem Sinne nach entnommen sind, habe ich in jedem einzelnen Falle durch Angaben der Quelle, auch der benutzten Sekundärliteratur, als Entlehnung kenntlich gemacht.

Konstanz, October 2013

Christoph Gebhardt

CONVENTIONS

Throughout this thesis the following conventions are used:

- The plural "we" will be used throughout this thesis instead of the singular "I", even when referring to work that was primarily or solely done by the author.
- Unidentified third persons are always described in male form. This is only done for purposes of readability.
- Links to websites or homepages of mentioned products, applications or documents are shown in a footnote at the bottom of the corresponding page.
- References follow the ACM citation format.

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INTRODUCTION

In 1973 Peter Drucker firstly popularized the term knowledge worker. He defines knowledge worker as "an employee whose major contribution depends on employing his knowledge rather than his muscle power and coordination" [12, p. 564]. Different studies show that the percentage of knowledge workers in between the different types of labor (production worker, agriculturist, etc.) is steadily increasing since the early 1900s and will continue to grow¹. In addition researchers argue for the ascending importance of knowledge workers concerning the general creation of value in the economy ([26], [28], [11]).

*Definition of
knowledge work*

As the importance of knowledge workers for the economy is rising their functioning is more and more in focus. It is common sense in research, that current technologies used at a workplace have shortcomings concerning the support of the functions of knowledge workers. The complexity and unstructured form of activities performed by a knowledge worker, like composing artifacts, editing or remixing content and making sense of information, etc. [31] makes it hard to have one tool supporting all of these. Therefore many knowledge workers use an individual combination of different electronic devices (e.g. laptops or tablets) as well as "old-fashioned" utilities like pen and paper. Integrating these different types of tools seamlessly into one workflow is a task which is a time-consuming and frustrating part of knowledge work. Especially if content only available in a paper document needs to be accessed through a digital device, or vice versa, nowadays technologies entail no or only an inconvenient way to perform such an operation². These operations normally require a discontinuance of the actually executed workflow and therefore decelerate the working process. If such operations need to be accomplished several times during one workflow this may result in a high level of frustration for the knowledge worker.

*The gap between
digital and analog
media*

The described problems define the so called *gap between digital and analog media*. This thesis aims to bridge this gap by designing a workplace which supports knowledge workers by easily transferring content between printed documents and a digital device. With the perspective of developing a new working environment the question

¹ An example for the development worldwide is published by McKinsey and Company in [53, p. 67]. A study which shows the development in Germany can be seen in [9, p. 1480]

² To digitize documents attended with a pen you can for example either scan in the whole document or typewrite the passages of interest. For the other way around, to make digital text available as an analog document, you can print out the passage of interest or if you want to integrate it into a handwritten document you need to copy it using a pen.

arises to what extent or even if analog media is needed to be considered in the conception process. Why not just replace analog media and utilities with adequate electronic devices and technologies?

Office of the future

This replacement of paper is standard practice, looking at visions of future workplaces presented by companies or institutions. In those visions, normally no or only very little paper can be seen (see [Figure 1](#)) and you can get the impression, that paper is obsolete in the workplace of the future. Those visions are the prosecution of what

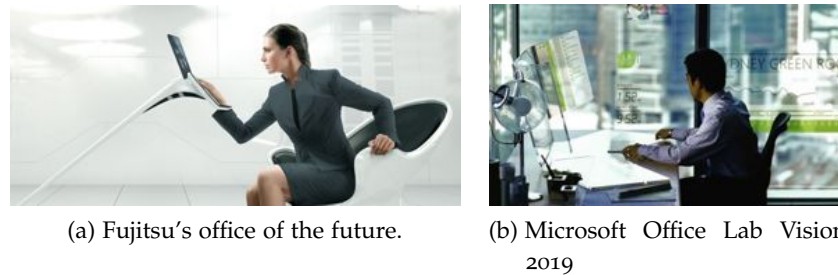


Figure 1: Two examples of workplaces of the future.

*Affordances of paper
regrading knowledge
work*

Sellen and Harper call *The Myth of the Paperless Office* [52]. In the same-named book they point out that since the early seventies research activities try to remove paper from the office, however until now none of them succeeded in doing so. As a reason they name four inherent affordances of paper:

- *Tangibility*: Paper helps us flexibly navigate through documents
- *Spatial flexibility*: Paper facilitates the cross-referencing of more than one document at a time
- *Tailorability*: Paper allows us annotate documents easily
- *Manipulability*: Paper allows the interweaving of reading and writing

The necessity of paper for knowledge work can more or less be considered common sense in human-computer interaction and is supported by many scientists (see [Section 1.1](#)). Based on this research we determine that to support knowledge workers, the goal cannot be the removal of paper from the workplace. For this reason our approach is "to accept the usefulness of paper as one kind of technology and attempt to develop ways of integrating that technology with another, namely, electronic" [52, p. 182]. For the development of the prototype this means we want to actively focus on the integration of paper and the therewith associated work practices. Therefore a system needs to be designed which facilitates the use of similar interaction techniques and input devices to process real and virtual texts in a same manner. The goal is to explore the seamless transfer of content between books and electronic devices and thereby bridge the gap between digital

and analog media. As a final step a user study is conducted, which evaluates user experiences in means of the goals of this thesis: the support of knowledge work and the seamless integration of paper into the digital device. Therefore users are observed while performing a knowledge-work-specific workflow to determine the potential of this solution for a concrete use in the working environment of the future.

1.1 IMPORTANCE OF PAPER REGARDING KNOWLEDGE WORK

As mentioned before, the importance of paper regarding knowledge work can be considered common sense in research. Sellen and Harper intensively argue for this importance by, among others, highlighting inherent affordances of paper (see [Chapter 1](#)) and naming aspects of knowledge work which are well supported by paper. In their opinion paper supports "at least" five important aspects of knowledge work [52, p. 53]:

*Aspects of
knowledge work
supported by paper*

1. *Authoring work*: knowledge workers refer to paper for creating documents.
2. *Reviewing of documents*: knowledge workers use paper for reflective reading. This involves annotating and commenting documents.
3. *Planning and thinking about projects and activities*: paper is primary mean for organizing work and writing plans.
4. *Collaborative activities*: paper supports collaborative activities, for example going through hard copies at a conference table.
5. *Information sharing*: important documents are shared via hard copy.

All of their findings were derived from the results of a study conducted at the International Monetary Fund. The study showed that 97% of knowledge work done by staff at International Monetary Fund involves paper documents.

Alison Kidd, who conducted a study about the functioning of knowledge workers, also argues for the use of paper in knowledge work [35]. She stresses the importance of paper as a tangible embodiment of ideas and information. Knowledge workers apply paper to construct a new mental model because it makes information accessible, tangible and gives it a persistent presence. Furthermore the study showed that the clutter of reading materials on a desk of a knowledge worker play different important roles for his work. First, it serves as a spatial holding pattern for current inputs and ideas which can not yet be categorized. Second, "the layout of physical materials on their desk gives them powerful and immediate contextual cues to recover

a complex set of threads without difficulty and delay" [35, p. 188]. And finally, paper is important for knowledge workers to show others with the help of tangible objects how much progress they have made.

Similar findings are presented by Catherine Marshall in her research [43]. She brings forward the argument that the accumulation of all physical records on a desk forms "a personal geography of one's own collection of reading materials" [43, p. 13]. The knowledge worker reads the different records on the desk and knows the passages which are in his interest. Therefore the collection of all these records indicates a general idea the knowledge worker has, but is not yet able to specify. In her opinion, to successfully spread the use of eBooks it is necessary to focus on the creation of "a paper-like reading experience" [43, p. 5]. And even by successfully doing so paper still "is too malleable and too useful to replace" [43, p. 12].

Paper enables a deeper reading experience

Mangen et al. name another advantage of working with paper [42]. They conclude that being able to touch pages while reading, constitutes a different and deeper reading experience than reading texts on a display. The intangibility of digital text is making us "read in a shallower, less focused way" [42, p. 407]. To proof their conclusion they list various studies whose results show that humans "tend to scan text on screen" [42, p. 409].

In their research Jan M. Noyes and Kate J. Garland summarized studies which examine the differences between computer- and paper-based tasks, from 1981 to 2004 [47]. They detected that in the earlier studies participant generally favored paper for better performance (according to the metrics of speed, accuracy and comprehension). As technology matures greater equivalence between computer- and paper-based tasks is achieved. However there will always be some tasks where it is not possible to achieve equivalence.

1.2 LOCALIZATION OF INTEGRATIVE WORKPLACE IN KNOWLEDGE WORK

To design a workplace that supports all activities concerning knowledge work is an error-prone goal, that becomes especially difficult in matters of evaluation. Therefore I decided to focus on some of the activities of knowledge work according to a defined model. The model I chose was developed by O'Hara et al. in the paper "Student Readers' Use of Library Documents: Implications for Library Technologies" [48]. The reason why this model was chosen is the localization of Integrative Workplace in the context of the research project Blended Library. Blended Library was initiated with the purpose to investigate and develop new concepts to support the research process in the physical library of the future [25]. As this model covers important aspects of knowledge work, its different phases offer the

The research project Blended Library

opportunity to define the scope of Integrative Workplace according to it. The following figure shows the model and its different phases.

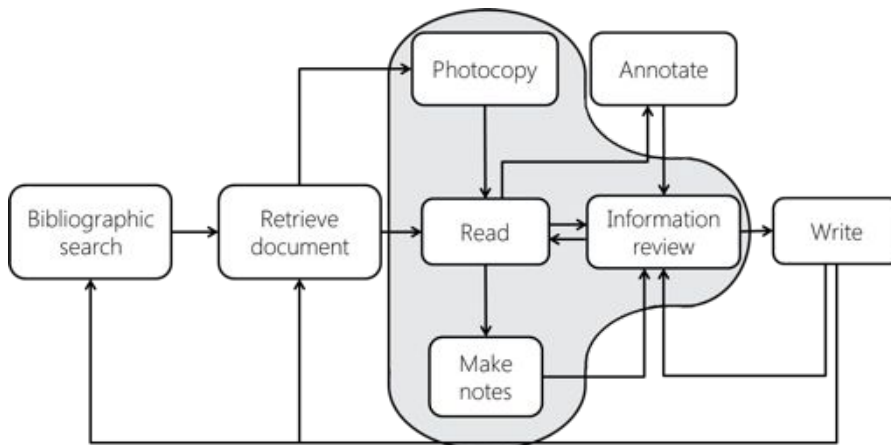


Figure 2: The model of O'Hara and the phases covered by Integrative Workplace (gray background).

In a study O'Hara et al. evaluated the previously defined phases of the use of library documents. The study confirmed that after bibliographic searching and retrieving a document students either photocopy or read it. While reading the document students annotate the text with their own thoughts and markings for having an easier return to continue their work. Additionally they have separate documents to make notes and write down own ideas. All the annotations, notes and the original text will be reviewed by them at a later point of time. This information review helps students to structure and re-think their own ideas and the read information. As a result they write down the acquired ideas and information in a separate document. This is an iterative process. After finishing one passage students either review new information or start again searching additional literature to acquire further insights.

*The phases of
O'Hara's model*

The focus of Integrative Workplace inside this model lies on information review. Additionally the project covers the related phases making notes, photocopying and reading (see gray background in Figure 2). Photocopying in the context of Integrative Workplace means the enrichment of printed media with digital content and the possibility to make information in printed media digitally available.

*The focus of
Integrative
Workplace*

Regarding Blended Library, Integrative Workplace is closing the gap between several other projects. As a result, all phases of the model of O'Hara et al. are covered by Blended Library. A new technology for the bibliographic search and the retrieval of documents is developed in the project Blended Shelf [36]. The project allows users to browse shelves and books "beyond the physical location of the library" [36, p. iv] by displaying a virtual 3D shelf on an interactive screen. Interactive Reading supports the phases of reading, information review, making notes and annotation using a digital pen and a

*The projects of
Blended Library*

pad-sized device [3]. In contrast to Integrative Workplace, this project deals with the editing of digital documents in the mobile context. A new way of writing a document is designed in the project Active Desk [51]. In this case pen and touch are used to operate as a word processor.

THEORY

The goal of this thesis is to develop a working environment which supports the working methods of knowledge workers. Since this environment will not only consist of a single application running on a laptop or a pc, the user interface will not be a classic WIMP³ interface but a post-WIMP interface. Latter interfaces leverage the users "pre-existing knowledge of the everyday, non-digital world" [30, p. 208] by adapting the computer interaction to real world interaction. As the final system's purpose is to support knowledge work, research findings regarding this area also need to be considered in the design process. For these reasons this chapter will provide insights into the definition and characteristics of Post-WIMP Interfaces and Knowledge Work as they can be found in literature. Additionally generally accepted design guidelines for the development of systems within these two domains are presented.

2.1 KNOWLEDGE WORK

As mentioned in the introduction the term *knowledge worker* was firstly defined by Drucker. A knowledge worker according to Drucker is primarily concerned with the use and the development of information [12]. He is not using his manual power for the creation of value in the process of creating a product. An operational definition of the abstract activities that are performed by knowledge workers is introduced by Jetter on the basis of different theoretical models and frameworks of knowledge-intensive and creative work (Framework for Mega-Creativity⁴, GEMS⁵, Information Journey⁶ and Knowledge Crystallization⁷) [31, p. 18]. According to him the goal of knowledge work is "to act on the results of a knowledge-intensive process" [31, p. 18], for example to make a decision, to apply new knowledge or to share information. This is created by composing, editing or remixing content and by writing articles or authoring presentations. These activities involve a phase of getting, acquiring or collecting information and a phase of making sense of information. These different phases

*Activities performed
by knowledge
workers*

³ WIMP stands for Windows, Icons, Menus and Pointer.

⁴ The Framework for Mega-Creativity intends to support the design of powerful tools that can facilitate creative work. It is defined by Shneiderman.

⁵ GEMS stands for Get, Enjoy, Maintain, and Share. It describes the life cycle of personal content usage. GEMS is defined by Lehtikoinen, Aaltonen und Huuskonen.

⁶ Information Journey describes how people interact with information. It is defined by Blandford and Attfield.

⁷ Knowledge Crystallization describes the process of making sense of information according to a specific goal. It is defined by Card.

of higher level activities "are separated in time and are executed either sequentially or in random order depending on the context, goals, and progress" [31, p. 18]. Each of these higher level activities includes smaller tasks, for example getting, acquiring or collecting information comprises the smaller tasks searching and browsing all available information.

Supporting low level activities

The problem of how to design computer tools to better support the activities performed by a knowledge worker is the focus of many research projects in computer science. Based on the operational definition of the activities performed by a knowledge workers described above, Jetter's approach is, that since knowledge work cannot be automated the goal of an interactive system is not to support the higher level activities, but the smaller tasks included in higher level activities. A simple example to explain this idea is the following: To support the getting, acquiring or collecting of information (higher level activity) it is not the goal to write a tool which actually selects information for the user, rather you should write a tool which helps the user to search and browse (smaller tasks comprised in higher level activity) all available information and thus helps him to select the relevant information himself.

This idea is also supported by Collins who prescribes, that an interface in the context of knowledge work needs to provide "a context for interaction to guide the user through a space of possible actions and results" [6, p. 31] by showing users all possible actions at each point in a workflow with the help of "a rich, graphical representation of the data or other objects of interest" [6, p. 31].

Characteristics of knowledge workers

Alison Kidd conducted a study with twelve knowledge workers to find an expedient way to support their work [35]. The study showed, that the defining characteristic of knowledge workers is that "they are changed by the information they process" [35, p. 186]. Beyond this, she defined three particular characteristics which "challenge established views on computer support for office work" [35, p. 186].

1. *Diversity of Output*: Faced with the same problem, each knowledge worker provides a different output. Companies value, and benefit from this phenomena.
2. *Low Dependence on Filed Information*: Knowledge workers do not write notes because they need an external memory store. They write things down to sort out their thoughts. After the newly acquired information is stored in their memory or composed in a report the notes are normally discarded.
3. *Importance of Spatial Layout and Materials*: Spatial layout and materials play several roles in knowledge work. First knowledge workers use physical space as a holding pattern for ideas which cannot yet be categorized or cannot yet be used. Second knowledge workers use sheets and notes as a "material correlate of a

model of the world which they are in the process of constructing in their heads" [35, pp. 187-188]. Third, the different materials covered on their workplace gave them "powerful and immediate contextual cues" [35, p. 188] to recover their work. Finally, knowledge workers use the materials they work with to show others the progress they made.

As a result of the study Alison Kidd concludes that "true knowledge work cannot be automated" [35, p. 190]. Based on this conclusion she deploys seven guidelines on how to best support knowledge work in a computer-supported office environment. In the context of this thesis three of those implications are highly relevant and are summarized as follows.

1. Avoid developing tools which try to understand the information they are holding and try to predict what the user wants to do with it. Only knowledge workers can give meaning to their muddle of marked documents on paper or on screen and "cannot predict what this meaning is until they have been informed by it" [35, p. 190].
2. Instead of interpreting the appearance of marks made by knowledge workers, tools should concentrate on capturing and reproducing them. These marks are the base on how knowledge workers carry information they cannot yet categorize.
3. Provide "a flexible environment for presenting a problem in ways which make it readily accessible" [35, p. 190] to the human mind. Therefore Kidd suggests extending the ability of the physical environment with computational power to inform an individual or a group of knowledge workers.

Another approach to support knowledge work is chosen by Sellen and Harper. In their book "The Myth of the Paperless Office" they highlight the affordances of paper regarding knowledge work (see [Chapter 1](#) and [Section 1.1](#)). From these affordances they derived five guidelines on how to design computer tools to really support knowledge work.

Guidelines to support knowledge work

1. *Support for Flexible Navigation:* Develop navigational techniques for documents which orientate at the navigation known from books. It is important to navigate through a document and be able to switch between reading and writing without interference. Furthermore it is necessary to support the spatial memory of readers. This memory helps readers to easily recall things in physical books.
2. *Support for Cross-Document Use:* A computer tool to support knowledge work needs to display at least two pages to support cross document interaction like cross-reading, referencing, etc.

3. *Support of Annotation while Reading*: The keyboard input is not sufficient for marking a text while reading. Pen and paper have advantages in this area. They are not bound to margins and it feels more natural to mark things with a pen. Technologies which support knowledge work should integrate a pen to support annotation while reading.
4. *Support for Interweaving Reading and Writing*: Readers choose different angles for reading and writing. This fact needs to be considered when designing new technologies.
5. *Support of Different Kinds of Reading*: Different kinds of professional audiences have different ways to read documents. These different kinds of reading need to be supported.

Support knowledge work by integrating pen and paper in computer based tools

To support knowledge work, Jürgen Steimle suggests to "draw upon the affordance of paper and upon traditional practices of working with paper" [55, p. 88] by integrating pen and paper in computer-based tools. Therefore he defined a new type of user interface: the pen-and-paper user interface (PPUI). According to him PPUIs are a part of post-WIMP user interfaces which extend computing into the physical world by turning traditional paper into a digital interactive medium. He demands that PPUIs should provide for rich interactions. It should be possible to use multiple sheets and commonly known tools in the working process. Moreover it is important to "cope with the restricted feedback capabilities of paper" [55, p. 89] by enhancing real-time feedback on paper or leveraging feedback "which is provided by the physical properties of paper" [55, p. 89]. Besides that, new technologies should leave interactional freedom to users by not constraining traditional working practices but enhancing them with computational power.

2.2 POST-WIMP INTERFACES

Definition of post-WIMP interfaces

Van Dam defines a post-WIMP interface as an interface which contains "at least one interaction technique not dependent on classical 2D widgets such as menus and icons" [58, p. 65]. The interaction with such an interface will involve all senses in parallel as well as natural language communication and multiple user collaboration.

Several research projects developed frameworks on how to design post-WIMP interfaces to support user-friendly and intuitive interaction. In this thesis two of these are going to be presented: Reality-based Interaction and Blended Interaction.

Reality-based Interaction

Reality-based Interaction is defined by Jacob et al. as an "attempt to make computer interaction more like interacting with the real, non-digital world" [30, p. 201] by encouraging interaction designers to draw upon special themes of reality when developing new post-WIMP interfaces. The four themes the framework is specifically focus-

Themes of reality

ing on are: Naïve Physics, Body Awareness and Skills, Environment Awareness and Skills as well as Social Awareness. What these themes stand for and how they can be understood is described as follows:

- Naïve Physics (NP): Naïve physics stands for the "common sense knowledge about the physical world" [30, p. 202]. This knowledge includes concepts like gravity, friction, velocity, the persistence of objects and relative scale which users know from interacting and living in the real world.
- Body Awareness and Skills (BAS): Body awareness and skills refers to the "understanding that people have of their own bodies, independent of the environment" [30, p. 202]. This theme builds upon the developed skills of humans to coordinate movements of their body parts in order to do specific actions. For example moving a leg to kick a ball.
- Environment Awareness and Skills (EAS): Environment awareness and skills utilizes the human "sense of orientation and spatial understanding" [30, p. 202]. People are aware of their physical presence in a spatial environment and developed many skills "for navigating within and altering their environment" [30, p. 202].
- Social Awareness and Skills (SAS): Social awareness and skills employs people's skills for social interaction. For example: "verbal and non-verbal communication, the ability to exchange physical objects, and the ability to work with others to collaborate on a task" [30, p. 203].

The reason why Jacob et al. suggest to base interaction on pre-existing real world knowledge and skills is that the mental effort required to operate a system may be reduced. Because the users already possess the skills needed. On the other hand they mention the qualities of the virtual world.

*Qualities of the
virtual world*

- *Expressive Power*: variety of tasks a user can perform with one system (system's functionality).
- *Efficiency*: "users can perform a task rapidly" [30, p. 205].
- *Versatility*: applications can offer different tasks from different application domains.
- *Ergonomics*: "users can perform a task without physical injury or fatigue" [30, p. 205].
- *Accessibility*: handicapped persons can perform a task.
- *Practicality*: "the system is practical to develop and produce" [30, p. 205].

*Trade-off between
real world qualities
and virtual qualities*

These qualities give computers their power and are the reason why we use them. The idea behind Reality-Based Interaction is to explicitly announce the trade-off between real world qualities and virtual qualities during the interaction design process of a system. The goal behind Reality-Based Interaction is "to give up reality only explicitly and only in return for desired qualities" [30, p. 205] of the virtual world. "The designer's goal should be to allow the user to perform realistic tasks realistically, to provide additional non real-world functionality, and to use analogies for these commands whenever possible" [30, p. 206].

Blended Interaction

Blended Interaction also addresses the trade-off between digital power and easy-to-learn interfaces in the design process of post-WIMP interactive spaces. Interactive spaces in the sense of the authors "purposefully blend the power of digital computing with natural work practices and collaboration styles" [32]. The goal is to create an environment where the computational power is ubiquitous and invisible so that the users "are freed to use them without thinking and 'mental gymnastics'⁸ and to focus beyond computers on new goals" [32, p. 2].

Conceptual blending

To achieve this goal Jetter et al. describe users' cognition and interaction with post-WIMP interactive spaces on the basis of conceptual integration. Conceptual integration or conceptual blending is a general theory of cognitive science and was defined by Fauconnier and Turner [16]. In our conceptual system, highly complex concepts are generated from less complex or basic-level concepts our mind already has internalized. It happens by integrating the new complex concept from two existing basic-level concepts. Therefore human beings are able to create new and more complex concepts from existing concepts as input. The output of the process of conceptual integration is the so called blend. It is the new concept integrated from the two input concepts and "has an emergent new structure that is not available from the inputs" [32, p. 6].

Jetter et al. transform the process of conceptual integration from the discipline of cognitive science to human-computer interaction to explain how the power of the digital world can be blended with the users' pre-existing skills and practices. [Figure 3](#) explains the key idea behind Blended Interaction. Blended Interaction assists designers in finding a good design trade-off between advantages of the familiar reality and the expressive power of the digital world. The result of the design trade-off is a consistent system with adequate blends which make it easy-to-use. In the context of human-computer interaction a blend integrates the computational power of a system with established interaction techniques from reality.

*Well-established
digital concepts*

In contrast to Reality-based Interaction in Blended Interaction the term 'reality' does not only consists of themes from the real world (naïve physics, environment awareness, etc.) but also of well-established

⁸ According to Mark Weiser's vision specified in *The Computer for the 21st Century*

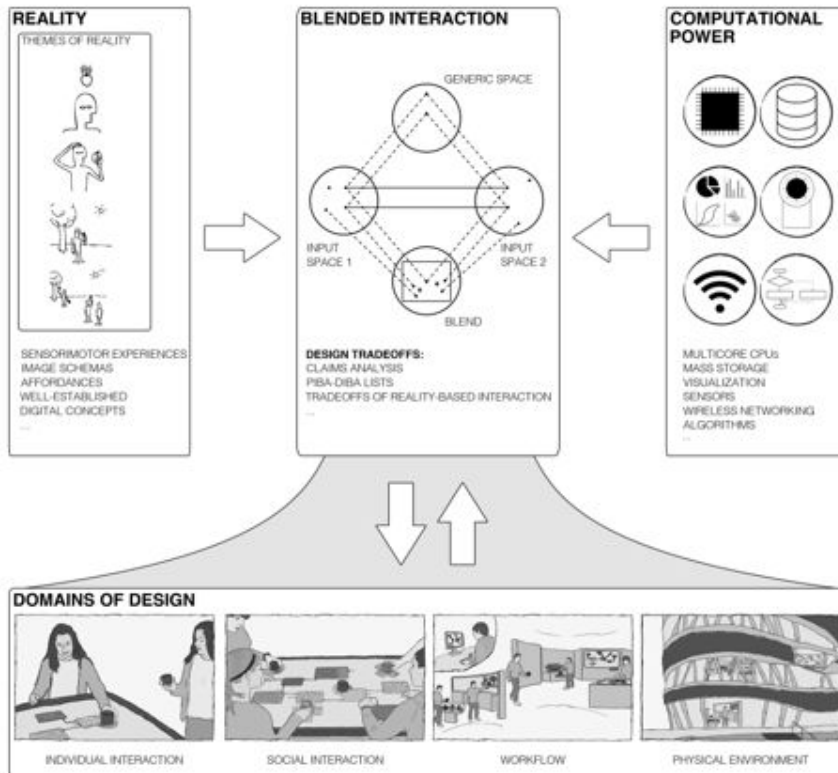


Figure 3: A visual overview of the framework of *Blended Interaction* [32, p. 13].

digital concepts. The authors argue that today it is not possible to consider reality as free from digital influences anymore. "Some concepts from the digital world have been adopted and deeply internalized by the user population and are applied almost as effortlessly as if it were basic-level sensorimotor experiences" [32, p. 11-12]. Therefore they need to be considered when we apply concepts from reality to design a highly functional but intuitive interaction.

The resulting designs are applied to the four domains of design of post-WIMP interactive spaces, which were introduced by the authors. Those four domains are:

Domains of design

1. *Individual interaction*: Interaction techniques forming the basis for collaborative working.
2. *Social interaction and communication*: Coordinates collaboration by creating group awareness of individual tasks.
3. *Workflows*: A higher level activity which consists of various smaller tasks.
4. *Physical environment*: The physical environment a workflow takes place.

When designing a post-WIMP interactive space designers should keep those domains in mind and be aware of their special requirements.

PRE-STUDY

In the previous chapter a literature review concerning knowledge work and post-WIMP-interfaces was presented to get a good starting point on how to develop an easy-to-use system which supports knowledge work. For further insights on the working methods of knowledge workers, a pre-study is executed. This study investigates and analysis a use case within the domain of knowledge work. The goal is to detect use-case-specific requirements, which are taken as additional guidelines for the development of the system. Furthermore the insights about the use-case-specific working methodology should inform the design of the system. The advantage of a concrete use case is that it qualifies the scope of this thesis regarding the pre-study, the functionality of the prototype and the user study in contrast of working within the general domain of knowledge work. However the developed designs and the determined study results can be generalized for the domain of knowledge work as they may apply in other sub-domains.

3.1 USE CASE

In this thesis the chosen use case is law science. We selected law science after looking at various scientific disciplines. According to this use case the purpose of the system is to support law students with the writing of a jurisprudential seminar paper. Inside the use case, the general goal of the project, the seamless transfer of content between books and electronic devices using similar interaction techniques and input devices, is still focused. Moreover the specified scope of Integrative Workplace according to the model of O'Hara et al. (see [Section 1.2](#)) is kept.

There are several reasons why law science was chosen as the use case. One reason is the schematic procedure which is applied when solving a legal case. The methods which are used to solve a case depend on the legal form and differ between public, criminal and civil law. However an abstract approach for all law forms can be recognized. This approach will be supported by the final system. Furthermore the literature of law science is accessible digitally as well as in physical books. Most of the law codes, jurisprudential journals, educational books and jurisprudential comments are only available as bounded books. However there are comprehensive juristic online-databases which allow users to access legal text and the comments which refer to the correspondent paragraphs. Another reason why

Law science

Reasons for law science as use case

law science was chosen is as follows: students have to compare common opinions from literature about the problems of the legal case they solve, and argumentatively choose one of them. Therefore the excerpting of text passages from literature is an essential part in the process of writing a seminar paper. Due to the composition of juristic literature, text passages from bounded books as well as web pages are merged together in the seminar paper. This functioning is particularly interesting when considering the main goal of this thesis: enabling the seamless transfer of content between books and electronic devices. Figure 4 shows a workplace during the composition of a seminar paper, as seen in the library. You can see digital content



Figure 4: Workplace of two students writing a jurisprudential seminar paper.

accessed via laptops as well as analog content accessed via numerous books. The final reason for using law science as the use case is that 14.2%⁹ of the students at University of Konstanz study law. It is the second biggest department of the university and therefore of special interest for the library of the university, which is a partner of the project Blended Library.

3.2 APPROACH

The pre-study consists out of two parts: the first part being the re-evaluation of the Blended Library questionnaire, which could be completed online between the 22.12.2011 and the 16.02.2012 from students and staff of University of Konstanz. The second part consisted of a survey conducted with law students who wrote a seminar paper in the summer semester break of 2012.

⁹ See "Statistik über die Studierenden der Universität Konstanz" (SS 12, S.11), <http://kops.ub.uni-konstanz.de/bitstream/handle/urn:nbn:de:bsz:352-196005/Studierendenstatistik%2020121.pdf?sequence=3>

The original purpose of the questionnaire was to motivate the different projects of Blended Library by investigating the general method of students with different types of media. Furthermore it attempted to expose problems, which could appear when working with those types of media. In this thesis we re-evaluated the collected data by comparing the responses of law students with the responses of students from other disciplines to identify potential differences in the method of law students. The amount of completed questionnaires was 682 (including academic staff). Thereof 70 questionnaires completed by law students and 529 questionnaires from students of other disciplines have been analyzed. The distribution of study courses among the participants of the questionnaire corresponds to the ratio at University of Konstanz. The average of university semesters of all surveyed students is 5.6 semesters, from which the standard deviation is 4.4 semesters.

*Blended Library
questionnaire*

The survey was conducted as context observation. Therefore law students, who wrote a seminar paper at the time, exemplarily explained their procedure. Afterwards an unstructured interview was held to further investigate known problems from the Blended Library questionnaire or the context observation. The focus of the survey rested on the detection of a schematic procedure in solving a legal case and the recognition of current problems during the composition of a juristic seminar paper. For this part 14 students have been surveyed. Thereof ten have been females and four have been males. The number of semesters the participants have been studying was between one and five semesters.

*Survey with law
students*

The next chapters present the results of the requirement analysis. They explain the working methodology of law students and define certain key requirements for a potential system.

3.3 WORKING METHODOLOGY OF LAW STUDENTS

One part of the requirement analysis is engaged in understanding the working methodology of law students when writing a seminar paper. The goal is to recognize a schematic procedure in their method and later on picture it with the prototype.

The task of a common juristic seminar paper is to solve a legal record in one of the three general German legal forms (public, criminal and civil law). The observations have shown that the procedural method differs in dependency on the field of law and the individual working methodology of law students. Nevertheless it is possible to define an abstract sequence of actions applied by law students to solve a legal case and write a seminar paper (see [Figure 5](#)). First of all law students intensively deal with the description of the record (*dealing with case description*). For example they mark and underline legal problems they have recognized in the description, persons who

*Abstract sequence of
actions*

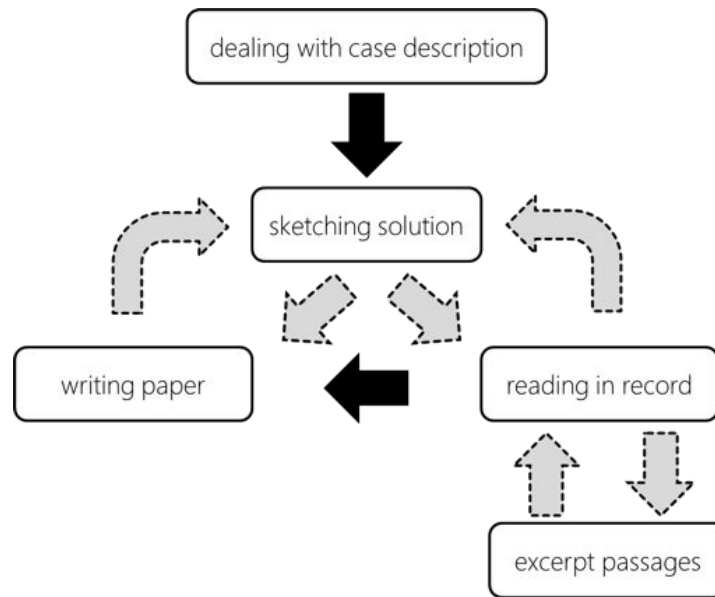


Figure 5: Abstract sequence of actions applied by law students to solve a legal case.

are involved in the case or described delicts (see Figure 6). Furthermore they make notes about initial ideas on how to solve the case. The second step is to build the solution sketch (*sketching solution*).

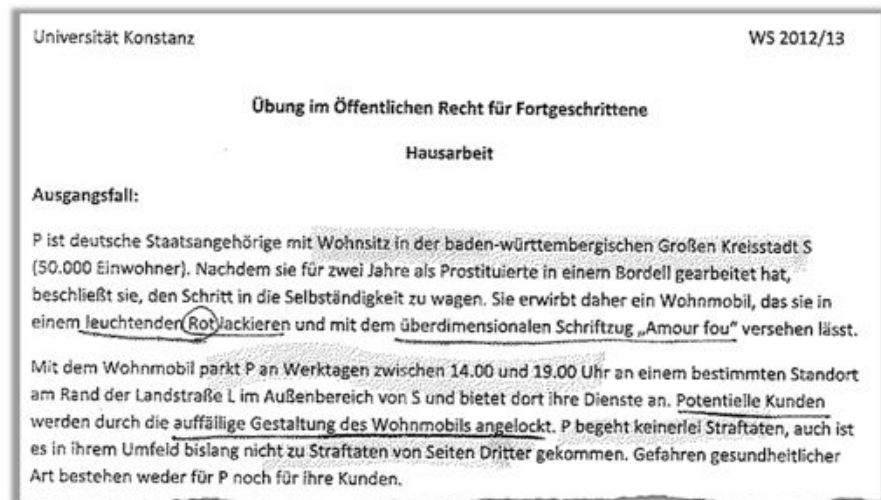


Figure 6: Part of a legal case description which was processed by a law student.

The sketch describes the evaluation order of legal issues which is applied to solve the case. The solution sketch forms the base for the structure of the seminar paper and the assessment of the professor. Therefore its accuracy is essential for a good grade. How the solution sketch is built, depends on the field of law the record is dealing with. In the case of public law the evaluation scheme of legal issues

*Building the
solution sketch
depending on the
field of law*

is roughly the same for every legal case. Therefore the structure can be taken from textbooks or solutions of similar cases. In criminal law the evaluation scheme of issues is given through the delict. Thus it is necessary to recognize the committed delicts in the description of the legal case. Every delict has a particular structure which again can be taken from textbooks. The complete structure for solving a criminal law case contains the lined up structures of every delict present in the case description. In civil law the evaluation scheme of issues highly depends on the suit which was submitted. The suit describes the charges which are asserted by the involved persons. To correctly specify all charges of a case description, law students design a sketch. These sketches show all legal persons who are involved in a particular case (see Figure 7). The persons are connected with arrows displaying the charges they have against each other. These charges form the base on which the solution sketch is built on.

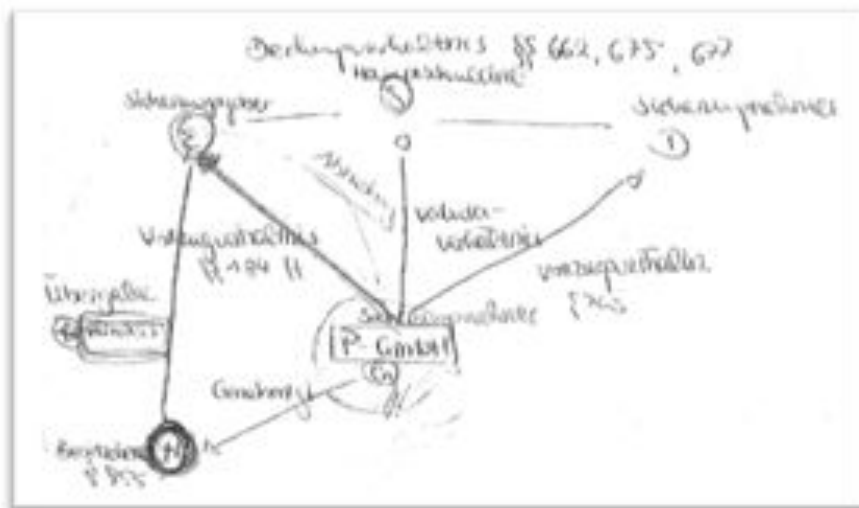


Figure 7: Sketch of charges and legal persons involved in a civil law suit.

After defining the solution sketch, it is possible to identify two different ways on how law students proceed with their work. On the one hand students have a first search for solutions of the issues they have identified in the case description (*reading in record*). Depending on their method they already excerpt passages of interest in a separate document, where they can re-read them at a later point of time (*excerpt passages*). Furthermore it is possible that they may need to restructure their paper and adjust it because of additionally acquired knowledge about one of the points of the structure (going back to *sketching solution*). After having a general idea on how to write the seminar paper they start the writing phase. On the other hand there are students who directly start with writing their seminar paper. In the writing phase they explicitly proof every issue specified in the structure and write down their insights into the seminar paper (*writing paper*). Again in this phase, it can happen that it is necessary to

adjust the solution sketch because of newly acquired findings. After finishing the actual writing they review their paper and check the correct citation. It is important to acknowledge that this chapter describes the procedural methodology of writing a juristic seminar paper in an abstract way. This means the sequence of actions only contains the most fundamental activities which may vary between individual law students.

3.4 KEY REQUIREMENTS

The key requirements presented in the following sub-chapters have been derived from the findings of the re-evaluation of the questionnaire as well as the survey and mainly highlight common problems in the working methodology of law students. A key requirement comprises of different requirements and features which should be implemented in the final system.

3.4.1 *Parallel Reading*

An important assessment criterion for jurisprudential seminar papers is the recognition and the correct emphasis of legal problems described in the facts presented in a case. For that purpose different comments, juristic journals and judgments are searched through for common opinions about a detected problem. Passages of interest are read sequentially or parallel in different sources to compare different opinions about a current problem. The challenge for the students is to discuss the different opinions expressed in literature, opt for one of the ideas and justify their decision.

*Assignment between
the source and a text
passage*

A problem in this regard is the assignment between the source and a text passage on electronic devices. Real books are tangible and have certain characteristics like size, color or position on the desk. These qualities simplify the mapping between a text passage and the according source. In contrast to books electronic documents do not have or do not use additional characteristic beside the title to help users to distinguish between them. For example PDF documents in Windows operating systems (Windows 7 and 8) all are represented by the icon of the PDF reader and only the explicit call of the icon makes the titles visible and a distinction possible.

*Books better support
juristic methodology
then electronic
devices*

In addition the majority of participants of the survey and the questionnaire independently from each other acknowledged that books support their working methodology better then electronic devices (laptops, PCs, tablets or smartphones). As a reason they name that different text passages in different books are better comparable with each other than different text passages on one electronic device. You can locate several journals, books or papers close to each other and thereby easily cross-read between multiple documents. In contrast,

on a typically sized display you only can place two documents beside each other to compare them.

The evaluation of the questionnaire confirms the findings listed above. In the question "How do you process relevant information from analog sources?" several options are given and the participants are allowed to select one or more of these answers. The ratio of answers given by law students can be seen in following figure.

Relevant information from analog sources

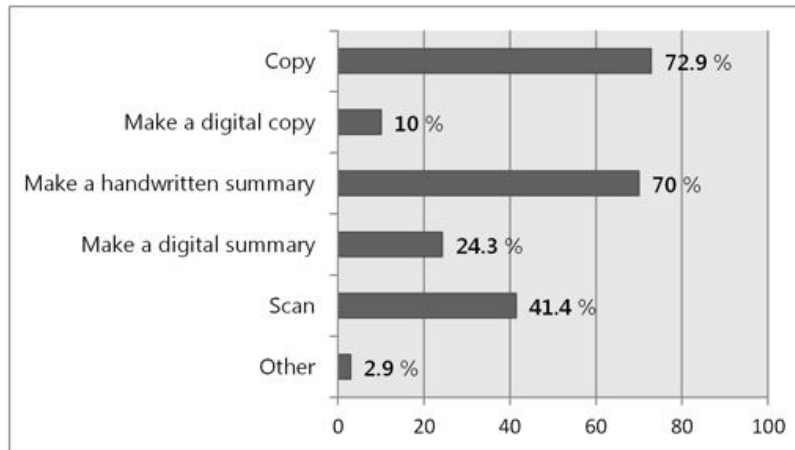


Figure 8: Result of the question: "How do you process relevant information from analog sources?" (N=70, only law students).

The two most frequently mentioned responses are copying (72.9%) and making a handwritten summary (70%). Subsequently, with a significant smaller percentage, responses have been selected, which target the digitalization of analog contents (scanning, making a digital summary or a digital copy).

In the questionnaire participants also have been asked how they process relevant information from digital sources (see Figure 9). In

Relevant information from digital sources

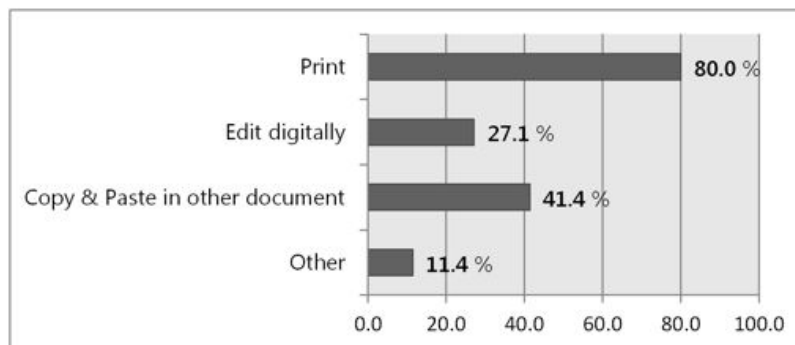


Figure 9: Result of the question: "How do you process relevant information from digital sources?" (N=70, only law students).

this question the most frequent response was printing (80.0%). Responses which digitally process the digital available information (copy & paste, editing digitally) have been selected less frequently.

No matter if relevant information is available analog or digitally the evaluation from both questions shows that students tend to "analogize" them. As a result you can generalize that law students prefer analog over digital media. The survey expresses that one of the reasons therefore is the better support of analog media relating to the parallel reading of documents. The parallel reading of documents is an essential working method when writing a juristic seminar paper and therefore needs to be ensured by a system which supports this process. Thus *parallel reading* is defined as the first key requirement. A system should allow situating digital and analog documents close to each other and thereby offer the possibility to compare (cross-read) text passages whether available digitally or analog. Similar requirements can be found in literature about knowledge work. Sellen and Harper defined "the need to lay out information in space" [52, p. 93] to be able to cross-reference more than one document at one time as an essential requirement for working with documents. Also Alison Kidd highlights the "importance of spatial layout" [35, p. 187] in matters of knowledge work. In her research Catherine C. Marhsall argues, that to be able to create "an experience that transcends paper" with technology you have to enable, among other things, the side by side comparison of different documents on a digital device [43].

3.4.2 *Excerption*

When writing a seminar paper law students need to prove everything they write. For this reason excerption is one of their basic working methods, as it simplifies the recovery of passages of interest. In the case of writing a seminar paper excerpted passages describe an opinion from literature about one of the problems defined in the facts of a legal record. As you need to copy passages of interest by writing either with hand or with a pc, the excerption from printed books often takes a large amount of time.

*Importance of
writing with the
hand*

The analysis of of both, the questionnaire and the survey, revealed that participants summarize important passages by hand because they feel that they can better understand and memorize self-written text. This discovery is a common finding in literature which is investigated and proofed in many research projects. Alison Kidd for example concludes that knowledge workers do not write notes to file important information in an external memory store, but for the process of note taking itself [35]. And already in 1941 Adler indicates that "the physical act of writing, with your own hand, brings words and sentences more sharply before your mind and preserves them better in your memory" [1, p. 11].

From these observations the key requirement *excerption* was derived. The new system allows students to easily excerpt text from digital and analog media. It is the use-case-specific counter-part of

the main goal of this project: the seamless transfer of text between printed documents and digital devices using similar interaction techniques and input devices. But as a kind of exception the handwritten summarization still needs to be possible. It is an important aspect of knowledge acquisition which goes beyond the normal excerpting of information and is used heavily in all kind of tasks concerning knowledge work.

3.4.3 *Backtracking of References*

Literature references are extensively used in law. A participant of the survey quoted: "If you retrieve a juristic comment from the library, it can happen that the first sentence you read contains a reference to the next tome". This referenced information often is essential for the understanding of the text. Because most of the juristic literature is available in bounded books, references normally need to be resolved by hand. And even online, if the referenced passage is not included in the juristic database, references need to be resolved.

Like mentioned before law students need to cite everything they write in their seminar paper. To correctly name the source of a passage cited in the seminar paper, participants quoted that they often needed to search again for a text they excerpted in a past iteration of their literature review. To avoid this time-consuming process one participant claimed for a document where he can save the passages of interest and which preserves the references to the original sources for having the possibility to re-read a passage in the original context at any time. This shows the importance of not losing the reference to the original source in the working process of writing a jurisprudential seminar paper.

*Repeated searching
of relevant passages*

In the survey law students mentioned that they often try to find an already read text passage with the help of the index of a book and a word they think to remember. In addition they declared to use the index of a book as a starting point for their literature review. In this case they use a catchword from the facts of the legal case and try to find paragraphs which apply to this word.

*The index of a book
as a tool*

From these examination results the key requirement *backtracking of references* was derived. This key requirement specifies the dissolving of references between citation and source as well as in between different documents. Thereby dissolving a reference should be possible no matter if it is in between two digital, two analog or an analog and a digital medium. Furthermore the key requirement claims for a full-text search in electronic texts and in bounded books.

In literature Sellen and Harper name "quick links to related materials" [52, p. 148] and "fast full-text searching" [52, p. 148] as affordances of digital devices in matters of knowledge work. The key requirement

backtracking of references sets the goal to realize these affordances of digital devices within analog media.

3.4.4 *Knowledge Archiving*

When asked what problems occur when working with pen and paper, the participants of the questionnaire indicated the archiving of written materials. Notes on paper get lost more easily in comparison to digitally saved notes. Additionally notes on paper need physical space for the archiving: they are filed in a folder and the folder is placed in a shelf. Furthermore it is more time consuming to relocate concrete information in a paper document that is filed in a physical archive, then retrieving the same information when it is saved digitally. At last the subsequent amendment of a printed or handwritten document is only possible in a provisional way.

*Information from
digital and analog
media*

Another problem, which was revealed by students who completed the questionnaire, is the transfer of information between digital and analog media. Thus a number of participants desired a fast method to digitize handwritten notes or documents. As an example, one of the participants in the survey wishes for a document where he can easily just save all passages of interest, no matter if they originate from printed books or web pages. Beyond this participants claimed the difficulty to set digital and analog media in relation to each other. It is neither possible to integrate a sheet of paper in a digital file directory nor to put a digital document on a pile of papers.

*Recall already
acquired knowledge*

Moreover law students expressed the wish to recall already acquired knowledge more easily. They complained that for example generally known juristic terms again and again need to be searched in literature. This is the case because it is required to proof every term used in a seminar paper with three references. As a result it can happen that students need to define the same well-known juristic term for every seminar paper they write. Therefore they either scan their old seminar papers or they search for the term the umpteenth time in law literature.

*Law students do not
use a reference
manager*

An interesting fact which arises from the evaluation of the questionnaire is that 84.3% of all law students do not use a reference manager. In contrast only 59.5% of the students from other disciplines indicated to do not use a reference manager. This is an interesting finding in the face of the big amount of literature which is needed to properly solve a legal case. Especially because the participants of the survey unanimously complained about the expenditure of time needed for the right citation and the relocating of sources of excerpted passages. A reason therefore surely is that a high percentage of law literature is only available as print media.

On the base of the mentioned findings the key requirement of *knowledge archiving* is defined. It specifies that all information whether

from analog or digital sources can be stored at the same place. Additionally the information should easily be grouped and clustered semantically. Moreover the system needs to map the functionality of a reference manager. As a result already acquired information will be retrieved fast and easy and the repetition of previously performed working steps will be avoided.

RELATED WORK

In this chapter related research works are presented which serve as an inspiration for the design and implementation process of this thesis. The presented systems and prototypes generally are post-WIMP interfaces which support knowledge work in different ways and therefore augment or integrate paper. Additionally the presented projects are checked for ideas and approaches on how to implement the detected key requirements of the chapter Pre-Study (see [Chapter 3](#)). In a first sub-chapter different digital enhanced desks or digital enhanced workplaces are presented. Works which directly use paper as interface are presented in the second sub-chapter. The third sub-chapter shows systems which visually archive information to easily access and retrieve them.

4.1 DIGITAL ENHANCED DESKS

Already in 1991 Pierre Wellner tried to digitally enhance a desk to simplify working steps underlying knowledge work. His project *DigitalDesk* "enables people to interact with ordinary paper documents in ways only possible with electronic documents on workstation screens" [46, p. 587]. The goal was not to make the electronic desktop like the physical desk, but "to give the physical desk electronic properties and merge the two desktops into one" [59, p. 27]. For the realization

DigitalDesk

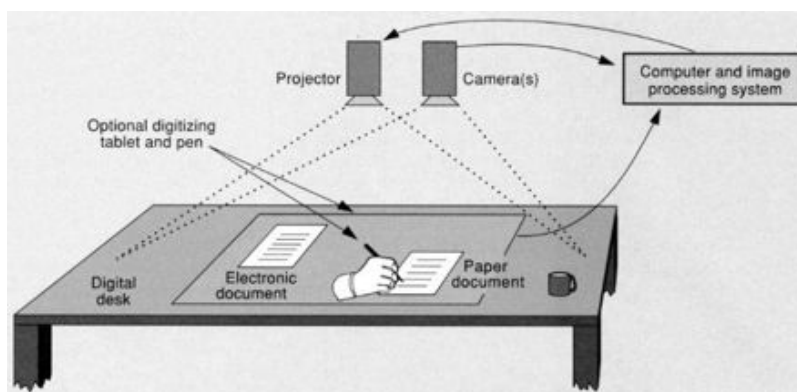


Figure 10: Pierre Wellner's *DigitalDesk* [60, p. 89]

of the goal a projector is mounted above the desk. It projects digital information onto the desk as well as onto printed documents. Activities, which happen on the desk and items, which are arranged on the desk are detected by a camera and processed by an image processing system. As a result the projection is adapted to the captured

image stream. To interact with the *DigitalDesk* users can use their fingers to e.g., move an electronic document, and a pen to e.g., select text on a paper document. For the evaluation of his concepts Wellner developed two applications: the Desktop Calculator and the Desktop Translator. The Desktop Calculator allows users to select numbers on a sheet of paper with a pen. These numbers are automatically pasted in a digital calculator, which is projected on the desk. After pasting two numbers in the calculator the user can select an arbitrary mathematical operation to combine them. The Desktop Translator creates the possibility to mark words on paper using a pen. The marked words are translated by the application and projected beside the paper in a digital window. Though it was developed in the early nineties, the *DigitalDesk* presents a lot of interesting features and abilities. The integration of pen and touch as well as the possibility to excerpt text from analog sources is a good starting point for the development of this thesis' prototype.

LivePaper

A system with a comparable technical setting, which offers similar functionality, is *LivePaper* [49]. With *LivePaper* digital contents are also projected next to and onto physical media and the interaction with the system is realized using pen and touch. In contrast to *DigitalDesk*, *LivePaper* supports remote live collaboration. Therefore it excerpts the writing from a sheet of paper on the one desk in real time and projects the written stuff on another sheet on a remote desk. In addition the system offers the possibility to create links between digital and analog media so that both types of media can be related to each other. Features of *LivePaper* which are especially interesting for this thesis'



(a) The *LivePaper* system in use.

(b) Collaborative drawing via the remote live collaboration application.

Figure 11: *LivePaper* [49]

prototype are the projections onto physical media and the possibility to link digital and analog media.

Pictionaire

Another system that uses a top-down projection to augment paper and other physical objects is *Pictionaire* by Björn Hartmann et al. [23]. The interaction with the system is realized using pen and

touch as well as mouse and keyboard. The goal of *Pictionaire* is to enhance "creative collaboration across physical and digital artifacts" [23, p. 421]. Therefore it offers the possibility to execute hybrid copy & paste operations from digital to analog media and vice versa. To create a digital copy of a paper-made sketch users execute a simple drag-off gesture. The other way, the creation of an analog copy of a digital artifact, is performed by snapping a digital, projected image on a physical surface like for example a sketch-book. Afterwards it is possible to treat the digital content like an analog sketch. You can for example move the image with the paper or edit the image on the paper. Additionally it is possible to capture images of physical objects located on the desk and project them onto the desk. If then a captured image is touched, the according physical object is highlighted. In the

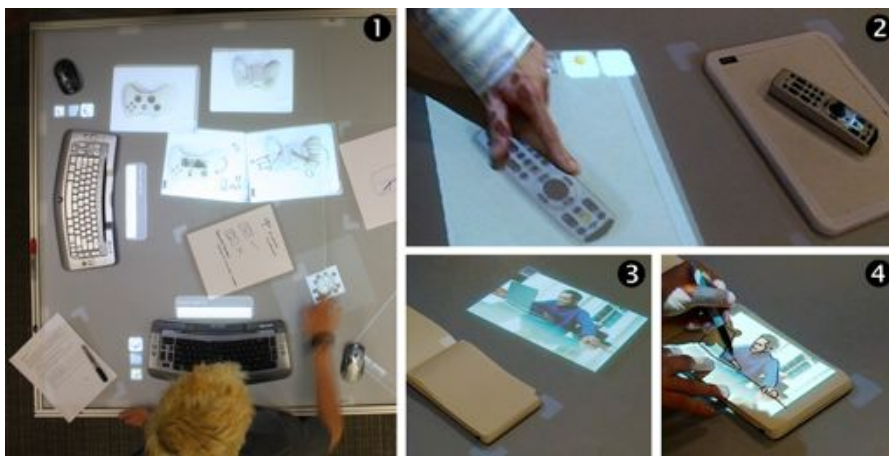


Figure 12: The *Pictionaire* system in use (1). Highlighting of a physical object when pressing its captured image (2). Copy & paste a digital image to an analog surface (3 and 4) [23].

context of this thesis the realization of a hybrid copy & paste operation from digital to analog and vice versa is an interesting inspiration. Furthermore the highlighting of physical objects when pressing its digital representations can serve as a first idea concerning the key requirement of reference backtracking. This function shows how a reference between the digital (the captured image) and the real world (the physical object) can be implemented.

A research work which realizes a similar concept is the project *Shared Design Space* by FH Hagenberg [22]. They also realized a system which allows the collaborative editing of sketches over the border between digital and analog media.

WikiTUI is another top-down projection system which has the goal to integrate digital media into physical paper books [61]. The authors want to create the possibility to "access the digital world through fingertip interactions on books" [61, p. 109]. Therefore traces are projected onto a physical book. The kinds of traces projected on a book depend on the user. For example they are adapted to the user's language. If

Shared Design Space

WikiTUI

the user taps on one of the traces, the systems projects information onto the desk next to the physical book (see left side of [Figure 13](#)). An interesting functionality of this system is the possibility to access

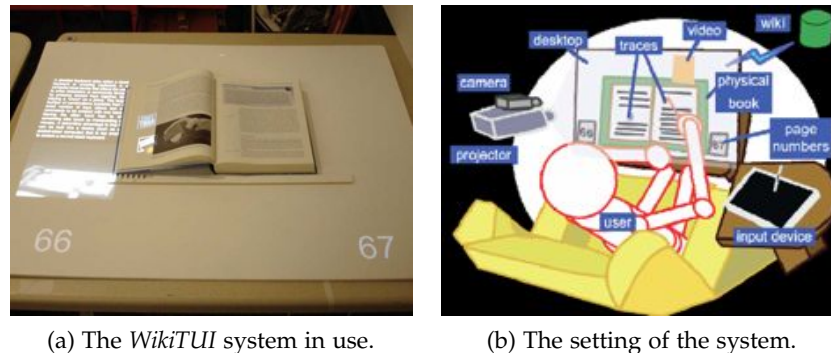


Figure 13: WikiTUI [61]

additional information about the contents of a physical book. This information is presented digitally and in dependence of the location of the book.

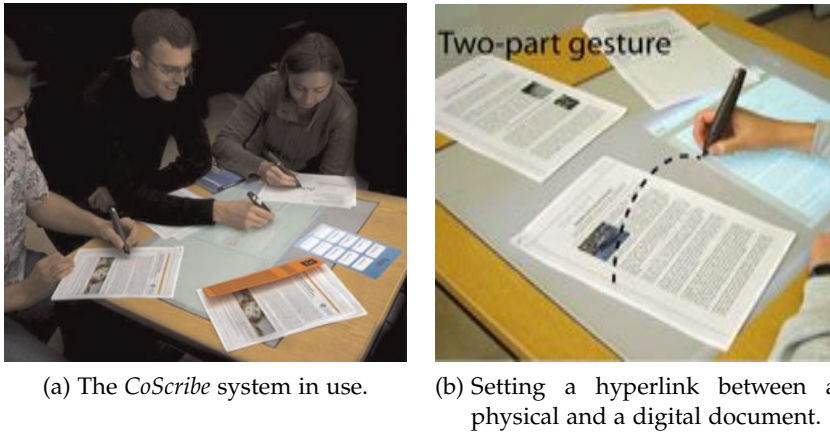
Comparable works are *EnhancedDesk* [37] and the research project *Hybrid Documents Ease Text Corpus Analysis For Literary Scholars* [8], which also enhance physical books with digital information. In contrast to *WikiTUI* these systems are tabletop systems. Due to the setting of tabletop systems, it is impossible to project digital content onto a physical artifact. Therefore the digital information always refers to the entire opened page of a book.

CoScribe

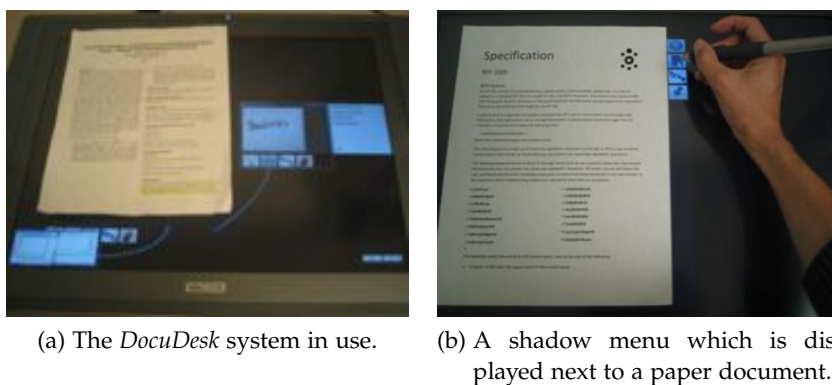
Another tabletop system which tries to fuse the digital and analog desk is *CoScribe* by Jürgen Steimle [56]. The application offers "cross-media support for annotating, linking and tagging printed and digital documents" [56, p. 93]. An important attribute of the system is the unified pen-based interaction with a document, no matter if printed on paper or digitally displayed on the tabletop. Thus it is possible to mark or annotate text passages in digital or analog documents with the same device. In addition the system allows the linking of text passages within, as well as in between digital and analog documents. The inspiring aspect of the system is the cross-media support of different low-level activities of knowledge work using a unified interaction technique and the same pen to interact with digital and analog documents.

DocuDesk

A research project which also offers the linking between digital and analog documents is *DocuDesk* [14]. It "provides several interactions for establishing many-to-many links amongst paper and digital content" [14, p. 4]. In contrast to *CoScribe* the paper documents themselves are not interactive. *DocuDesk* displays a shadow menu next to a paper document on the tabletop, which allows the linking to digital content and other paper documents. The defined links are

Figure 14: *CoScribe* [56]

used to "quickly rehydrate task state when an associated document is placed atop the desk" [14, p. 4]. If an already edited paper document is placed atop the tabletop the linked digital contents and the links to other paper documents located on the desk are again displayed by the system. The adaption of the displayed digital content according

Figure 15: *DocuDesk* [14]

to detected analog documents is an interesting concept in the matter of this thesis.

4.2 PAPER USER INTERFACES

In this sub-chapter another kind of research projects is presented. In contrast to the works shown in the previous chapter these projects do not have a desk with a projector or a tabletop as a base. The user interface is the paper itself. This kind of systems generally enhances paper with digital qualities by directly projecting supplementary information on it. The interaction with the system happens directly on or with the paper.

Fact A part of this kind of projects is *Fact* by Liao et al. [41]. Its setting consists out of a camera-projector unit which is pointing directly on a paper document. The system allows a user "to issue pen gestures on the paper document for selecting finegrained content and applying various digital functions" [41, p. 361]. One of these functions is a digital full-text search in a printed document. After initially marking the word to search for, every of its occurrences are highlighted in the full-text (see 3 and 4 in Figure 16). In addition *Fact* offers features



Figure 16: *Fact* prototype (1), close-up of the camera-projector unit (2), digital full-text search (3 a. 4) [41, p. 361].

which support cross-media interaction. One is the possibility to mark text or and image on a physical paper and copy the marked content to a digital document on a laptop. Thereby the link to the original document is kept. Moreover the system can project a trace next to a word, which is described in a Wikipedia article. When the trace is tapped the corresponding article is opened on a laptop. The final cross-media feature of *Fact* is the synchronous navigation on a map and a laptop. In this scenario the user points with a pen on a physical map. On the synchronized laptop a street view of the actual location at the according street is displayed. *Fact* presents some ideas for the

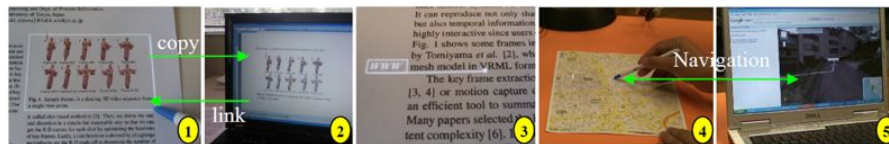


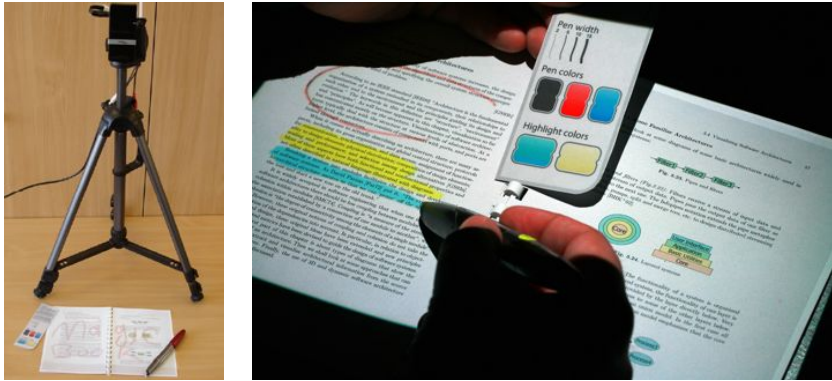
Figure 17: Copying from paper to laptop (1 & 2). A Wikipedia page annotation for the word "VRML" (3). Synchronous navigation on a map and a laptop (4 & 5) [41, p. 367].

concepts of this thesis' prototype: the excerption of text, the linking of digital content to analog documents and the projection onto analog documents. Especially the realization of a digital full-text search as a part of the key requirement reference backtracking is a remarkable piece of work.

Projective Augmented Books

The research work *Projective Augmented Books* has a similar hardware setting like *Fact* [7]. An integrated pico projector displays information onto the pages of a physical book. The interaction with the book is realized using a digital pen and paper technology. For that reason digital marks and annotations can be drawn on the physical book. Contrary to *Fact*, *Projective Augmented Books* is not using an additional pc, on which the various functions of the system can be

triggered, but a paper palette that serves as a user interface. Via the paper palette the user can select functions to look up words in a dictionary or translate them, to copy content to scrapbooks and to share information by sending them with email. The scrapbook, in which the user can paste selected content, is digitally available and can be accessed using a pc or a laptop. The combination of a digital pen and



(a) The setup of the prototype. (b) A user marking text with the digital pen and using the paper palette.

Figure 18: *Projective Augmented Books* [7]

paper technology and a projection to augment paper used to realize *Projective Augmented Books* can be taken as a first reference point for the realization of this thesis' prototype. Although this approach employs easy-to-use technologies, the result seems to be appropriate in matters of the visualization and the interaction with the prototype.

A different approach on how to use paper is shown by the research project *PaperWindows* [27]. Holman et al. try to simulate the use of digital paper displays by projecting windows on physical paper. The system uses paper as an input device by tracking its motion and shape as well as the manipulations performed with a paper (collocate, flip, point, staple, etc.). In addition *PaperWindows* can be operated using pen- and touch-input. With these interaction techniques a range of activities is enabled: copying windows from your computer to paper and back, navigating through content on various paper displays, copy & paste content between paper displays and annotating content on a paper display. In the context of a digital enhanced workplace this system shows what is possible with the digital augmentation of paper.

PaperWindows

Another work which even goes further with the use of paper augmentation is *PaperLenses* [54]. This project allows the exploration of three-dimensional projections in real world by moving "paper lenses".

PaperLenses

PapierCraft by Liao et al. also uses paper as a user interface but in contrast to the other systems presented in this chapter it is not projecting graphical content on the paper [40]. The system is a "gesture-based interface that allows users to manipulate digital documents

PapierCraft

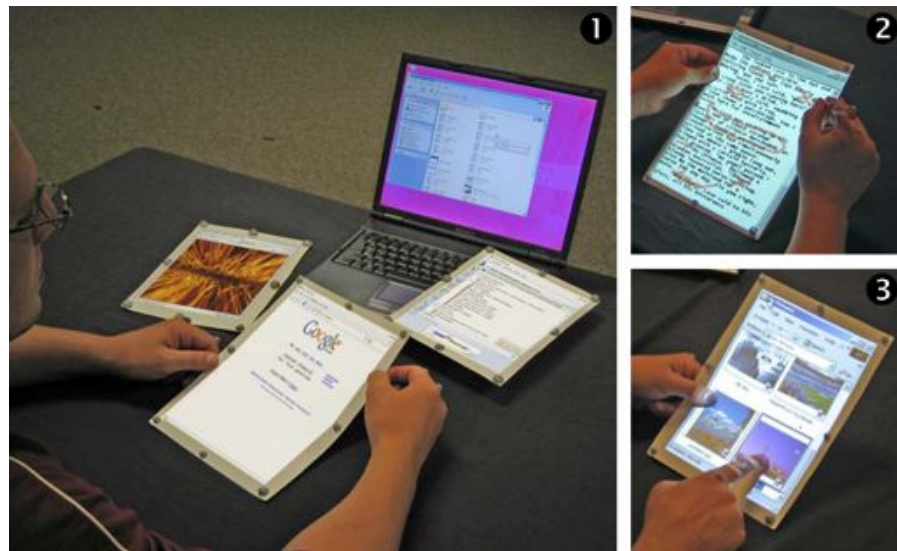
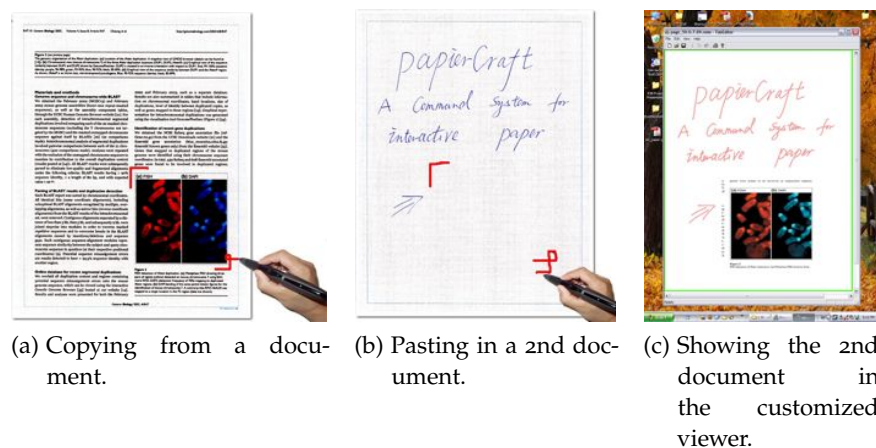


Figure 19: *PaperWindows* in use (1). The annotation of a digital paper display with a pen (2). The selection of contents on a digital paper display (3) [27].

directly using their printouts as proxies" [40, p. 241]. This means the user can edit a digital document by annotating its printed copy. Moreover the system offers several command gestures to indicate operations. The possible operations are copying a document area, pasting an area previously copied and creating a link between passages of the same document or two different documents. The infrastructure of the system executes the various commands on the digital document and presents the result in a customized viewer. *PapierCraft* presents



(a) Copying from a document. (b) Pasting in a 2nd document. (c) Showing the 2nd document in the customized viewer.

Figure 20: *PapierCraft* [40]

another approach on how to use paper as an interface which offers high potential concerning the mobile use of paper. With this thesis' prototype, the use of gesture-based commands is an additional learn-

ing effort for the user which becomes redundant by the projected visualizations.

4.3 VISUAL INFORMATION ARCHIVES

One important aspect of knowledge work is the archiving of acquired information in a way they can easily be re-accessed. This fact was emphasized by the law students who participated in the survey and the questionnaire of the requirement analysis. They complained for example about the difficulty to recall already acquired knowledge no matter if it is stored on paper or on electronic devices. Storing huge amounts of information in files and directories is not supporting the functioning of knowledge workers, especially when it comes to re-access special information out of the muddle of files and folders. Since "knowledge work involves finding and re-using previously seen information" [13, p. 72] there are different approaches in research on how to simplify this task. Exemplary we present three of these approaches: tag-based document management systems (e.g. *Presto*¹⁰, *WinFS*¹¹), prototypes which search documents based on associated information (e.g. *Stuff I've Seen*¹², *Feldspar*¹³) or systems which access information through visual representations. Due to the visual character of the prototype the focus of this sub-chapter is on the latter. The following works are reviewed on the basis of finding ideas for the key requirement knowledge archiving. Therefore the different systems are checked in the matters of fast retrieving of already acquired information and the easy semantic grouping and clustering of information.

The first system which fits in this category is *MediaFinder* by Kang and Shneiderman [33]. *MediaFinder* is a personal media management tool which uses semantic regions to organize and retrieve media content. Semantic regions are rectangular fields which enable users to specify a mental model concerning a special type of media. A semantic region stands for example for a place or a time a photo was taken. In *MediaFinder*, users can apply several semantic regions simultaneously to search their media collection. In Figure 4 12 three conceptual models, the US map, a quarter year calendar and a friends group are combined. All of these semantic regions show the same photos. By applying several mental models onto one media collection it is easier for the user to relocate a special item of interest. This ability of

MediaFinder

10 P. Dourish et al., "Presto: an experimental architecture for fluid interactive document spaces", ACM Transactions on Computer-Human Interaction, vol. 6, no. 2, pp. 133-161, Jun. 1999.

11 <http://msdn.microsoft.com/de-de/library/aa480687.aspx>

12 [13]

13 D. Chau et al., "What to do when search fails: finding information by association", Proceedings of CHI '08, pp. 999-1008, 2008.

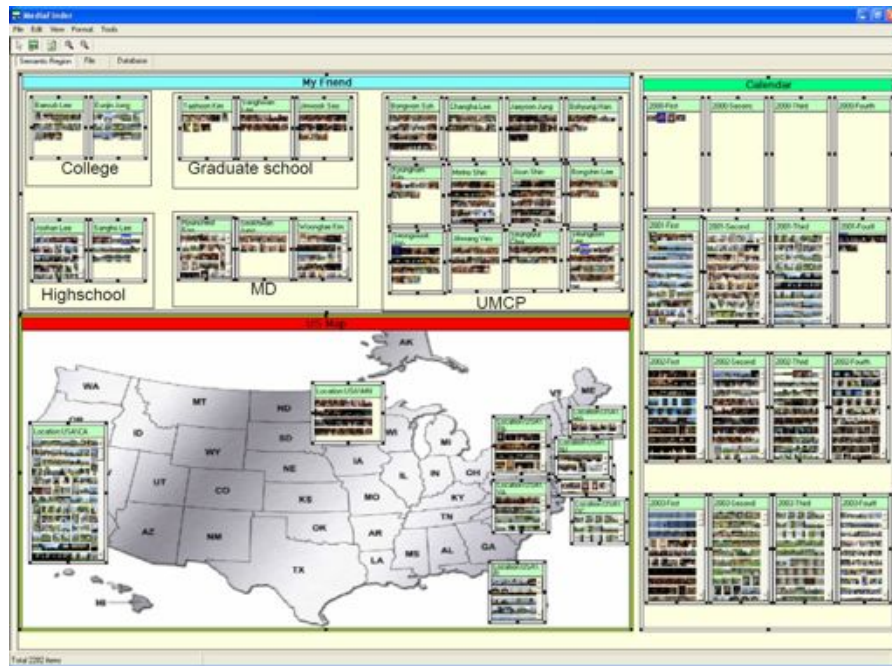


Figure 21: Three semantic regions, friend groups (on the top left), quarter year calendar (on the right), and US map (on the bottom left) combined together in *MediaFinder* [34, p. 17].

the system is interesting concerning the fast retrieving of gathered information.

Data Mountain

A system which takes advantage of the human spatial memory to access information is *Data Mountain* by Microsoft Research [50]. It is an alternative favorites mechanism for the Microsoft Internet Explorer, which allows "users to place documents at arbitrary positions on an inclined plane in a 3D desktop virtual environment using a simple 2D interaction technique" [50, p. 153] (see Figure 22). The idea behind the system is as follows: With *Data Mountain* a user does not need to search the whole list of favorites to find a desired website, as it is in the classic Microsoft Internet Explorer favorites management. Instead he can restrict the searched space due to his spatial memory and, for example, only search the upper right corner of the three-dimensional environment. The authors evaluated this idea in a user study by comparing *Data Mountain* with the favorites mechanism of Microsoft Internet Explorer. The study shows that *Data Mountain* has "statistically reliable advantages" [50, p. 154] over the Microsoft Internet Explorer favorites mechanism according to the number of incorrect retrievals and the time needed to retrieve a web page. In matter of the key requirement knowledge archiving, the study of *Data Mountain* emphasizes the spatial organization of gathered information. Spatial organization not only supports semantic grouping and clustering of information but, as the study has shown, the fast retrieval of already acquired information.



Figure 22: Browser favorites mechanism of *Data Mountain* [50, p. 153].

Another system which visually archives information is *Freed* by Mendels et al. [45]. The system "enables design students to spatially organize their digital collection, define relations between collection content and reflect on it" [45, p. 1481]. Therefore the students can apply different nodes displaying their digital design items and relate them to each other using differently styled connectors. As a result students obtain a map or path, which present their digital collection in a visual way. The main advantage of the system is the possibility to create different views of a digital collection. "A view is a spatial organization of a selection of the collection content and its relations" [45, p. 1481]. Students can for example create different views for different purposes: a view for the own usage, another view for public presentations, etc. To see the differences and the relations between the different views of one digital collection view switches are animated. Content of both views is gradually animated while the other content either fades in or out. Though it is out of the scope of this thesis switching views on the same base of information is an interesting concept. In the context of this thesis the spatial organization of information and the concept of relating information items to each other using connectors are of special interest. The resulting mind maps not only help finding stored information by taking advantage of the human spatial memory, but also are useful to explore new subjects, record and take notes, reflect on ones thought processes and look for patterns when synthesizing information [15]. As these activities should be supported with this thesis' prototype, mind maps seem to be an appropriate tool for the archiving of information. An additional fact which supports the usage of a mind map is the amount of commercially available mind map applications (e.g. XMind¹⁴, mindmeister¹⁵,

Freed

¹⁴ <http://www.xmind.net>

¹⁵ <http://www.mindmeister.com/>



Figure 23: One view of a digital collection in *Freed* [45, p. 1484].

Docear¹⁶). This means that users generally have accepted mind maps as a tool to organize their information and are aware of their benefits.

¹⁶ <http://www.docear.org/>

This chapter covers the design of this thesis' prototype. As the prototype will not be a graphical user interface running on a desktop pc but a physical environment supported by ubiquitous computing, the frameworks for the design of post-WIMP interfaces, Reality-based Interaction and Blended Interaction (see [Section 2.2](#)), are applied to guide the design process. The key requirements defined during pre-study (see [Chapter 3](#)) and the design implications for systems within the domain of knowledge work (see [chapter Section 2.1](#)) are taken as the base for the development of the hardware setting and the features of the prototype. In addition the previously presented related work (see [Chapter 4](#)) is used as inspiration on how to realize the key requirements. The design of the system was conducted in four stages:

1. *Paper-based sketches*
2. *Hybrid sketches*
3. *Narrative storyboard*
4. *Realization as prototype*

At the stage of paper-based sketching initial ideas on the realization of the key requirements have been drawn on paper. After iteratively discussing and evaluating the sketches, the best ideas have been implemented as hybrid sketches. In their book, *Sketching User Experiences - The Workbook* [20], Greenberg et al. use the term hybrid sketch for the combination of sketched elements with a photo. This sketching technique helps designers to easily add details to sketches. Those details make the sketches easier to understand because the context of use is emphasized by showing the surrounding environment (c.f. [20, p. 127]). The approach of hybrid sketching is to take a photo and sketch the systems functionality onto this photo¹⁷. In contrast to this approach we firstly sketched the user interface or a certain feature of it, displayed the sketch on a tabletop pc and then took a photo of a person who pretends to use the system. As a result the sketch appears even more realistic because it is hard to distinguish if it is a sketched or a real user interface (see sketches on the top right and the bottom right of [Figure 24](#)).

After discussing and evaluating the hybrid sketches again the best

Design process

Paper-based sketching

Hybrid sketching

Narrative storyboard

¹⁷ For example a person looking at a train schedule app on a smartphone is sketched in a photo of a train station.

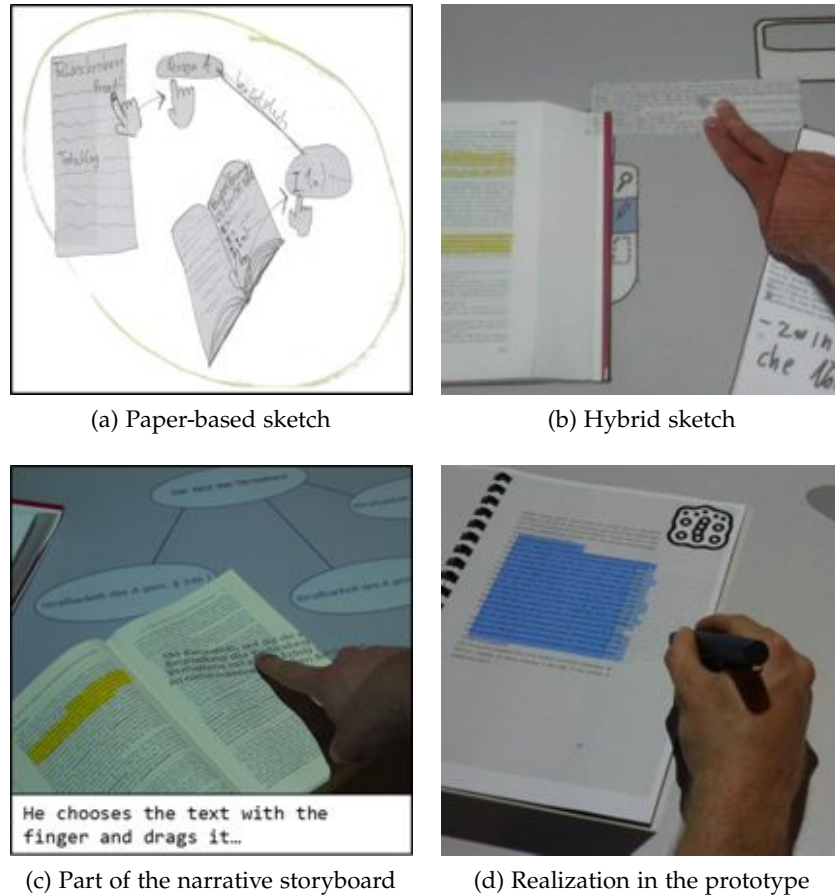


Figure 24: Design process of the text drag gesture

ideas have been taken for the use in a narrative storyboard¹⁸. A narrative storyboard "uses a sequence of images to tell a more complete story about people's interaction over time" [20, p. 167]. To get a deeper understanding on how a system works it pictures the system's environment or it tells the thoughts and the intention of a user. This thesis' narrative storyboard tells the story of a law student who solves a legal record using Integrative Workplace¹⁹. It was designed in addition to the hybrid sketches to motivate discussions with usability and domain experts. The narrative storyboard helped usability experts to understand the domain and domain experts to understand the technology-based concepts which should support their working practices.

Experts evaluation

The group of usability experts consists out of research assistants and the professor from the department of human-computer interaction at University of Konstanz. They generally liked the concepts in matters of usability and interaction design. The participants of the group of domain experts were a professor of law and a field librarian

¹⁸ The narrative storyboard can be seen in [Appendix A](#).

¹⁹ Integrative Workplace is not only the title of the thesis but the name of the prototype.

for law, both working at University of Konstanz. They felt that the ideas were very helpful and practical. However they indicated that every legal record has a specific sequence of titles, which needs to be examined. Therefore the linearity of this sequence must be reflected in the visualization of Integrative Workplace. But as the free structure of a mind map also facilitates a linear way of working it was kept as visualization of the prototype.

After adjusting the concepts to some minor improvements the final ideas have been realized in a prototype. With the help of the prototype the design ideas are evaluated in a user study. Figure 24 summarizes the characterized design process at the example of the drag'n'drop gesture performed to drag text from a book to the landscape.

Realization as prototype

The following sub-chapters present the design of the physical setting (see Section 5.1) and the key features of the system (see Section 5.2, Section 5.3, Section 5.4 and Section 5.5) resulting from the literature review and the requirement analysis. For a better understanding the technical implementation of some of the designs is described. For a detailed account about the implementation of Integrative Workplace have a look at the technical report of this master project [19].

5.1 INTERACTIVE DESK

As the design approach is reality-based, the system's environment should be similar to the normal workplaces of knowledge workers. Therefore the base of the physical setting is a table with a high affinity to a common desk. The goal is to design an environment which makes knowledge work possible even without digital augmentation or digital features. Like argued by Sellen and Harper [52, p. 94] as well as by Kidd [35, p. 187] the spatial layout of materials is an important need of knowledge workers. For that reason the table of the system has to have a certain size to be able to for example locate documents next to each other or to build paper piles.

Spatial layout of materials

The key requirement of parallel reading defines that this thesis' prototype needs to offer the possibility to cross-read text passages whether available digitally or analogously. Thus, as well as the table, the digital display has to have a certain size, so that it is possible to situate analog and analog, analog and digital as well as digital and digital documents close to each other and cross-read between those materials²⁰.

Cross-read digital and analog documents

As paper has some inherent advantages concerning knowledge work (see Chapter 1) the goal of this project is to integrate paper into electronic technologies. It should be possible to seamlessly transfer content between books, electronic texts and vice versa. Therefore it is

Real-time feedback on paper

²⁰ Similar to the design implication for software supporting knowledge work "Support for Cross-Document Use" in [52, p. 152].

necessary to give real-time feedback on paper. Real-time feedback on paper is the first of six important aspects for future research in the area of pen and paper user interfaces specified by Jürgen Steimle [55, p. 172]. For that reason the system has no rear projection, like common digital tables, but a top-down projection. In contrast to a rear projection a top-down projection not only allows to display digital information on a table but to augment analog documents with digital contents.

*Same input devices
for real and virtual
texts*

For an easy transfer of contents between books and electronic texts similar interaction techniques and input devices shall be used to process real and virtual texts in a same manner. Due to the reality-based design approach the selected input devices are pen and touch. Touch facilitates an easy interaction because it utilizes the people's "common sense knowledge of the physical world"²¹. In the case of Integrative Workplace users know from the real world that objects can be moved by touching them. Using a pen is a highly developed body skill which most of the people are familiar with since they start learning to write or to draw²². Because the system accesses this body skill the learning effort to be able to interact with the system is further reduced. With the combination of pen and touch knowledge workers are able to interact with the new system in the same way they interact with artifacts on common desks. They can move digital documents with their hands or process digital text using a pen. In addition other established working practices, for example the reorientation of paper during writing [10, p. 51], can be adopted into the interaction with the new system.

*Development
process of the
interactive desk*

Due to the above mentioned requirements a first 3D sketch of the interactive desk was designed. In [Figure 25](#) you can see a projector to

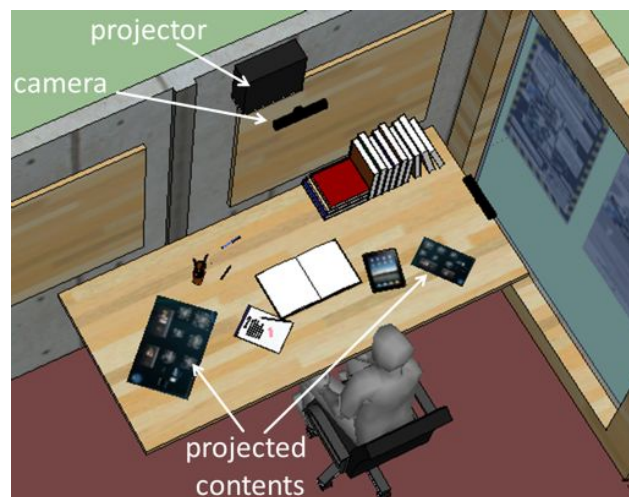


Figure 25: 3D sketch of the interactive desk

²¹ The concept of the *Reality-Based Interaction* theme "Naïve Physics" [30, p. 202].

²² The concept of the *Reality-Based Interaction* theme "Body Awareness and Skills" [30, p. 202].

digitally augment table and documents and a camera to track the documents on the table and the fingers of the user. The table has the measures of a typically sized desk and thereby supports the spatial layout of materials. On the table the projected contents are situated next to a book, a paper, and a tablet. This enables cross-reading between digital and analog media. This sketch was the base for the development of the first prototype of the interactive desk. In the first prototype the

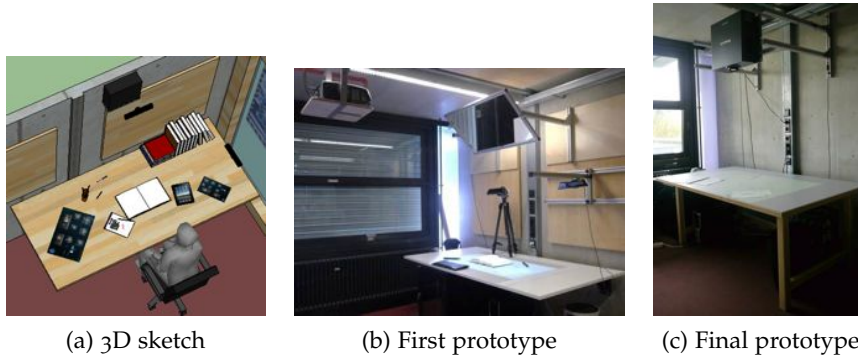


Figure 26: Development process of the interactive desk

projection was deflected via a mirror to get a bigger display on the table. The pen input was realized using *Anoto*²³ technology and the touch input was detected by two depth cameras. Because the touch detection using depth cameras did not work properly this technology was replaced with a special table developed for pen and touch interaction. The schematic setup is shown in Figure 27.

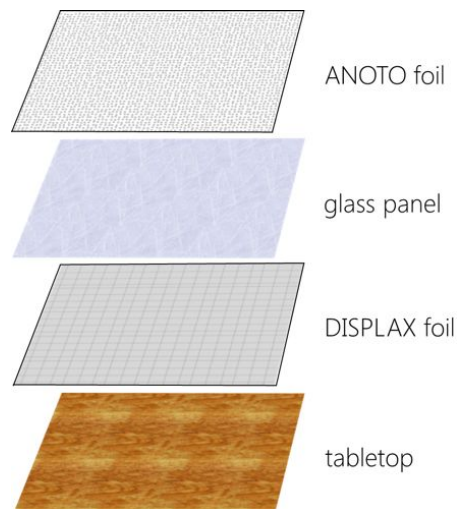


Figure 27: Layers of the table

Above the tabletop a foil²⁴ is mounted, which detects touches on the basis of capacitive voltage differences. On this foil a glass panel

²³ <http://www.anoto.com/lng/en/mode/sublist/documentId/1150/pid/480/>

²⁴ <http://www.displax.com/en/products/products/skin-multitouch.html>

is situated, which serves as dielectric and regulates the voltage difference in-between a measurable range. Overhead, a foil imprinted with the *Anoto* pattern is affixed. This pattern enables the position detection of *Anoto* digital pens on the tabletop.

In the final prototype the mirror was replaced with a wide-screen beamer. The beamer directly is projecting contents onto the desk with a special daylight technology. This results in a sharper and wider display²⁵.

5.2 A LANDSCAPE FOR VISUAL INFORMATION ARCHIVING

*Recall of
information*

Like quoted before "knowledge work involves finding and re-using previously seen information" [13, p. 72]. Because of the visual character of the prototype the recall of already acquired knowledge is supported by a visual information representation. The base of this representation forms a 2.5 dimensional digital information landscape which is projected on the surface of the interactive table. Its size is bigger than the size of the actual desk and can be panned and zoomed to change the part which is visible on the display of the table. With increasing the size of the landscape in comparison to the desk the spatial layout of materials, one of the design guidelines, is even better implemented.

*Taking advantage of
the human spatial
memory*

The idea behind the information landscape is to spatially arrange visually displayed information items at different positions on the landscape. The study of the research project *DataMountain* showed that due to the human spatial memory the retrieval time of spatially organization information is reduced (see [Section 4.3](#)). By using a spatial landscape the user interface takes advantage of the human spatial memory when it comes to the relocation of deposited information. Another advantage of the use of a spatial information landscape is the possibility to place digital artifacts at different angles and positions on the landscape. This is one of the preconditions defined by Sellen and Harper to support the interweaving of reading and writing on digital devices. In their study they conducted that people are placing a display at different angles when reading than when writing. With the possibility to place the document to write on at another angle and position on the landscape than the document to read from, the prototype fulfills this precondition.

Mind mapping

The visualization which is graphically presenting the information items located on the spatial landscape shall provide a "flexible environment for presenting a problem in ways which make it readily accessible to human mind" [35, p. 190]. The tasks which are implied in knowledge work generally are unstructured thus it is important that a user interface does not try to provide the structure that is lack-

²⁵ For more information on the technical implementation of the hardware setting see chapter 2.1 in the technical report [19, p. 7].

ing in the task itself [6]. For the visualization this means to choose a graphical representation which allows the knowledge worker to structure information items himself. An appropriate form of visualization which fulfills these requirements is mind mapping. Besides offering structural freedom, a mind map has the advantage to help users exploring new subjects, recording and taking notes, reflecting on ones thought processes and looking for patterns when synthesizing information [15]. Furthermore mind maps should emphasize the effect of human spatial memory for the fast retrieving of information by providing the possibility to connect information items and thereby semantically group or cluster them²⁶. Another fact which emphasizes the usage of mind mapping comes from the examination of the working methodology of law students. When solving a civil law record students draw a sketch showing all legal persons who are involved in a particular case. These sketches are very similar to mind maps (see Figure 7).

Different visualizations for different kind of information items have been designed for the mind map. These items each have a different meaning and an associated functionality (see Table 1).

Mind map items






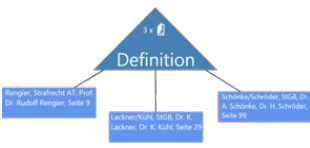
ITEM	DEFAULT VIEW	DETAIL VIEW
Dummy		-
Header		-
Excerpted Text		
Definition		

Table 1: Visual items of Integrative Workplace's mind map

The *Dummy* item supports the spatial clustering of other visual items. It was designed to be able to cluster information which cannot

²⁶ Semantic grouping and clustering of information is part of the key requirement of knowledge archiving.

yet be categorized by a common header. In contrast to the *Dummy* the *Header* was composed to be able to cluster information under a mutual term. The item *Excerpted Text* represents an excerpted text passage. In the default view the reference of the passage is displayed. The detail view shows the extracted text passage itself. Furthermore it is possible to use *Excerpted Texts* to write own notes in its detail view. These notes can be written with the keyboard or the digital pen²⁷. *Definition* was designed on the base of complains about a missing possibility to easily re-use definitions of juristic terms (see Section 3.4). The item allows you to encapsulate different items of the type *Excerpted Text*. If you tap the *Definition* item all connected *Excerpted Text* items get hide. If you tap it another time the items are shown again.

Focus and context views

When displaying the mind map visualization on the information landscape the idea is to show an overview of all applied mind maps on the smallest zoom level (see Figure 28). In the case of law students writing seminar papers each mind map for example shows the solution sketch for a legal record. In a first prototype the idea was to

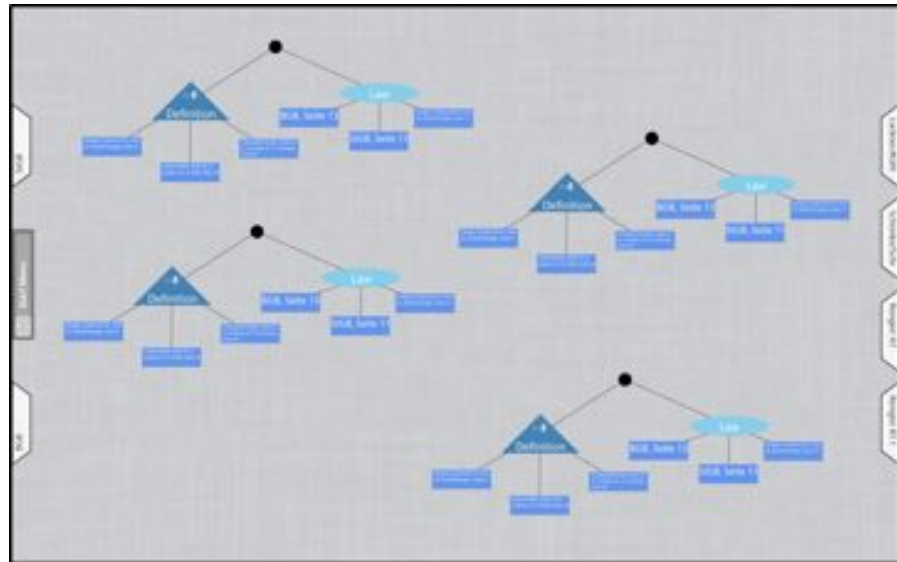


Figure 28: Overview of several mind maps

change between default and detail view of an item with the help of semantic zooming. This means to fade in to detail view and fade out to default view on a certain zoom level. With this technology you can either see all items in detail view or all items in default view. Because it is not possible to see one item in detail view and keep the context of this item another mechanism was chosen to switch between views. The design to change between default and detail view in the final prototype is based on two of the interface schemes for switching between focus and context views examined by Cockburn et al. [5]

²⁷ The handwritten summarization of text is part of the key requirement excerption (see Section 3.4).

zooming which uses temporal separation and cue-based techniques which selectively highlight or suppress items within the information space. In Integrative Workplace zooming is used to change the focus on the information landscape and thereby the area you are working on (see the left side of Figure 5.7). Cue based techniques are used to trigger the switching between default and detail view of a mind map item by touching it. Thereby the context of the item is kept (see the right side of Figure 29).

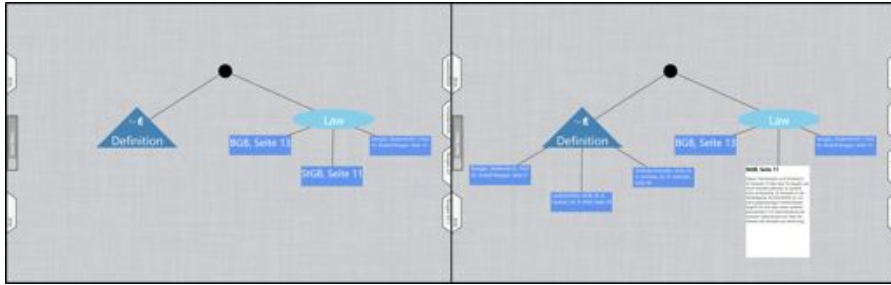


Figure 29: Focus and context view of the mind map.

To create the mind map in a reality-based way the different items and connections between the items are drawn using the digital pen. This was designed on the base of a general design guideline:

Design guideline for pen and touch interaction

Every interaction which leaves ink traces on the user interface, that means somehow changes the visualization of the UI, is performed by a pen²⁸.

In a user study Frisch et al. investigated how people edit node-link diagrams on an interactive tabletop (Frisch et al. 2009). Therefore participants were asked to perform spontaneous gestures for creating, moving, and deleting diagram elements. They could interact with the system using one hand, both hands and a pen. On the base of different metrics Frisch et al. present two common gestures for each task. One gesture which supports diagram sketching (e.g. draw an edge with a pen or a finger) and another gesture which supports structural diagram editing (e.g. dragging an element from a tool menu). Because a mind map in general is a node-link diagram the results are highly relevant for this thesis. Table 2 shows that either the structural editing-gesture or the sketching-gesture defined by Frisch et al. is equal to the gesture used to interact with the mind map. This validates the interaction design of Integrative Workplace. The only slight difference can be seen in the case of deleting a node or an edge. Frisch

Gesture comparison

²⁸ This guideline was preserved for the complete implementation of the prototype, but for two exceptions. One exception is the movement of marked text. This was technically only possible to realize using the digital pen. The other exception is the interaction with web pages. As the juristic online database is designed for mouse interaction, it is not possible to properly operate the page with the finger. Therefore the pen was specified to select hyperlinks, etc.

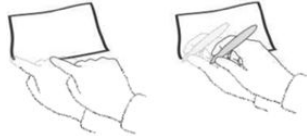

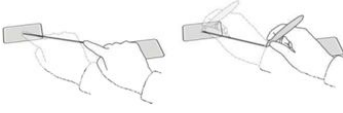

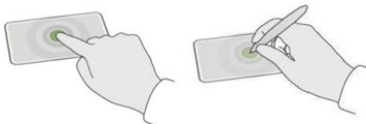





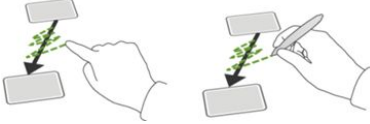

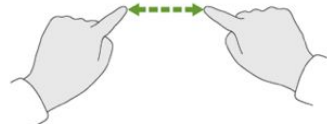

Task	Gestures defined by Frisch et al.	Gestures of Integrative Workplace
Create node		
Create undirected edge		
Select single node		
Move single node		
Delete node		
Delete edges		
Zoom whole diagram		

Table 2: Equivalent gestures of Frisch et al. [17, p. 154] and Integrative Workplace. Gestures of the type *diagram sketching* are identified by white hands and gestures of the type *structural diagram editing* are identified by gray hands.

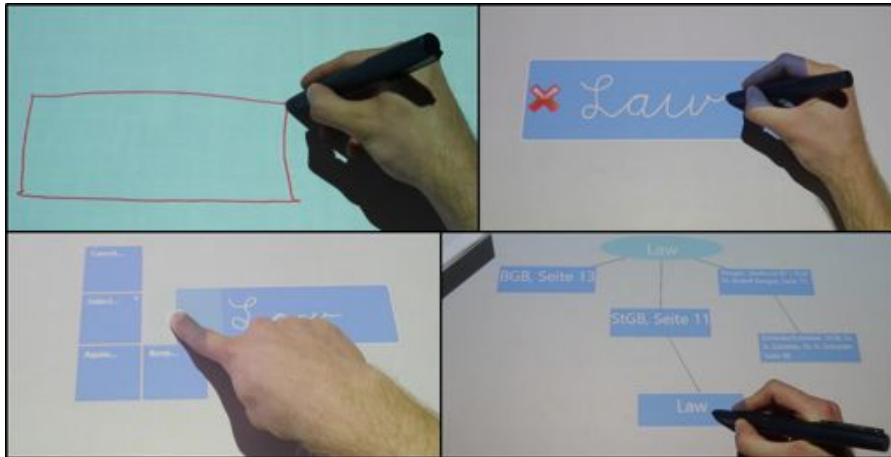
et al. use a wipe gesture while in this thesis' mind map a single stroke is sufficient.

Create a mind map item

For a better understanding of the functionality of the mind map [Figure 30](#) shows the workflow to create a mind map item, to write on a mind map item and to connect the new item with a mind map. Thereby the designed workflow is contrasted with the implemented workflow. As the recognition of handwritten text in nowadays technologies still is prone to errors, it can happen that written words are



(a) Hybrid sketch



(b) Prototype

Figure 30: Workflow to create, write on and connect a mind map.

not always recognized. To minimize this error the prototype, after writing a word, shows a control which allows the user to select one of several recognized words. If none of the shown terms equals the actual written word the user additionally has the option to re-write the word.

The possibility to draw controls or to write handwritten text on the mind map items reduces the semantic and articulatory distance of the system in terms of the execution of an action and the evaluation of the according system response [29]. According to Hutchins et al. the semantic distance is the relationship between the user's intention and the meaning of the in- or output expression. In contrast the articulatory distance is the relationship between the meaning of the in- or output expression and its physical form. These distances can be determined for the action performed by a user to interact with a system as well as for the evaluation of the according system response by the user. By using the metaphor of drawing or writing with pen and paper to create a mind map the interaction with the system and the system response corresponds on semantic and articulatory level with the interaction and the response of the real world. This results in a small semantic and articulatory distance for both, the execution of an action and the evaluation of the system response.

In addition to the already mentioned functions the mind map offers

*Semantic and
articulatory
distance*

*Copying a mind
map item*

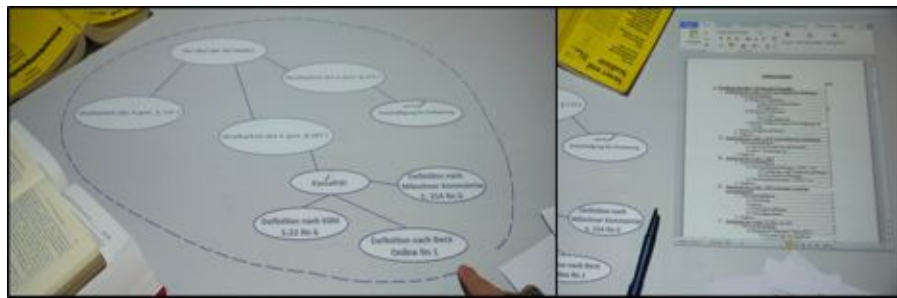
the possibility to copy items. Therefore a user touches one of the items with both hands and tries to pull it apart. Thus the original item is copied and the user moves an item with each of his hands. Following figure visualizes the process.



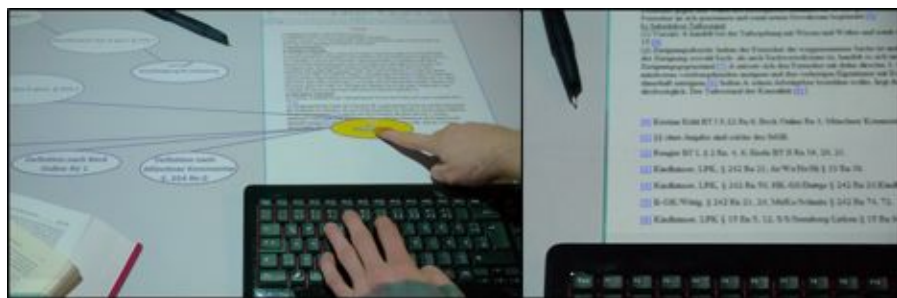
Figure 31: Copying a mind map item

*Not implemented
concepts*

Several other ideas have been developed during the design process of the system but have not been implemented due to their high implementation effort. Two of them can be seen in the next figure. You can see the designed sequences of interaction for exporting a table of contents out of a mind map (see [Figure 32a](#)) and for using a juristic definition inside a word processor (see [Figure 32b](#)).



(a) Exporting the table of contents for a seminar paper from the system.



(b) Using a definition of the mind map in the seminar work.

Figure 32: Unimplemented concepts

5.3 EXCERPTION FROM ANALOG AND DIGITAL SOURCES

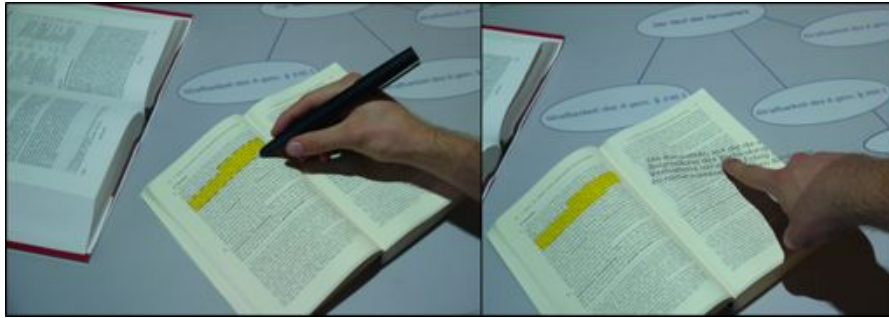
*An easy way to
excerpt text from
digital and analog
sources*

The main goal of this thesis is to explore the seamless transfer of text between printed documents and the digital information landscape.

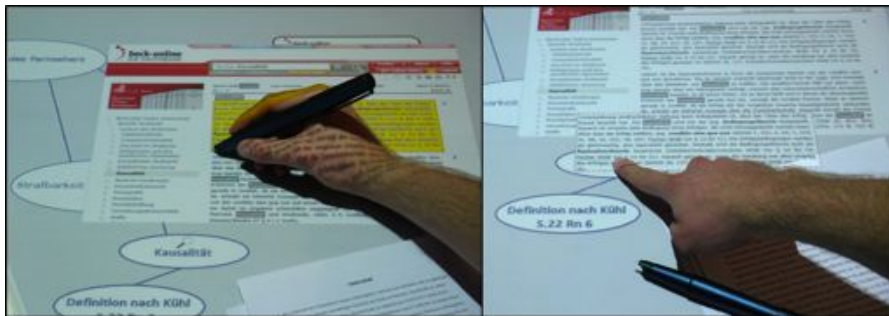
Therefore same interaction techniques and input devices are used to excerpt text from analog and digital media in the same manner. This matches with a finding of the pre-study. Law students required an easy way to extract text from digital and analog media.

On the base of the goal and the finding of the pre-study sketches have been designed, which present a way to realize this requirement (see [Figure 33](#)). After marking a certain passage on a book or a browser

Designed interaction



(a) Excerption from a book



(b) Excerption from a web-page

Figure 33: Hybrid sketches for the excerption of text

with the digital pen, the according text is highlighted. The user can select the highlighted passage and drag it on the information landscape of the prototype. In the moment the user drops the text above the landscape a mind map item is automatically built at the according position.

To excerpt text from a document and add it to the information landscape the system uses the concept of drag'n'drop. Since the early implementations of WIMP-interfaces the drag'n'drop metaphor is used to move or copy content and so can be considered a *well-established digital concept*. According to the theory of Blended Interaction the use of *well-established digital concepts*, like reality-based concepts, supports a user-friendly and intuitive interaction by allowing the user to adopt internalized concepts to operate a system [32].

Drag'n'drop - a well established digital concept

The key requirement of knowledge archiving implies the need to store all information whether from analog or digital sources at the same place. This is realized by the possibility to drop content from digital as well as from analog sources on the information landscape.

Store all information at the same place

Marking method for text

To ease up the use of a pen in matters of marking a text passage a method was chosen which extends the possibilities of a real pen. Therefore the determination of the marked area is based on an approach which has established in mouse operated applications and was chosen the most eligible in a user study about different methods to mark text with a digital pen [3]. The following figure explains the functioning of this method.

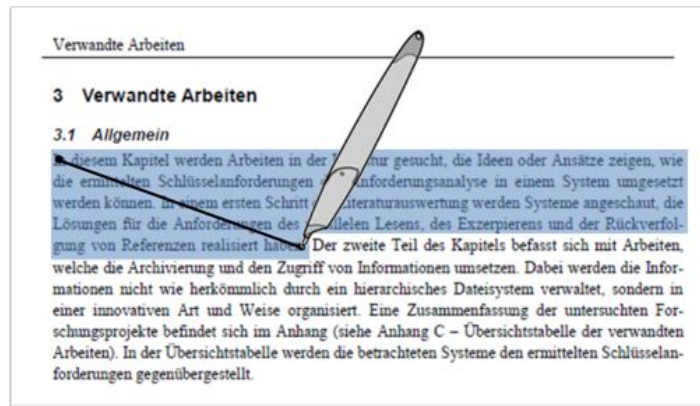


Figure 34: Marking method for text

A user selects text by drawing a line on the according area of a document. All lines of text located between the starting position and the actual position of the pen are marked completely. The last line is only marked up to the position of the pen. With this method it is possible to select single words as well as entire text passages.

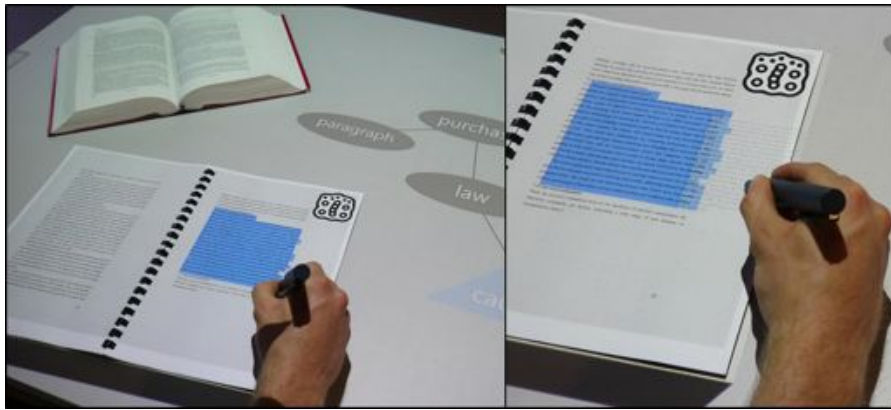
Excerpt of text in the prototype

In contrast to the sketches, it is not possible with the prototype to drag text with a finger from a book to the information landscape. This is due to the fact, that a finger on a book cannot be recognized by the capacitive foil (see chapter 5.1). For this reason the drag'n'drop operation is performed with a digital pen (see Figure 35). In case of the browser, it is possible to drag text with a finger to the information landscape but in matters of consistency the pen is used too.

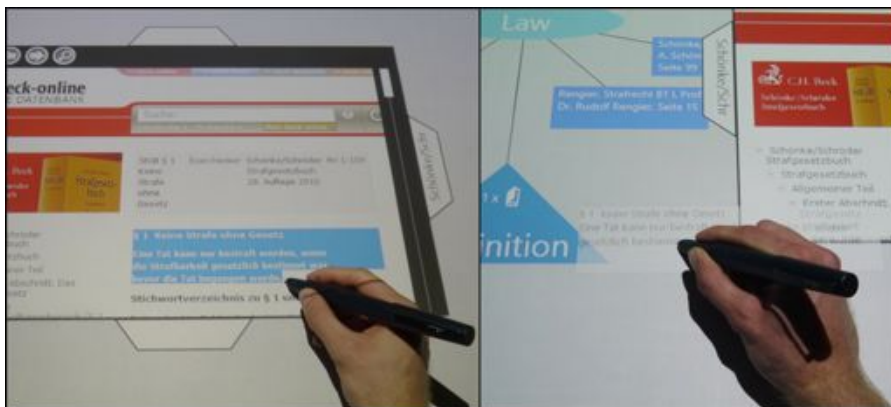
Implementation of document detection

Because the implementation of the document recognition using image processing algorithms would break the scope of a master thesis, the document detection and the interaction on a document are prototyped using different frameworks and tools. To determine the location of a document on the table and its opened page reactIVision²⁹ is used. reactIVision is an image processing framework for tracking markers and recognizing multitouch gestures. The framework is designed for tabletop computers with rear projection. It allows the cost-effective development of multitouch and tangible user interfaces for these systems. reactIVision processes the video stream of a camera and tries to detect specially designed marker with the help of segmentation. In Integrative Workplace such a marker is assigned to every

²⁹ <http://reactivision.sourceforge.net/>



(a) Excerption from a book



(b) Excerption from a web page

Figure 35: The realization of the excerption of text

page of a book. Based on the detected markers the system identifies the position of the documents on the table and their opened pages. Figure 36 explains the use of reactIVision in the context of Integrative Workplace³⁰.

To enable the interaction with printed documents and to access printed text digitally, again Anoto technology is used. Every analog document is imprinted with the Anoto pattern. At the same time their digital representations are parsed and words as well as images are stored as tokens in an XML file³¹. A token comprises the corresponding word or picture and its position on a page. If the digital pen marks a certain area of a page, the positions of its tokens are intersected with the position of the stylus. If a token intersects with

Implementation of the interaction with printed documents

³⁰ For more information on the technical implementation of the document detection see chapter 3 in the technical report [19, p. 18].

³¹ The program for parsing PDF-documents has been implemented by Andreas Wehler, member of the department of Database and Information Systems at University of Konstanz

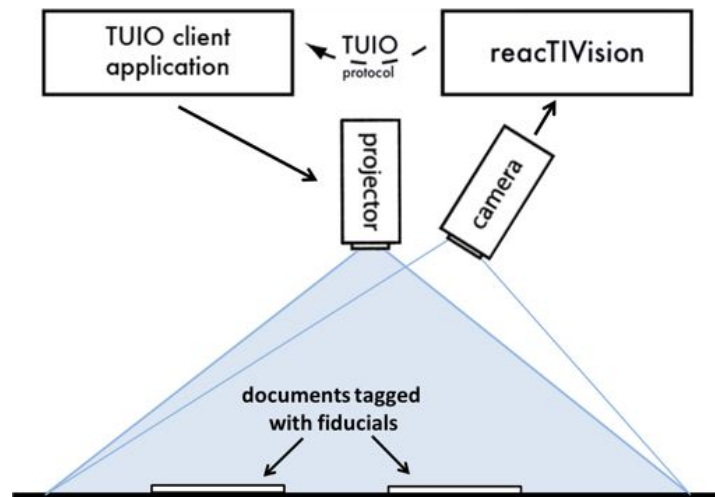


Figure 36: reactTIVision in the context of Integrative Workplace

the position of the pen its content and location is given back to the application (see Figure 37)³².



Figure 37: Excerpt of digital text from printed documents

5.4 FULL-TEXT SEARCH

Merging the advantages of books and digital documents

Sellen and Harper named "fast full-text searching" [52, p. 148] as an affordance of digital devices in matters of knowledge work. Furthermore the key requirement backtracking of references claims for a full-text search in electronic texts and in bounded books. For this reasons a full-text search for books and analog documents is designed for Integrative Workplace. A digital full-text search in printed documents merges the advantages of paper documents concerning the browsing

³² For more information on the technical implementation of the document detection see chapter 4 in the technical report [19, p. 26]

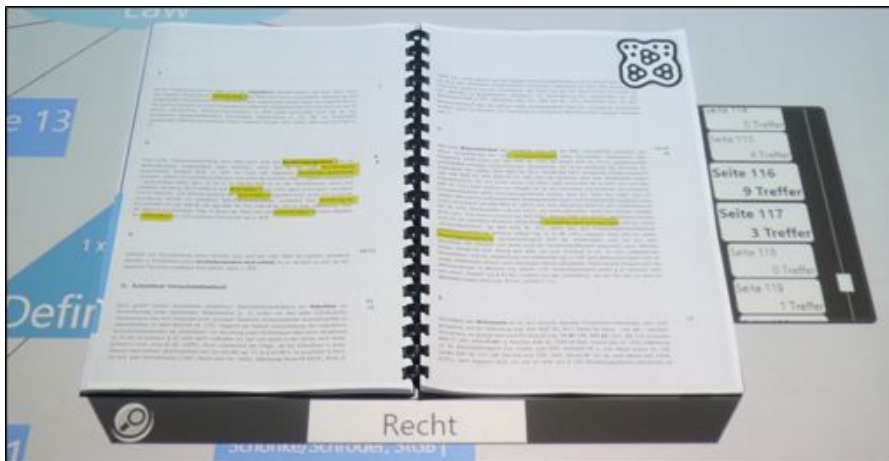
of a document [52, p. 145] with the affordances of electronic technology in matters of keyword searching [52, p. 148].

Figure 38 shows the sketched full-text search and the realization in the prototype. After writing a search term all occurrences of the

*Full-text searching
in the prototype*



(a) Hybrid sketch



(b) Prototype

Figure 38: Full-text search in a book

word are highlighted in the text on the opened page. When a page gets flipped again every matching word is highlighted. On the hybrid sketch the front edge of every page is highlighted, which contains words matching the search term. Because it is very hard to technically implement the highlighting on the front edge of a book, the prototype displays a visualization which shows the number of matching words per page. Users can scroll this visualization, for example to search for pages with a large amount of matches. When flipping to a certain page this visualization is adjusted according to the page on top.

5.5 BACKTRACKING OF REFERENCES

Quick links to related materials

Backtracking of references is one of the key requirements derived in the requirements analysis of this thesis. Its main point is the dissolving of references between citation and source as well as in between different documents. This functionality is named as an affordance of digital devices in matters of knowledge work by Sellen and Harper, because it facilitates "quick links to related materials" [52, p. 148]. With this prototype the goal is to enable quick linking not only for digital but also for analog and in between digital and analog media.

Dissolving printed references

In an early phase of the design process of this project a workflow to dissolve printed references was designed. As you can see the

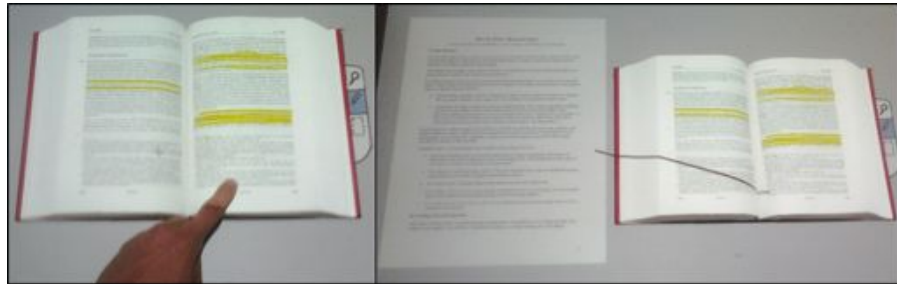
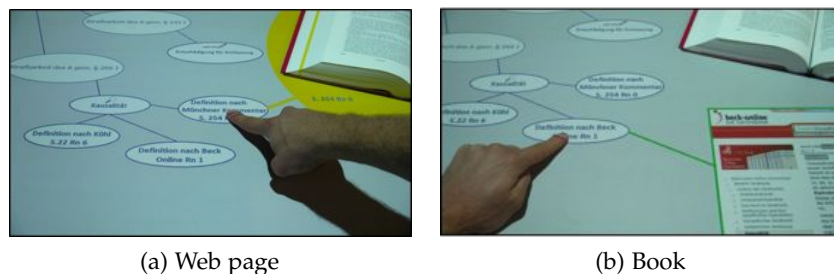


Figure 39: Early hybrid sketch for the dissolving of a reference between a book and a digital document.

user touches a printed reference and a digital document showing the source pops up. The same concept can be used for a reference which refers to an analog document. In this case, if the source is present on the desk a line between the reference and the book is displayed and the passage of interest gets highlighted. Because the technical implementation of this concept is highly complex, it was not considered when implementing the prototype.

Backtracking to the source of a mind map item

Another idea enables backtracking to the source of an excerpted text passage. The workflow for doing so is sketched in [Figure 40](#). To



(a) Web page

(b) Book

Figure 40: Hybrid sketches showing the interaction to link a mind map item with its source.

see the source of the text displayed in a mind map item the user performs a hold gesture by touching the according item for a certain

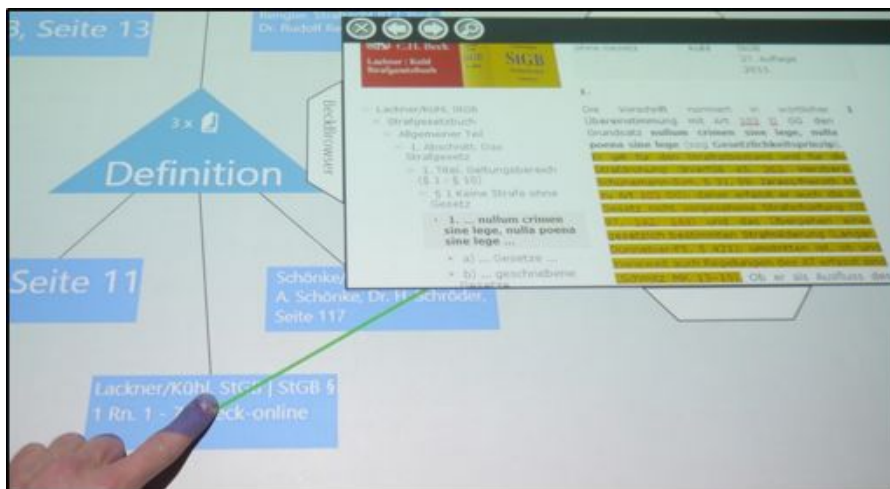
amount of time. If the source is a web page, a browser pops up on the information landscape and displays the digital document. In case the source is a book and it is located on the table a halo highlights the document and displays the number of the page the text was excerpted from. Additionally the system helps the user finding the original page by highlighting it on the front edge of the book.

By being able to save references in the mind map and having the ability to dissolve them the prototype matches some of the function of a reference manager. The functioning of the prototype as reference manager was demanded as part of the key requirement knowledge archiving.

Figure 41 shows the realization of the reference backtracking mechanism in the prototype. The major difference in the design of the pro-

Some kind of reference manager

Reference backtracking in the prototype



(a) Web page



(b) Book

Figure 41: Reference backtracking

tototype and the hybrid sketch is that instead of highlighting the front edge of a book another solution was designed to help users find a corresponding page. Besides augmenting the book with the page number an arrow is displayed which indicates the direction a user needs to flip pages to find the page the text is excerpted from. The size of

the arrow specifies the amount of pages which need to be flipped. The smaller the size of the arrow, the closer the referenced page is located to the actual opened double page. When the original page is opened the referenced text passage is automatically highlighted.

EVALUATION

The goal of the project is to integrate printed media into a digital environment to explore the seamless transfer of text between documents and a digital device. Therefore similar interaction techniques and input devices are used to process real and virtual texts in a same manner. With the implementation of this goal we want to generally support knowledge work and more concretely the juristic working methodology when writing a seminar paper. On this account the objective of the evaluation of the prototype Integrative Workplace is clearly determined and can be divided into *two research goals*:

Research goals for evaluation

1. The first goal is to investigate whether Integrative Workplace approximates the different ways of working with digital and analog media and manages to successfully integrate analog media in the digital system. Thereto it is important to determine if the user is still annoyed when switching between digital and analog media.
2. The second goal of this study is to find out to what extent the prototype supports students when writing a jurisprudential seminar paper. Since the prototype does not cover the entire process of writing a research paper, it should be particularly examined whether or not students can integrate the prototype into their individual working methodology.

Because of the nature of these research goals a case study was chosen as study type to proof them. As both objectives aim at the subjective experience of the user, the type of data which is collected mostly is qualitative. For that reason an experiment, where you proof internal and external validity on the base of quantitative data is the wrong choice. To examine the goals, law students are asked to solve a legal record with the help of Integrative Workplace in the living lab of Blended Library. According to Lewis this kind of task could be considered a usability test³³. Nevertheless the focus of this study is not to find as many usability or user interface issues as possible, but to gain a deeper understanding on how the user perceives Integrative Workplace in the context of his regular work. Therefore the working methodology observed at Integrative Workplace is compared with the working methodology observed in the pre-study. This can be considered an in-depth investigation, which is one of the four key aspects

Case study

³³ "Usability testing includes three key components: representative participants, representative tasks, and representative environments, with participants' activities monitored by one or more observers" ([39, p. 29] according to common industry format for usability test reports (ANSI-NCITS 354-2001)).

to describe a case study specified by Lazar et al. [38, pp. 147-150]. To clearly define this study as a case study the characteristics of this evaluation are remodeled onto these key aspects of Lazar et al.:

1. *In-depth investigation on a small number of cases:* As mentioned before this study examines the use of Integrative Workplace by law students solving a legal case. Thereto the focus is not to find usability flaws but to gain a deeper understanding on how the students can use or cannot use Integrative Workplace for the purpose of their regular work. The observations of the actual study are compared with the results from the context observation on law students writing a seminar paper (see [Chapter 3](#)). Because of this pre-study it is possible to observe how the working methodology of law students changes with the use of Integrative Workplace.
2. *Examination in context:* The study takes place in the living lab of the Blended Library, which is part of the library of University of Konstanz. Although this is the place where law students write their seminar papers, it is not the reason why the study can be considered an examination in context (because in the course of the study the library does not play a role). The reason why the study is an examination in context is because the prototype is not only an application but a whole environment. Therefore the students are able to apply working methods they are familiar with from their own desk onto the table of Integrative Workplace, which may provide additional insights.
3. *Multiple data sources:* Multiple data sources are used in the context of the study to increase the confidence in the observation (observations, interviews, questionnaires and data logging, see [Section 6.3](#)). The goal is to detect a finding in multiple sources. This so called data triangulation strengthens the results of the study.
4. *Emphasis on qualitative data and analysis:* As mentioned above the nature of the goals of this study specifies the collection of qualitative data. Both objectives aim at the subjective experience of the user, which predominantly can be measured on the basis of qualitative data. Quantitative data is only used as additional triangulation tool to strengthen findings determined in qualitative data.

The case study is not used to formally test hypotheses and try to use results to claim generality, but to get an idea how law students use Integrative Workplace and why they like using it or dislike using it. In addition the surveyed data is used to suggest formally testable hypotheses. The following sub-chapter presents the research questions and the hypotheses derived from the questions. Afterwards the study

design and the methods of analysis are introduced. In the final sub-chapters the results are presented and discussed by means of implication.

6.1 RESEARCH QUESTIONS & HYPOTHESES

Two research questions have been formulated out of the objectives of the study presented in the previous chapter:

F1: Does Integrative Workplace successfully integrate printed media into the system and the digital ways of working with text?

F2: Does Integrative Workplace support law students when writing a jurisprudential seminar paper?

These two research questions are based on six hypotheses. Since this is a case study, these hypotheses are not formally testable. They rather serve as a reference point for the subsequent evaluation of the study and define the issues to be examined. This approach is based on a method to design case studies presented by Lazar et al. [38, p. 161]. Research question *F1* can be answered on the base of the examination of the following hypotheses:

H1: The ratio of excerpted passages from digital and analog sources changes in favor of analog sources, when comparing the normal working methodology with the methodology at Integrative Workplace.

H2: Using Integrative Workplace law students even more prefer analog over digital sources.

H3: Qualitative data reveals that participants consider analog media to be well integrated into Integrative Workplace.

One of the advantages of digital over analog media is the easy excerption of text from these sources. You can easily copy and paste a passage of interest in an own document. With the use of Integrative Workplace law students are able to excerpt text as easy from analog sources as from digital sources. Therefore *H1* expresses the assumption that the ratio of excerpted passages changes in favor of analog sources. In the pre-study law students indicate that books support their working methodology better than electronic devices. As the main reason they argue, that you can spread books spatially, which simplifies the recovery and comparison of text passages in different sources. With the possibility of Integrative Workplace to easily extract text from books, this advantage of digital sources is adopted by analog sources. For this reason *H2* argues, that with Integrative Workplace law students even more prefer analog over digital sources. The

*Research question
F1*

purpose of H_3 is to examine how participants experience the integration of analog media into Integrative Workplace. Therefore different participants are asked different questions in a questionnaire and in an interview. If hypotheses H_1 , H_2 and H_3 can be accepted on base of the qualitative finding, you can conclude that analog sources have been well integrated into Integrative Workplace.

Research question
 F_2

To answer research question F_2 these hypotheses need to be examined:

H_4 : Law students can use Integrative Workplace for writing a seminar paper.

H_5 : Using Integrative Workplace students can apply the mind map to build the solution sketch of a legal record.

H_6 : Participants will intensively use the reference backtracking function.

H_7 : Participants will intensively use full-text searching in books.

These hypotheses tend on different aspects of Integrative Workplace which were designed to explicitly support the working methodology of law students. While H_4 addresses the subjective user opinion about the whole system, H_5 explicitly examines the usefulness of a mind map to build a solution sketch. As the reference backtracking function supports law students, when re-reading excerpted text passages in context, H_6 supposes that this function is intensively used. Full-text searching supports the method of law students to use the index of a book as a starting point for their literature review. Therefore H_7 argues that law students will intensively use it.

Informal
operationalization

As mentioned above these hypotheses are not formally testable and for this reason are not formally operationalized. Furthermore, because the study is a case study and its methods of analysis are qualitative and not comparative, no dependent or independent variables have been defined. The informal operationalization of hypotheses arises from the presentation of the results (see [Section 6.4](#)) and is not additionally listed in this sub-chapter to avoid replication. For a detailed informal operationalization of the hypotheses you can see the outline of this study in [Appendix C](#).

Research question
 F_3

In addition to the two research questions described above, a further research question is asked with the purpose to reveal issues in the usability design, which emerge during the interaction with the prototype.

F_3 : Is it possible for users to easily interact with Integrative Workplace? Which usability problems emerge?

This research questions is not based on hypotheses. It will be answered on the basis of exploratory data analysis and the System Usability Scale. Exploratory data analysis is an approach which was promoted by John Tukey and argues for the importance of broad general inquiries of data for science and engineering [57]. He recommends analyzing data, also using visual methods, and suggesting hypotheses and research questions as a result. The System Usability Scale is "a reliable, low-cost usability scale that can be used for global assessments of systems usability" [4, p. 1] (for more information see Section 6.3). The focus of research question F_3 clearly is on the evaluation of input devices used in Integrative Workplace, but generally addresses all kind of usability issues caused by erroneous interaction design.

6.2 STUDY DESIGN

In the following sub-chapters the different aspects of the study design are listed. These include the actual task, the requirements subjects need to fulfill to be allowed to participate as well as the properties of the study. Finally the setting and the procedure are presented.

6.2.1 Task

The task of the case study is to solve a legal record with the help of Integrative Workplace. This is generally the topic of every juristic seminar paper and for that reason matches the use case. The subjects' task is to solve the legal record in the way they learned it in their courses of study. In contrast to the writing of a juristic seminar paper, participants of the study only need to build the solution sketch for solving the case. Therefore they use the mind map of the system. In addition participants search in literature for common opinions about the facts they detected in the case description. The passages of interest are as well excerpted and stored in the mind map. This procedure corresponds to a literature review, law students typically conduct before writing a seminar paper.

To be able to answer the research questions, the legal record has to match some requirements. First of all, the record needs to be solvable in a study's typical duration. Second, the available literature needs to be adapted to the facts of the record. And finally, to proof the hypotheses H_1^{34} and H_2^{35} , it is important that every piece of literature is available in both, digital and analog media.

To fulfill this requirements we developed a legal record in coop-

Requirements of the task

The legal record used as study task

34 The ratio of excerpted passages from digital and analog sources changes in favor of analog sources, when comparing the normal working methodology with the methodology at Integrative Workplace.

35 Using Integrative Workplace law students even more prefer analog over digital sources.

eration with a law student who was preparing for his final exams. We specified the course of actions happening in the record, the literature which is needed to solve the record and a sample solution of the record. The content of the record is as follows:

T visits L to discuss the further course of events after the sudden death of M a week ago. M, the mother of T, did meet L shortly before her death, and immediately moved in his apartment. An early engagement was up for discussion.

L tells T that her mother had mentioned in a conversation that he in the event of her death "will get everything". Therefore he is not seeing any reason to give T a part of the estate of her mother.

T is appalled by this announcement. Particularly the loss of an old ring, which was always in the possession of her family, is painful. As L goes into the kitchen, T noticed the ring on a dresser. She purses the ring in her pocket and goes home.

The task is to detect to what extent T has committed an offense. The solution of this record is as follows (a summary):

According to German civil law the oral statement of M to make over her estate to L is not valid. For this reason T, as direct descendant of M, already is in possession of the ring. Therefore her effort to steal the ring is judged as "ineffectual attempt", which is not chargeable according to German criminal law.

*In the context of
O'Hara's model*

In [Section 1.2](#) of this thesis the prototype Integrative Workplace is located in a model for student readers' use of library documents developed by O'Hara et al. [48]. Inside this model Integrative Workplace focuses on information review, reading, making of notes and photocopying³⁶ (see [Figure 2](#)). As the functionality of the prototype only covers the specified phases of the model, the study needs to provide the outputs or the functionality of the uncovered phases. The phase of writing is explicitly excluded from the scope of the study. Annotation is made possible by providing a real pen and a text marker, subjects can use to mark and annotate the case description. Bibliographic search and the retrieval of documents are simulated by providing all literature which is sufficient to solve the case. The literature consists out of selected law texts, comments on law texts and juristic textbooks.

³⁶ In the context of this project photocopying was specified as the enrichment of print media with digital content and the possibility to make information in print media digitally available.

6.2.2 Participants

For the specified goals of the study it is important to choose representative cases. Therefore only law students were allowed to participate in the study³⁷. As a further restriction they need to at least have written two juristic seminar papers during their studies. Thus it is sure that they are familiar with traditional working practices necessary for solving a record. Because the record is located in the field of criminal law, students additionally need to know about this legal form. Age, sex or the number of semesters are not of interest.

To increase the confidence in results several participants need to solve the legal case with Integrative Workplace. In dependence on the participant acquisition (the study was conducted in the summer break) the goal was to have 5 to 10 participants for the study. With this number of participants it is not possible to claim for generality, but results are feasible for a broader group in comparison with a case study of only one or two subjects.

Multiple cases for higher confidences in results

6.2.3 Study Characterization

In literature they distinguish into four different goals of case studies [38, p. 150]:

Case-study-specific goals

- *Exploration*: understanding novel problems or situations, often with the hopes of informing new designs.
- *Explanation*: developing models that can be used to understand a context of technology use.
- *Description*: documenting a system, a context of technology use, or the process that led to a proposed design.
- *Demonstration*: showing how a new tool was successfully used.

This case study focuses on two of them. On the one hand the study focuses on the goal of exploration. With the prototype we want to expose issues arising by faulty interaction design, try to understand them and inform new designs which may illustrate a solution. On the other hand this study focuses on the goal of description. Taking the pre-study into account we describe the process that informed the design of the prototype. In addition this study tries to investigate how the prototype influences or changes the working methodology of law students and if it is possible to integrate the new system in the working methodology for solving a legal case (a context of technology use). The following table characterizes the type of this case study.

Characterization of the case study

³⁷ Only law students are able to solve the task of the study which is the solution of a legal record.

Characteristic	Explanation
<i>cross-sectional</i>	Several participants are observed at one moment of time.
<i>instrumental</i>	The results are used for a broader understanding of the case domain "writing a juristic seminar paper" and some of the results are discussed in the general domain of knowledge work.
<i>multiple case</i>	A larger spectrum of participants is chosen for a higher confidence in results.
<i>embedded</i>	We try to answer three different research questions on the base of this study's data. For this reason the study can be considered to have multiple units of analysis.

Table 3: Characterization of the case study

6.2.4 *Setting*

The study is conducted in the Living Lab of the Blended Library which is located inside the library of University of Konstanz. The prototype runs on the interactive table which is described in [Section 5.1](#). The setting of the study can be seen in [Figure 42](#). The participant works at the interactive table. On the interactive table the prototype Integrative Workplace is displayed which is used by the participant to solve the legal record. Beside the interactive table a camera is located which records the activities of the participant. At the back the workplace of the conductor is located. With the display he monitors the touch driver, the driver for the pen and the settings of the camera which tracks the documents on the desk. His main task is the observation of the participant. Therefore he can either directly have a look at what the participant is doing or he watches the video stream of the tracking camera filming the table from top.

6.2.5 *Procedure*

The overall duration of the study is 90 minutes. Therefrom the participant has 30 minutes to solve the legal record, the actual task of the study. Another 10 minutes are needed for an introduction in to the interaction and the features of the system. After the introduction the participant again has 10 minutes to get used to the functionality of the prototype. [Table 4](#) shows the exact course of actions.

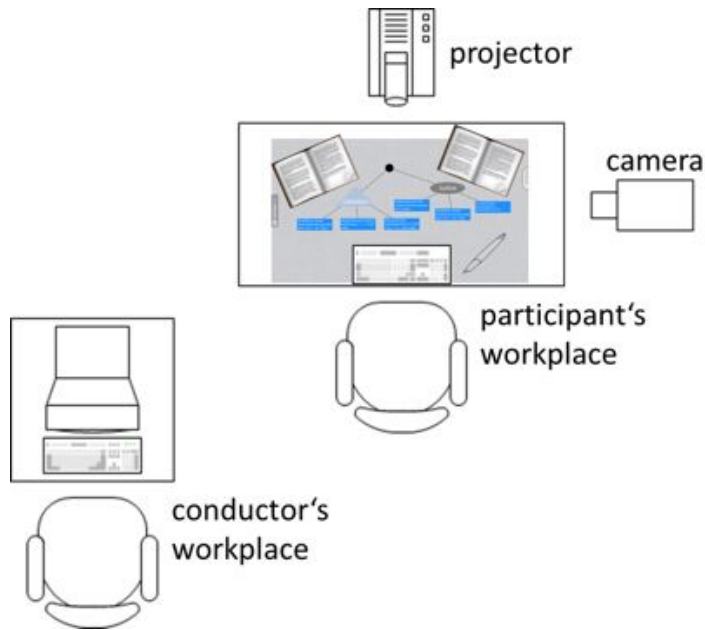


Figure 42: Setting of the study

Action	Time
Welcoming	5 min
Pre-questionnaire	5 min
Introduction	10 min
Training	10 min
Solving the legal record	30 min
Post-questionnaire	5 min
System Usability Scale	5 min
Interview	15 min
Farewell	5 min
<i>Total time</i>	90 min

Table 4: Procedure of the case study

As the correct solution of the legal record is not necessary in matters of the evaluation of the study, the time is fixed on 30 minutes. If a participant is not finished after 30 minutes the conductor interrupts the participant and asks him to continue with the questionnaires.

6.3 SOURCES OF DATA ACQUISITION

In this case study four different types of data sources are used: observations, questionnaires, interviews and data logging. The combina-

tion of multiple sources strengthens a finding, when found in two or more sources (data triangulation). The different sources are used to collect qualitative and quantitative data to answer the research questions and to explore interaction or design problems. The following sub-chapters explain in detail for which purpose what data source is used for.

6.3.1 Observations

Thinking-aloud

The conductor of the study observes the participants while they are solving the record. To be able to not only observe what participants are doing, but to know why they are doing it and what they experience while doing it (like, dislike, etc.) thinking-aloud is used. To log the observations and the thinking-aloud the conductor uses a guideline where he can write down all special happenings and the time they occurred. Figure 43 shows a part of this document³⁸. As addi-

ID: ____

Guideline for Observations

1. Which usability problems occur?

Time	Problem

Figure 43: Log file for observations

Focus of observations

tion to the observations, everything the user does while solving the case is recorded with a video camera. For the evaluation of the video recording, the guideline for observations serves as a reference. Using the notes on the guideline, you can see where you need to dig deeper in the video recordings, for example to see the context of a usability problem. The observations are focusing on the following seven points:

1. Which usability problems occur during the usage of Integrative Workplace?
2. Is the participant using the full-text search function of Integrative Workplace?
3. Is the participant using the reference backtracking function of Integrative Workplace?

³⁸ For the whole document see [Appendix D](#)

4. Are there any misappropriations of pen and touch?
5. Where and when does the participant make notes?
6. Does the participant give feedback about the prototype during the study?
7. Did the participant have a preference for digital or analog sources?

With misappropriations of pen and touch, situations are meant in which the participant is using the pen for an interaction which by design is executed with the finger and vice versa. This point arises from the observations of the trial studies. All participants had problems with the assignment of a feature to the input device triggering it.

6.3.2 Questionnaires

Three questionnaires are used in the context of this study: a pre-questionnaire, a post-questionnaire and the system usability scale³⁹. The pre-questionnaire is used to collect demographic data (sex, age, handedness, and number of semesters). Additionally the questionnaire asks the participants for their common working methodology to be able to distinguish how the use of Integrative Workplace changed their method. After a participant finished the task of the study he needs to answer two semantic differential questionnaires. A semantic differential questionnaire has a Likert scale and can be considered "a product-independent method that can yield reliable quantitative data" [24, p. 444].

Participants first complete the post-questionnaire. It has a five point Likert scale and collects quantitative data about the subjective user opinion concerning design decisions of Integrative Workplace. It evaluates the usage of a mind map to build a juristic solution sketch and the usage of finger and pen to operate the system. Furthermore it asks if the participants can use Integrative Workplace to solve a legal record and to what extent the prototype changed their working methodology.

Post-questionnaire

The second semantic differential questionnaire is System Usability Scale (SUS) which was developed by John Brooke [4]. It has 10 standardized items which measure the usability of the system by using a five point Likert scale. The SUS is a robust, extensively used and widely adapted questionnaire [24, p. 447] which provides a single numeric score as result. This single numeric score is in the range of zero and 100 and rates the usability of a system (zero = poor usability, 100 = good usability). On the base of numerous completed SUS questionnaires of different products Bangor et al. developed a scale which rates the acceptability of a SUS score and on base of the SUS

System Usability Scale

³⁹ To see the documents have a look at [Appendix D](#)

score assigns an adjective rating to the usability of a system [2]. This scale is used to assess the usability of Integrative Workplace.

6.3.3 Interview

The interview is used to go deep into the questions which are already approached in the questionnaires and to collect additional qualitative data concerning the research questions. According to Lazar et al. the possibility to go deep is the strongest argument in favor of interviewing (Lazar et al. 2010, p. 178). The questions of the interview can be clustered into three groups:

1. *Qualitative design evaluation*
2. *Changes in working methodology*
3. *Ideas for improvements*

The group of *qualitative design evaluation* gives participants the possibility to reason their ratings in the post-questionnaire. The other part of questions of this group tries to get deeper in-sights on the evaluation of design decisions by allowing participants to mention own ideas or criticism. The group *changes in working methodology* tries to collect opinions of participants on how their methodology of writing a seminar paper has changed with the use of Integrative Workplace. The last group *ideas for improvements* consists of questions which explicitly ask the participants to give own ideas on the design of this prototype.

6.3.4 Data Logging

In Integrative Workplace special events concerning the interaction with the prototype are logged in a XML file. This quantitative data is not used for statistical comparison, but as additional triangulation tool. Quantitative data can help to reason findings which emerged from qualitative data. The special events which are logged are as follows:

- Usage of the full-text search function
- Usage of the reference backtracking function
- Excerpt from digital media
- Excerpt from analog media
- Finger interaction (x- and y-coordinate of a touch point)
- Pen interaction (x- and y-coordinate of a touch point)

- Movement of documents on the table (x- and y-coordinate of the marker)
- Creation of a mind map item
- Deletion of a mind map item
- Opened web page
- Opened book page

6.4 RESULTS AND DISCUSSION

The following sub-chapters present the results of the study in relation to the defined research questions. Because the results are not quantifiable and therefore it is difficult to retrospectively refer to them, they are discussed in the same chapter. At this point it is again important to mention that because this study is a case study, it is not possible to formally test hypotheses and statistically accept or decline them. Rather the goal is to determine a trend for or against the benefit of a hypothesis and on base of the trends of several hypotheses reason how to answer a research question.

6.4.1 *Demographic Data*

The study was conducted by nine participants, six male and three female law students. The goal was to have the same number of male and female participants. But, because of the technology-orientated task, it was difficult to motivate female participants. The average age of all participants was 23.9 years with a standard deviation of 1.5 years. They studied 6.3 semesters (standard deviation of 2.9 semesters) and on average wrote 3.4 seminar papers (standard deviation of 1.2 seminar papers). All participants are right handed.

6.4.2 *Integration of Analog Media*

The research question $F1$ is answered on the base of the hypotheses $H1$, $H2$ and $H3$. In the following the results concerning these three hypotheses are listed. First the hypothesis $H1$ is evaluated.

The ratio of excerpted passages from digital and analog sources changes in favor of analog sources, when comparing the normal working methodology with the methodology at Integrative Workplace.

As a start, the assumption which led to this hypothesis, that law students excerpt more text from digital than from analog sources, is proofed. Therefore participants need to answer a question in the

F1: Does Integrative Workplace successfully integrate printed media into the system and the digital ways of working with text?

Results of hypothesis H1

pre-questionnaire which asks for the kind of sources participants extract text from with a higher commonness. The answer possibilities are digital media, analog media and none of the two. Table 5 shows the results.

From what kind of source do you normally excerpt more text passages?	
<i>Media type</i>	<i>Participants</i>
Analog sources	3
Digital sources	3
None of the two	3

Table 5: Results of question no.9 of the pre-questionnaire

Interestingly the results are evenly distributed. Respectively three participants voted for analog sources, digital sources and none of the two. As it is easier, we expected more participants to extract more text from digital sources, even if more literature is available as analog media. In the second part of the question the participants were asked to give reasons for their decision. The reasons why they prefer to extract text from digital or analog sources are as follows:

- *Digital sources*: It is easier to extract text from digital media and electronic texts are available outside of the library not like physical books.
- *Analog sources*: You can better concentrate and work more precisely using physical books. Additionally not all literature is available digitally.

On the base of logged data we examined how many text passages have been excerpted from digital and analog sources. Over all participants the quantitative frequency of excerpts can be seen in Table 6. The data reveals that more excerpts have been made from analog

Type of media	Total number of excerpts	Average number of excerpts per participant	Standard deviation of excerpts per participant
Analog	30	3.33	1.58
Digital	20	2.22	2.19

Table 6: Quantitative frequency of excerpts from log data

sources. Furthermore, in the case of digital media, the standard deviation equals the average number of excerpts. This exposes that participants either intensively or not at all used digital sources to excerpt

text. In contrast the standard deviation of analog media indicates that most of the participants actually excerpted text from analog media.

In addition we used the logged data to compare for each participant if he excerpted more text passages from digital or from analog sources. The following table shows the results.

Preferred media type in matters of excerption	
<i>Media type</i>	<i>Participants</i>
Analog sources	5
Digital sources	3
Equally	1

Table 7: Preferred media type in matters of excerption

Five participants excerpted more text passages from analog sources, three from digital sources and one participant equally used both types of sources. In comparison with the results seen in Table 5 a trend in the direction of analog media can be seen.

To see for each participant individually how the ratio of excerpted text passages from digital and analog sources changed in comparison with the answer stated in the pre-questionnaire we developed a model (see Figure 44). The unit to measure the occurred change is

Model to describe changes for working without and with Integrative Workplace

DIGITAL \leftarrow step \rightarrow NONE \leftarrow step \rightarrow ANALOG

Figure 44: Model to describe the changes of media preference for working without and with Integrative Workplace.

indicated in steps. For example, if a participant stated he normally excerpts more text from digital sources and the log data revealed that with Integrative Workplace he excerpted more text from analog sources, he moved two steps to analog. The different answers from all participants have been analyzed and the results can be seen in Figure 45.

As for most participants the stated preference equals the logged ratio, the average steps done, are 0.22 steps in the direction of analog media.

In the post-questionnaire participants have been asked if they have excerpted more text passage from digital sources in comparison with their normal working methodology. The same question was asked for analog sources. The scale on which they answered the question is a five point Likert scale in the range of one ("I agree") to five ("I disagree"). For both types of media the average values show that par-

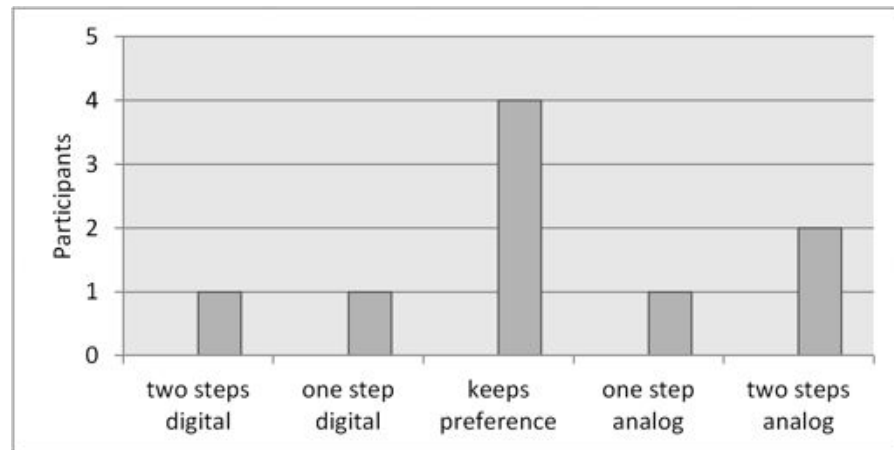


Figure 45: Changes in matters of exception for working without and with Integrative Workplace

Question	Average	Standard deviation
Did you excerpt more text passage from <i>digital sources</i> in comparison with your normal working methodology?	2.44	1.42
Did you excerpt more text passage from <i>analog sources</i> in comparison with your normal working methodology?	2.33	1.5

Table 8: Perceived difference in matters of exception for digital and analog sources

Participants felt to slightly excerpted more passages in comparison with their normal working methodology (see Table ??).

Discussion of the results regarding H1

In case of *H1* no obvious trend for or against the benefit of the hypothesis is visible. The statistical analysis of the log data shows that more text passages have been extracted from analog media (see Table 7). In addition we determined that with Integrative Workplace five participants excerpted more text from analog media, in contrast to three participants who excerpted more text from digital media and one participant who excerpted the same amount of passages from analog and digital media. In comparison with the question of the pre-questionnaire (see Table 5) this shows a tendency in favor of analog media. But the model which examines the changes of preference does not show a distinct shift in the direction of analog sources. Participants changed their preference with no recognizable pattern. Furthermore the higher rate of excerpted texts from analog media may

be reasoned by the fact that the possibility to digitalize text from a printed book is a novelty for participants and for that reason they have used it more frequently.

The second hypothesis the first research question is built on is *H2*:

Using Integrative Workplace law students even more prefer analog over digital sources.

To evaluate this hypothesis a question in the pre-questionnaire asked for the type of sources law students prefer in their common method. [Table 9](#) shows the results.

Results of hypothesis H2

With what kind of sources do you prefer to work with when writing a jurisprudential seminar paper?	
<i>Media type</i>	<i>Participants</i>
Analog sources	5
Digital sources	3
No preference	1

Table 9: Preferred media type in matters of writing a jurisprudential seminar paper

Four participants prefer analog sources, two participants prefer digital sources and three participants stated to have no preference. The reasons for the use of digital and analog sources are indicated by participants as follows:

- *Analog sources*: They are easier to read and it is better to concentrate when working with printed text. In addition it is easier to relocate books and passages in books. Additionally literature is available more often as print than as digital media.
- *Digital sources*: It is easier to excerpt text from and share digital documents. Additionally it is possible to execute a full-text search on digital text and its available everywhere.

To see how the usage of digital and analog media changes with Integrative Workplace, the study conductor observed if a participant preferred digital or analog sources for solving the record. The results can be seen in [Table 10](#).

For each of the three cases, three participants have been classified. To see how the use of Integrative Workplace changes participants' preference for digital or analog sources the model presented in [Figure 44](#) is used. The results can be seen in [Figure 46](#). Again most of the participants kept their preference.

In the post-questionnaire the participants have been asked if their preference for one type of media would change with the use of Integrative Workplace. The participants gave the following answers:

Observed preference of digital and analog media with Integrative Workplace	
<i>Media type</i>	<i>Participants</i>
Analog sources	3
Digital sources	3
No preference	3

Table 10: Observed preference of digital and analog media with Integrative Workplace

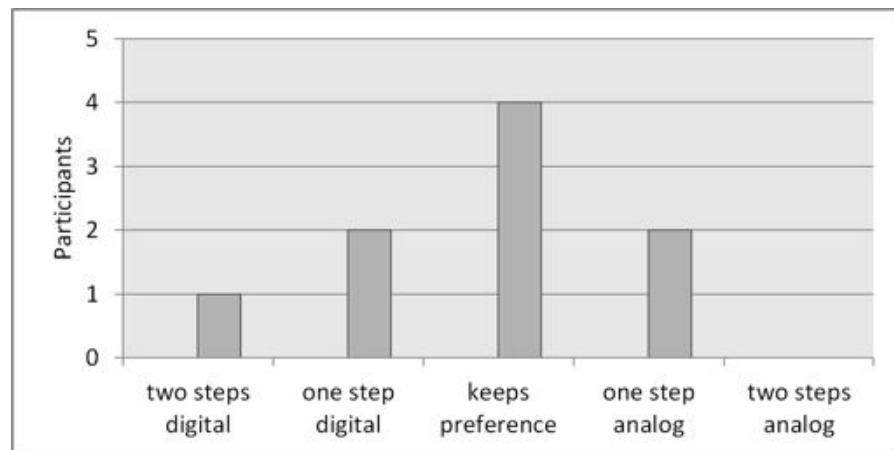


Figure 46: Changes in matters of preference for working without and with Integrative Workplace

- One participant did not have a preference in his common working methodology and indicates to "rather use more analog sources" with Integrative Workplace.
- One participant preferred analog sources in the common working methodology and would "mix sources" with Integrative Workplace.
- One participant indicated to still prefer analog sources with Integrative Workplace.
- One participant indicated to still prefer digital sources with Integrative Workplace.
- Four participants would stay with their preference.
- One participant gave no clear information.

Discussion of results regarding H2

Concerning H_2 , again no distinct trend in or against favor of the hypothesis can be examined. The evaluation of the model as well as the evaluation of the question of the post-questionnaire does not

show a clear shift of the preference in the direction of analog media. If any, a slight shift in the direction of digital media can be observed (see [Figure 46](#)). A possible explanation for this finding is that digital sources probably have more affordances for users who prefer them, then full-text searching and easy excerption. In addition the possibility of spatial layout, the feature which caused law students to prefer analog media for their work, with Integrative Workplace also is feasible for digital sources. Furthermore to really see the change of usage for one type of media a cross-sectional study is not sufficient. As law students probably need time to break with their habits, a longitudinal study would be the appropriate choice to see if Integrative Workplace changes the usage of media.

The hypothesis H_3 focuses on the opinion of the user about the integration of printed media into Integrative Workplace.

Results of hypothesis H_3

Qualitative data reveals that participants consider analog media to be well integrated into Integrative Workplace.

Therefore participants have been asked in the interview to name advantages and disadvantages which come with the integration of books into Integrative Workplace. The answers have been semantically clustered and the occurrence of a cluster can be seen in the next table.

ADVANTAGES	DISADVANTAGES
<ul style="list-style-type: none"> • Easy excerption of text from printed books (5 participants) • Full-text search (5 participants) • None (1 participant) 	<ul style="list-style-type: none"> • Projection bothers reading (2 participants) • Annotation of books must be possible (2 participants) • None (6 participants)

Table 11: Advantages and disadvantages which come with the integration of books into Integrative Workplace

As you can see the advantages, easy excerption and full-text searching, have been called more often than any disadvantage. Actually six participants said that there is no disadvantage. The disadvantage of not having the possibility to digitally annotate books is due to the fact that annotation was delimited from the range of functions of Integrative Workplace according to the model of O'Hara et al. (see [Section 1.2](#)). In addition, asked for the biggest advantage of Integrative Workplace four participants answered with "easy copying of text

from physical books". This was the answer which was called the most. For the evaluation of this question the answers of all participants about the biggest advantage of Integrative Workplace have been semantically coded and the occurrence of every code has been counted. With easy excerption, the possibility to deposit extracted text from all sources in one place has been the most frequently cited response (four times). This feature also is a benefit coming from the integration of printed media into Integrative Workplace.

*Discussion of results
regarding H₃*

To sum up this section, you can say that the findings coming from the different questions of the interview show that the participants generally like the way printed media is integrated into Integrative Workplace.

*Discussion of
research question F₁*

With all these results, coming from different data sources, regarding different hypotheses, we can conclude that the design of Integrative Workplace to integrate printed media into a digital device is leading into a good direction. Although the examination of *H₁* showed that the ratio of excerpted text passages from analog sources did not increase significantly and *H₂* did not show a higher usage of analog sources (but as argued above the reasons are not necessarily a poor integration into the system), the interview revealed evidence that the integration of analog media into the system is positively experienced by users. In addition we are confident that with the improvement of the technology used to detect pen and finger the results concerning hypotheses *H₁* and *H₂* will further improve. All in all, we conclude that the first research question can be positively answered and therefore the goal of this project, to explore the seamless transfer of content between books and digital devices, can be considered as achieved. Abstractly speaking, the evaluation showed that Integrative Workplace took the right direction to bridge the gap between digital and analog media at the workplace.

*Melting of the real
and the virtual
world*

A nice example in the study which emphasizes the melting of these two worlds is given by two participants who used full-text searching in printed books. Both tried to open book pages by touching the visualization which displays the matching words per page (see [Figure 47](#)). This example demonstrates that user perceived the combination of printed media and the digital device as a unity and not as two separate worlds.

6.4.3 Support of the Juristic Working Methodology

*F₂: Does Integrative
Workplace support
law students when
writing a
jurisprudential
seminar paper?*

The second research question approaches the support of law students when writing a seminar paper. This question is based on four hypotheses. *H₄*, the first of these hypotheses, reads as follows:

Law students can use Integrative Workplace for writing a seminar paper.

It is evaluated on base of a question in the post-questionnaire, which

*Results of
hypothesis H₄*

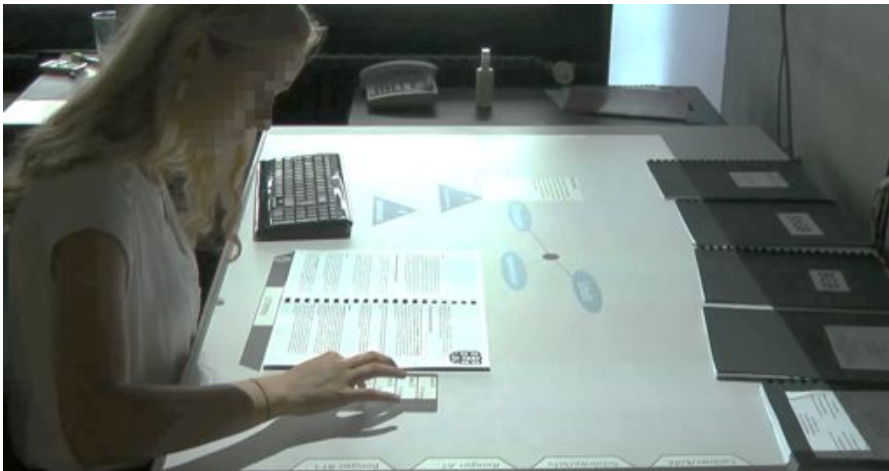


Figure 47: Participant who tried to open a book page by tapping the hit list visualization.

asks students, to what extent Integrative Workplace is useful in matters of their working methodology ⁴⁰. The average response value was 1.78 which clearly emphasizes the usefulness of the system⁴¹. In the interview participants needed to reason their answers. The reason which was given the most is the high clarity over all excerpts (five participants). Excerpts, no matter if they are from analog or digital sources, are deposited at the same place and with the help of the mind map it is possible to semantically organize and cluster them. The interview question asking for the biggest advantage of Integrative Workplace comes with the same result. Again most participants (four) indicated the high clarity about excerpted texts which are deposited in one place, no matter from what kind of source they originate. These results confirm the design goal to enable the possibility to save text passages no matter if they are excerpted from digital or analog sources. This goal was defined according to the finding of the pre-study, that law students mostly excerpt text in a separate document before they quote it in their seminar paper. To proof this finding we asked law students in the pre-questionnaire how they precede with interesting text passages. The result of this question can be seen in [Table 12](#). The highest number of participants stated to firstly extract text to a separate document (four participants). Three participants indicated to directly quote interesting text in their seminar paper and two quoted to handle these passages in another way. This result additionally indicates that the possibility to save all excerpts at one place matches the common working methodology of law students. In the interview one participant quoted to normally only extracts text pas-

⁴⁰ The post-questionnaire has a five point Likert scale with value one standing for "I agree" and value five standing for "I disagree".

⁴¹ Seven out of nine people gave a positive feedback; only two participants rated the question with three.

How do you precede with interesting text passages?	
<i>Response possibility</i>	<i>Participants</i>
I write the text into a separate document and afterwards into the seminar paper.	4
I write the text passage directly into the seminar paper.	3
Other matters	2

Table 12: Results of question no.6 of the pre-questionnaire

sages that are hard to relocate or difficult to understand. Everything else is not extracted to increase clarity. As the results have shown Integrative Workplace increases the clarity about excerpted text passages, and therefore directly addresses the issue of this participant. If this is no isolated case the usage of Integrative Workplace may result in a higher amount of excerpts. This is a benefit which can be quantitatively evaluated in a follow-up study.

The second hypothesis this research question builds on is H_5 :

Using Integrative Workplace students can apply the mind map to build a solution sketch for the legal record.

Results of hypothesis H5

Before writing the seminar paper law students always build a solution sketch directing the way on how to solve a legal record. From this sketch the structure of the seminar paper is derived and it builds the base for the grading of the professor. Therefore building this sketch is a very essential phase of writing a seminar paper and needs to be supported by Integrative Workplace. To proof, if the mind map is useful to build a solution sketch, the participants have been asked to rate the two statements⁴². The results can be seen in the following table.

With these ratings the participants assigned both statements more or less exactly to the neutral value of this Likert scale. This is kind of surprising because in the interview the responses to more or less the same question⁴³ are more critical. Five participants clearly indicate that a mind map is not beneficial in matters of solving a legal record. One participant quoted: "In law there is a distinct evaluation order of legal issues. It is not possible to reflect this order with a mind map". Three participants gave a neutral response: "you just need to let yourself into it", "it's ok, but I am not a mind map person", "it's good, but you need to improve it". Only one participant clearly gave a positive response: "I don't know how else to visualize a solution

⁴² The statements have been rated on a five point Likert scale, with one meaning "I agree" and five meaning "I disagree"

⁴³ Do you experience the usage of a mind map as beneficial?

Statement	Average	Standard deviation
I could use the mind map to create a solution sketch.	3	1.5
The mind map is an appropriate visualization for knowledge preservation in the context of writing a jurisprudential seminar paper.	2.9	1.45

Table 13: Rating the usefulness of a mind map regarding the juristic working methodology.

sketch than with a mind map. A mind map specifies no structure⁴⁴. This is good".

With these responses we assume, that when it comes to a concrete rating of the function, like in the post-questionnaire, the Rosenthal effect⁴⁵ plays a role. If you use this knowledge to compare the results of the two statements with the other responses of the post-questionnaire, the value three is the most negative and 2.9 is the second most negative average response of the entire questionnaire. In combination with the responses from the interview, this suggests that a mind map is not an appropriate visualization for building a solution sketch.

To further examine this finding we explored the logged data. It stands out, that 46.15% of the drawn mind map items are deleted later on. This is an indication for an uncertainty of participants when applying a solution sketch with the mind map. This insecurity can further be seen in solution sketches participants designed using Integrative Workplace (see [Figure 48](#)). As you can see the solution sketches build with Integrative Workplace appear very differently. This is due to the fact that law students are not used to create a solution sketch with a mind map. We clustered all mind maps into three different types on base of their visual appearance and their semantically correctness ⁴⁶:

- Actual mind map (*S1, S4 and S7*)
- No structure (*S2, S3, S6 and S9*)
- Linear structure (*S5 and S8*)

Uncertainty when using the mind map to create a solution sketch

⁴⁴ One of the reasons why mind mapping was chosen for visualization is that it is not specifying a certain structure. It is nice that one participant recognizes this fact as a benefit.

⁴⁵ The effect says that positive expectations, attitudes, beliefs, and stereotypes of the conductor impact the participant as a form of self-fulfilling prophecy.

⁴⁶ [Figure 48](#) is only an overview. To see the detailed solution sketches have a look at [Appendix B](#)

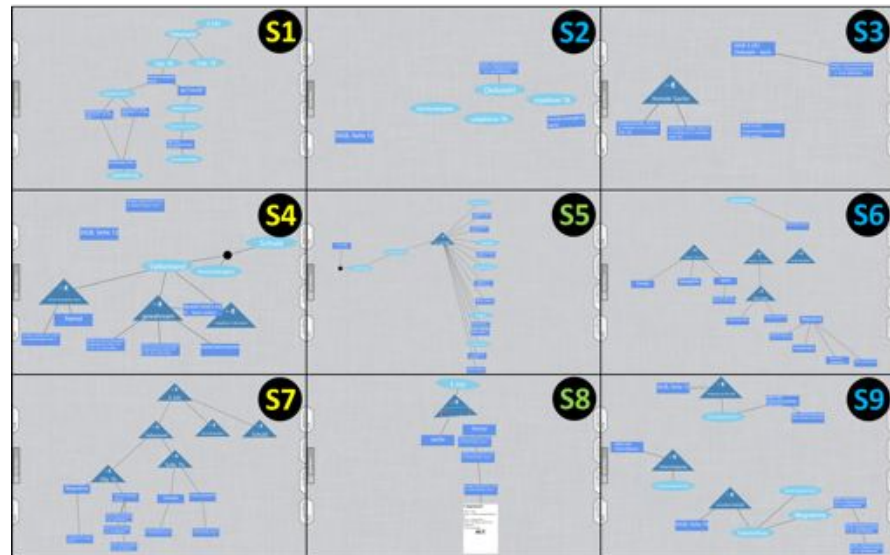


Figure 48: Solution sketches designed with Integrative Workplace

Three participants built a visually proper mind map, which distinctly reflects the sample solution. For the solutions sketches *S2*, *S3*, *S6* and *S9* no distinct direction for solving the case, a solution sketch normally should point out, can be recognized. *S2* and *S3* visually do not have any similarity to a decent mind map and the items of *S6* and *S9* are not connected in a way which leads into a direction for solving the record. The solution sketches *S5* and *S8* display a linear structure. This is the common way law students solve a legal record.

*Ideas for
visualizations better
picturing solution
sketches*

In the interview the participants have been asked to give ideas for visualizations which better describe a solution sketch than a mind map. Four participants require a visualization which somehow pictures a linear scheme. This requirement matches the main issue the experts in the expert evaluation after the design phase had. They required that the linearity of the evaluation sequence of claims must be reflected in the visualization (see [Chapter 5](#)). The hope was to cover this requirement with the free structure of a mind map, but the study results show that the structure needs to be restricted in a more linear way to support the common way of solving a legal record.

Two participants stated it would be better to use no visualization at all but to be able to insert excerpted text passages into continuous text. This is not possible with Integrative Workplace. With Integrative Workplace every excerpted text passage which is dropped on the information landscape is displayed as a mind map item. One of the two participants, which prefer to drop text passages in continuous text, built the solution sketch in the detail view of a mind map item, as the item offers the possibility to write continuous text. Therefore he built the outline of the solution sketch inside the item and typed out passages of interest from different sources. Building the solution sketch in continuous text is the common way law students work. This ex-

ample shows how important it is to let knowledge workers use their common ways of working by integrating them into a newly designed system. To complete the results from the question of the interview it is necessary to say that one participant requested a predefined mind map pattern to simplify the building of a solution sketch and two participants had no ideas for alternative visualizations.

One of the reasons why we decided to choose mind mapping as form of visualization is the possibility to build person sketches (see Section 5.2). Person sketches are used by law students to determine the suits of a civil law case. The observations showed that one participant actually built a person sketch with Integrative Workplace (see Figure 49). This somehow proves the design decision.

Mind map was used to create a sketch of legal persons

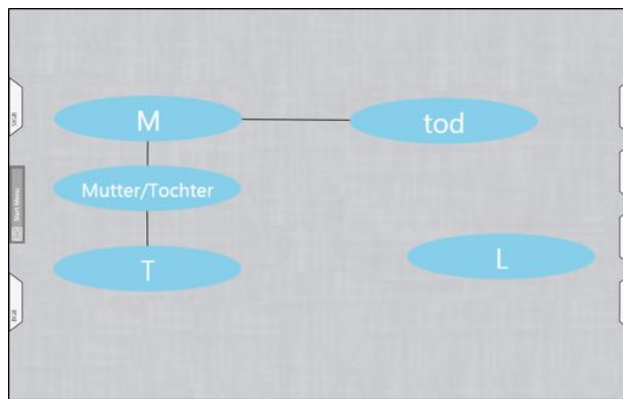


Figure 49: A person sketch created using Integrative Workplace.

With the analysis of hypothesis *H6* the usefulness of the reference backtracking function in context of the jurisprudential working methodology is evaluated.

Participants will intensively use the reference backtracking function of Integrative Workplace.

The function was designed to be able to re-read excerpts in the original context and to check the correctness of the citation. The evaluation is conducted in two steps. First the XML files containing the logging data and the observation logs are examined to check the actual utilization of the function. In the second step the users are asked for their opinion about the function.

Results of hypothesis H6

The examination of the logging data reveals that only three participants have used the reference backtracking function during the entire study. When matching these results with the log files of the observation there is a presumption that actually only one participant consciously used the function for only one time⁴⁷. A reason why the reference backtracking function is not used by participants is the

⁴⁷ This assumption is supported by the fact, that a well-known issue of the prototype is the accidental throwing of hold gestures. This gesture is used to activate the reference backtracking function.

short duration of the study. In a 30 minute case study students do not need to re-read text in context or check their citations. A study over a longer period of time with a task which forces students to engage them multiple times with the same topic, would facilitate the usage of the reference backtracking function and probably increase the actual use.

The results of the interviews facilitate this presumption, because in contrast to the minor usage, the general user feedback was positive. Participants have been asked if and how the reference backtracking function supports their common ways of working. All participants positively answered the question. Therefrom two participants gave cautious approval ("small saving of time, "I think so") and two participants gave enthusiastic consent ("pretty awesome", "very important"). As benefits of the function, they consistently named an easier retrieval of text passages and the safety to recover a passage of interest.

The results of another question of the interview enhance the positive feedback about the reference backtracking function. Asked for the biggest advantage of the integration of a browser into Integrative Workplace three participants stated the possibility to backtrack references. This was the most frequently cited response for this question. The same question was asked about the integration of books. In this case one participant named the reference backtracking function to be the biggest advantage. All in all it is distinctly possible to conclude that the reference backtracking function facilitates the working methods of law students.

The hypothesis *H7* evaluates the usefulness of full-text searching in books.

Participants will intensively use full-text searching in books.

*Results of
hypothesis H7*

The full-text searching in books is designed due to the fact that law students often use the index of a book as a starting point to search for terms of a legal record. The evaluation of this hypothesis is conducted executing the same two steps like in the evaluation of hypothesis *H6*: the examination of logged data and the analysis of subjective user feedback.

According to the logged data three participants did use the full-text searching in books while solving the legal record. Two participants searched one time and one participant searched four times in a book. In comparison with the results of the reference backtracking function, three participants actually using the searching function is quite significant. To proof this finding the results of the interview are examined. Asked if and how full-text searching supports their working methodology, all participants answered positively. One participant stated that with full-text searching an advantage of digital sources is adapted by printed media. Other participants classify the function as "very important" and "certainly useful". Generally all participants agreed that full-text searching in printed media speeds up their common working

methods. To summarize the findings which belong to this hypothesis you can conclude that digital full-text searching in analog media is supporting the common working methodology of law students. For this hypothesis the logged data actually reveals the usage of the function and therefore proofs the case.

To sum up this sub-chapter on research question two, you can say that Integrative Workplace offers features which support the juristic working methodology. The possibility to save excerpts at one place no matter if extracted from digital or analog sources was appreciated by law students, as it was the most cited advantage of Integrative Workplace. Although they did not extensively use the features, the user feedback about the reference backtracking function and the full-text searching in printed books was very positive. The major design problem of Integrative Workplace regarding the working methodology of law students is the usage of a mind map to visualize a solution sketch. As every record has a distinct evaluation order of legal issues the system need to supports this linear way of working. Due to the free structure of a mind map, it is possible to model a linear evaluation order, but the system should guide law students more restrictively. For this reason a new visualization needs to be designed to really support the creation of a solution sketch. On the one hand the visualization needs to picture the linear way of working when solving a legal record. On the other hand the results showed that not only when writing a seminar paper but already when building the solution sketch law students need to have a word processor. The adapted design of Integrative Workplace is presented in the future work chapter of this thesis (see [Section 7.3](#)).

*Discussion of
research question F2*

6.4.4 Usability and Interaction Design

The last research question addresses the evaluation of the usability of the actual prototype and tries to uncover flaws in the conceptual interaction design. To evaluate the usability of the actual prototype the participants had to answer the System Usability Scale. This questionnaire asks ten questions to measure the usability of a system. As result it provides a single numeric score calculated on the base of SUS scores which are computed for every item of the questionnaire. A SUS score has a range from zero to four. Zero is the worst and four is the best response possible in favor of the system. In [Table 14](#) the average SUS score of every item of the questionnaire can be seen. The reason why law student do not see themselves using the system frequently, maybe is the problem of not knowing how to build a solution sketch with a mind map (see [Section 6.4.3](#)). The low value for consistency of the system maybe reflects the problem of participants to not know which function to use with a pen and which function to use with a finger (see [Table 15](#)). All other items show a score which assesses Inte-

*F3: Is it possible for
users to easily
interact with
Integrative
Workplace? Which
usability problems
emerge?*

*System Usability
Scale*

Question	Average SUS Score
Frequent use of the system	1.89
Complexity of the system	3.56
Usability of the system	2.67
Technical support necessary	3.44
Integration of functions	2.89
Consistency of the system	1.89
Learnability of the system	3
Exhausted using the system	2.22
Confident using the system	2
Knowledge necessary	3.22

Table 14: Average SUS scores per item

System's adjective rating and acceptability

grative Workplace positively, though in some cases only slightly. The overall average SUS Score is 66.94. According to Bangor et al. [2] this classifies the system's adjective rating in between OK and GOOD and the system's acceptability as marginal acceptable (see Figure 50). This

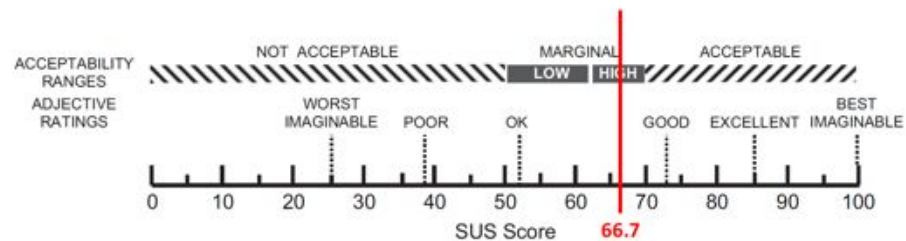


Figure 50: Acceptability ranges and adjective ratings of Integrative Workplace's SUS score (according to [2]).

is a remarkable result, since users are explicitly asked to evaluate the current usability of the system and not the conceptual usability design. Due to the fact that Integrative Workplace is a prototype, it still has some technical issues. The touch sensor is not working properly and the detection of documents highly depends on the lighting conditions of the environment. In conclusion, the SUS score shows that these issues do not frustrate users in a serious extend.

Problems with the functionality of the mind map

Quantitative and qualitative data of the case study have been examined to uncover flaws in the conceptual interaction design. This data exploration primarily was conducted to evaluate the input devices of Integrative Workplace, but also to find other design issues of the prototype. An area which obviously has some interaction design issues is

the mind map. To build a mind map you can use differently shaped items. Depending on their shape these items offer certain functionality (see Figure 5 5). This mapping of functionality and shape was not very intuitive for the participants. During the study participants frequently asked: "Is this shape offering that function?", and one participant actually complained about the variety of shapes and their assigned functions. A functionality users specially had problems with was the possibility to hide and show descendant items. Only the triangular shaped item offered this feature. The importance of this feature is emphasized by four participants who required that every item of a mind map need to offer this function. A further issue which was revealed during the study is the customization of colors. Two participants asked for the possibility to change the colors of mind map items themselves. This option would help users to build an intelligible semantic clustering according to their individual requirements.

As a possible guideline for the development of mind map based systems, these findings show that it is a good starting point to give items of a mind map a consistent set of features and make their color and shape adjustable. Interaction designers should not map functionality of mind map items to certain shapes.

The big part of research question three is the evaluation of input devices in matters of user satisfaction. Therefore the first step was to build two heat maps out of the logged positions of pen (see Figure 52) and finger (see Figure 51) interactions on the table of Integrative Workplace. First of all, it need to be said, that it is not possible

Guideline for the development of mind map based systems

Evaluation of input devices

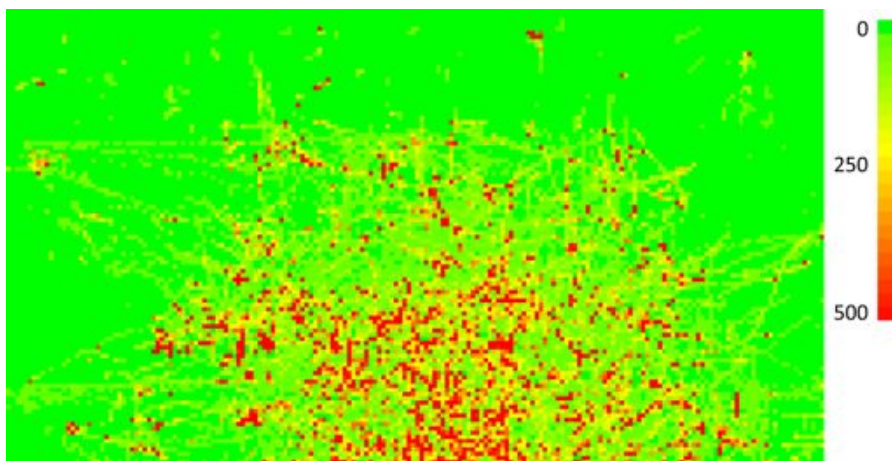


Figure 51: Heat map of touch interaction

to conclude from the legends that participants are using their fingers way more often than the digital pen. Because the sampling rate to detect touches of fingers was significantly higher than the sampling rate to detect touches of the digital pen, the two legends can not be compared.

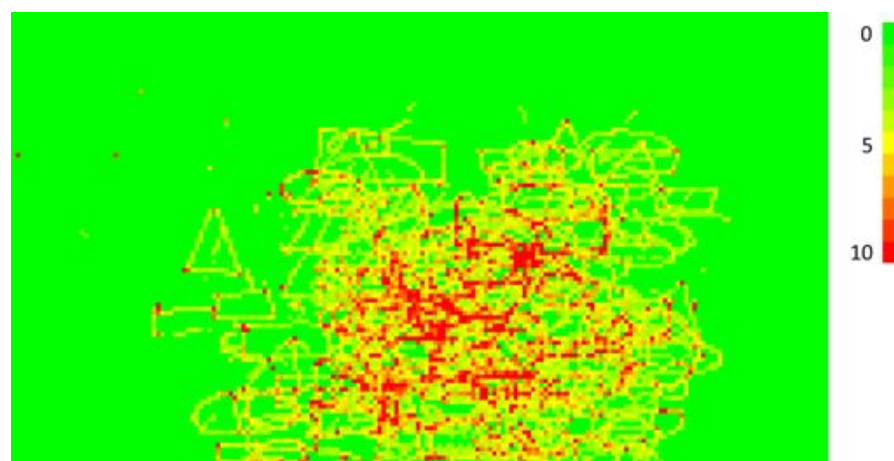


Figure 52: Heat map of pen interaction

An interesting fact that can be recognized when comparing the two heat maps is that hot spots of touch interaction are further spread than hot spots of pen interaction. Hot spots of pen interaction all are positioned in the middle of the table, slightly shifted to the right, which is due to the fact that all participants are right-handed. To get a deeper insight on why the heat maps of pen and touch have a different distribution of hot spots the video recordings of the study have been examined. The examination shows that users generally have sought out an area where they plan to apply their mind map. The position of this area tends to be located on the middle of the table. Its exact location is decided on base of books and opened web pages located on the table. Participants used their left hand to adjust the information landscape onto this area. Inside this area the right hand is used to draw, write on and link mind map items.

*Kinematic chain
model*

The positioning of hot spots and the characterized cooperation of non-dominant (left) and dominant (right) hand somehow proofs the kinematic chain model developed by Yves Guiard which describes the "asymmetric division of labor in human skilled bimanual action" [21, p. 486]. A good summary which explains this model is given by Frisch et al.:

"the dominant hand moves within the frame of reference set by the non-dominant hand, the non-dominant hand precedes the dominant hand, and the dominant hand performs more precise actions" [17, p. 150].

This definition basically matches with the observation and the distribution of hot spots.

*User opinions about
the input devices*

To get qualitative responses regarding the selection of input devices the participants have been asked about their opinion in the interview. They interestingly gave very different responses about if the interaction with pen and touch is intuitive and meaningful in the context of

Integrative Workplace. The interview question for the biggest advantage and the biggest disadvantage of Integrative Workplace illustrates this fact. While one participant stated that the biggest disadvantage of Integrative Workplace is the "unusual and not very intuitive interaction with pen and fingers", two participants indicated that the biggest advantage of Integrative Workplace is its intuitive and easy application. This contrariety is continued in the results of the interview question asking for the experience when interacting with finger, pen and keyboard. Table 15 displays a classification of answers into the categories positive, neutral and negative. There are several possible reasons why pen and touch did not satisfy the participants. First, they normally work at their pc with keyboard and mouse and if they do not regularly operate any touchable device they need to learn how to interact with Integrative Workplace or need to get used to this kind of interaction. And even if participants are experienced with touchable devices, working with mouse and keyboard is faster than working with finger and pen, as relative movement (mouse) is faster than absolute movement (finger and pen). In the context of writing a seminar paper the study revealed that it is important to be able to work fast. One participant complained two times during solving the legal record that he is faster with his normal method than with Integrative Workplace. Another participant said that the biggest disadvantage of Integrative Workplace is that you are slower than with your normal method. For two participants the fact that they are slower with Integrative Workplace than in their normal method is also reasoned by the interaction with finger and pen in comparison to the interaction with mouse and keyboard. Asked in the interview how they perceived the interaction technique to excerpt text, one of them said it is faster working with a keyboard at a PC then moving text passages with a pen. The other participant expressed that he thinks the interaction technique is too complicated as you need to cover distances. He indicated it is better "to determine what happens at the text and later on specify the location of insertion".

Another problem is the simultaneous use of stylus and keyboard. During solving the task of the study two participants complained about the continuous switching between keyboard and pen. Additionally, in the answers of Table 15 two participants indicated that the switching between keyboard and pen is frustrating. Furthermore these two participants recommended abandoning the stylus. In addition one participant indicated to perceive the interaction with pen and finger at one hand (right hand or dominant hand) as disturbing (see Table 15).

The negative user feedback about the pen seems obvious, since it provides no actual benefits for the tasks it is used in. In an experiment Matulic et al. ascertained that for rapid tracing tasks opting for pen or for finger "has no or little consequence on accuracy" [44, p. 8]. As the

Pen and finger in matters of accuracy

How do you experience the interaction with finger, pen and keyboard?		
POSITIVE	NEUTRAL	NEGATIVE
<ul style="list-style-type: none"> • Keyboard is the best for writing. With pen and finger the interaction is "natural and simple". • Good aids. A pen is a "wonderful tool" 	<ul style="list-style-type: none"> • "As natural as digital things are." "Maybe better than mouse." • Initially: it takes some getting used to. "Sometimes you need to use the finger sometimes the pen". After a learning phase: "unproblematic" • Participant is used to this kind of interaction, because he operates his laptop with the touchpad and is using a phone with a touchscreen. • "Didn't know when I had to use the pen and when the finger." Though the change between input devices wasn't perceived as disturbing. 	<ul style="list-style-type: none"> • "A bit annoying." Pen and finger are no problem. Switching between keyboard and stylus is frustrating. "Cool, if you could abandon the pen". • Three controls are too much. Keyboard needs both hands; therefore the best solution is to abandon the pen. Suggestion: Use two fingers to move a mind map item, use one finger to link two items. • Interaction with pen and finger at one hand (right hand) was disturbing.

Table 15: Results of question no.10 of the interview

tasks of Integrative Workplace, which are performed with a stylus can be considered rapid tracing tasks; the use of a pen is not resulting in a relevantly higher accuracy. And since additionally, the nature of tasks

used to build a mind map does not acquire any accuracy, participants do not feel the need to use a pen when drawing a mind map item.

For writing on mind map items or for marking text passages the pen firstly seems to offer advantages with respect to accuracy. But as most of the participants used the keyboard for writing, the advantage of a pen in comparison to a finger in matters of writing, were not really perceived by the participants. Furthermore since Integrative Workplace still is a prototype the marking of text passages with the pen was not as precise as expected when working with a stylus. This is a general problem of digital pens. Because "people have experience with traditional writing implements and therefore expect digital counterparts to meet similar levels of precision, handiness and responsiveness" [44, p. 9], they scale pen input at a higher measure than for example touch input. A quote of one of the participants proofs this statement: "an electronic pen and a real pen is not the same". For these reasons it is obvious that some participants do not see benefits regarding the usage of a stylus.

Users compare digital with traditional pen

If the usage of a pen does not provide any benefits in terms of the tasks of Integrative Workplace the question arises why the pen is needed anyway. The answer is that the pen is needed as context switch. Examining diagram editing on interactive displays using multitouch and pen gestures, Frisch et al. detected the same conflict, which arose in the design phase of this prototype. The problem of creating an edge versus moving a node:

The pen for context-switching

"When a node is touched and the finger or pen starts moving, it is not clear if the node should be dragged or an edge should be inserted" [18, p. 188].

In addition in this prototype, the conflict between moving the landscape and drawing a mind map item emerged:

When the information landscape is touched and the finger or pen starts moving, it is not clear if the landscape should be dragged or a new mind map item should be inserted.

To resolve these conflicts we used the pen as context-switch between moving and tracing. For the first conflict the solution is as follows:

When a node is touched with a finger and it starts moving, the node is dragged. When a node is touched with a pen and it starts moving, an edge is inserted.

For the second conflict the nature of the solution is the same. Basically for the whole design process of this prototype a design guideline was developed (see [Section 5.2](#)):

Design guideline for pen and touch input

Everything which leaves ink traces on the user interface is done with a pen.

This means that the user needs to use the stylus for drawing an edge or a mind map item as well as to write on a mind map item or to mark text. On the other hand operations like moving, scaling, scrolling, etc. are performed with fingers.

*Misappropriations
of pen and finger*

This guideline is based on reality and we supposed it is easy to understand for users. But the evaluation of the study showed that the conductor did observe misappropriations of pen or finger, after the training phase and during the task, for all participants but two. In the following section some examples of misappropriations are listed:

- Participants tried to move a mind map item with the pen.
- Participants tried to draw a mind map item using a finger.
- Participants tried to link two mind map items using a finger.
- Participants tried to scroll text using the pen.

For most of the activities designed according this guideline, misappropriations have been detected. The only exception, for which certainly no finger was used, is writing on a mind map item. It seems like the reality orientated guideline, to draw with a pen and to move with a finger, is not so natural for participants like expected. This also becomes clear when looking at the answers of two participants in the interview (see [Table 15](#)). Both stated they had problems to distinguish between when to use the digital pen and when to use a finger.

*Use the pen for
context-switching?*

If participants do not take the reality-based, inherent differences between pen and finger into account when using a pen and touch interface, it raises the general question:

Is it reasonable to use a pen as context-switch between tracing and moving tasks, when it provides no advantages concerning accuracy?

And due to the nature of tasks performed by a pen within the prototype, the question arises:

Does the use of a stylus make sense in the case of Integrative Workplace?

Interestingly enough Frisch et al. have determined similar outcomes, conducting a user study which investigated how people edit node-link diagrams on interactive tablets. Participants had to perform spontaneous gestures for different tasks, which in some way manipulate a node-link diagram [17]. All tasks could be accomplished on the base of structural editing or with sketching. They interestingly observed that in the sketching part most of the users drew elements with fingers as well as with pen: "participants hardly distinguished between fingers and pen" [17, p. 155]. A quote of a participant of this case study confirms this finding. The participant stated: "pen or finger makes no difference".

In a follow-up paper they present a prototype which is built on base of the results of their study [18]. As they did not identify a general preference for one of the modalities when it comes to sketching, they decided not to use the distinction of input modalities for context switching. Instead they decided to add an interactive border region around every node. Depending on, if the user touches or not touches this region a node is moved or a link is drawn.

Similar findings were obtained by Matulic et al. evaluating uni- and bimodal pen and touch interaction [44]. They detected that a majority of users agree that a pen is more adequate for a tracing task, but nevertheless a few people preferred direct touch input. These results are quite surprising since coming from reality the clear cut division of labor between performing tracing tasks with a pen and moving tasks with a finger seems to be the apparent way to go for pen and touch interfaces. An explanation why users obviously not agree with this division of labor is given in the following section:

"With the proliferation of tablets, smartphones and other touch-only devices, the interactive ecosystem is heavily biased towards the latter. In this changing ergonomic context influenced by touch-operated appliances, people are gradually developing a habit of using their fingers for all kinds of interactions, including quite a few that one would think would be more adequately performed with a pen" [44, p. 9].

Explanation for problems of the distinction between pen and touch

Though literature gives some interesting insights, no final answers regarding the questions asked above can be found. For this reason the question of context-switching in pen and touch interfaces can be considered an interesting area of future research.

A quick and case-specific solution for the problem of context-switching in Integrative Workplace is presented in the following section. Since the study of Frisch et al. showed that users generally do not distinguish between fingers and pen, all tasks of Integrative Workplace are executable using both. For applying the mind map, a special context-switch like the interactive border region presented by Frisch et al. is displayed at every item. Additionally the guideline is specified, that if a function exclusively can be triggered by a pen, the stylus should bring tangible benefits. Otherwise, there is the risk that users perceive the switches between finger and pen as annoying. An example for a function where the pen has obvious advantages, in contrast to the use of a finger, is any kind of handwriting.

Solution for the problem of context-switching

CONCLUSION

This chapter concludes the thesis. It summarizes the results according to the defined goals and gives a short outline of the implementation. In the course of this chapter the lessons learned during the project are stated. Finally a new design of Integrative Workplace which takes the findings of the study into consideration is presented and a possible direction of future research is illustrated.

7.1 SUMMARY

Within the scope of this thesis an interactive workplace which supports knowledge workers by integrating printed media has been developed and evaluated. This thesis' prototype enables a digital full-text in search as well as the simple excerpting of contents from paper documents. Furthermore, digital content and its analog sources can be related to each other. This possibility to use features only known from digital devices within paper documents is the major benefit of the prototype regarding knowledge work. To operate the system, the same digital pen and the same interaction techniques are used to process digital and printed texts in a identical manner. In addition the printed documents on the table are tracked and the visualization is adjusted according to their position.

The unique characteristic of this system is the combination of mentioned features and their integration into a real working environment. With participants solving a legal record, the study has shown that, in the defined scope of the model of O'Hara et al. (see [Section 1.2](#)), Integrative Workplace actually facilitates knowledge work.

The system's design and implementation has been developed based on a literature review on design guidelines for knowledge work and post-WIMP interfaces as well as on related work. Furthermore a pre-study was conducted to determine requirements relating to the use case (the writing of a jurisprudential seminar paper) of this thesis.

The results of the conducted case study revealed that paper is successfully integrated into Integrative Workplace. The amount of excerpts from analog sources over all participants is 1.5 times as high as the amount of excerpts from digital sources. Furthermore the user feedback about the integration is encouraging. The possibility to excerpt text and to execute full-text searching in bounded books was named as the biggest advantage of the integration of books into Integrative Workplace. Asking for disadvantages regarding the integration of books into the system, six out of nine participants indicated

*Outline of
implementation*

*Paper is successfully
integrated*

that there are none. In addition the possibility to easily excerpt text from printed documents was one of the two most cited responses on the question for the greatest advantage of the system.

*The extend
Integrative
Workplace supports
the juristic working
methodology*

The examination of the study in matters of the support of the juristic working methodology revealed that law students generally agree with this hypothesis. Especially the possibility to save texts at the same place regardless if excerpted from analog or digital sources was appreciated by law students. A major problem of Integrative Workplace regarding the juristic working methodology is the fact, that a mind map is unable to map the linear structure of a juristic solution sketch. Additionally participants highlighted the importance of a word processor to be able to apply their common working methods when using Integrative Workplace. The developed ideas for the reference backtracking function and the digital full-text search in printed documents have been stated as very useful in the context of juristic working practices.

*Usability of
Integrative
Workplace*

The evaluation of the usability of Integrative Workplace revealed that, according to the overall average SUS score of 66.94, participants rated the system as in between ok and good. Due to the fact that Integrative Workplace still is a prototype this is a remarkable result. In addition the evaluation of input devices discovered that using a pen for context-switching between moving and tracing tasks is not as clear cut as one might think. Although this behavior is adapted from reality seven out of nine participants had problems to distinguish between when to use the finger and when to use the pen. A quick solution for this problem is to allow users to use fingers or the pen for the same interaction, whenever it is possible and to restrict the usage only to pen if it offers tangible benefits. Otherwise, there is the risk that users perceive the switches between finger and pen as frustrating.

*Image film of
University of
Konstanz*

The ideas and concepts realized in Integrative Workplace fascinates people. This is the reason why Integrative Workplace was chosen as one of a few research projects of University of Konstanz to be presented in the university's image film. The film was shot in summer 2013 and will be published in autumn 2013.

*Fujitsu's system to
interact with real
world objects*

A matter that emphasizes the topicality of the concepts which are presented in this thesis is that Fujitsu is developing a system with similar features (see [Figure 53](#))⁴⁸. The system facilitates the easy excerption of contents from printed documents and the linking between digital contents and contents on printed documents. In addition it offers other possibilities such as the gesture-based moving of 3D objects. Fujitsu aims to develop a commercial version of this system by fiscal 2014.

⁴⁸ <http://www.fujitsu.com/global/news/pr/archives/month/2013/20130403-01.html>



Figure 53: Fujitsu's system for interacting with real word objects like on touch-based computer systems.

7.2 LESSONS LEARNED

Two components of the prototype had technical issues and therefore reduced the user experience. The first component was *reactIVision* for the detection of printed documents on the table. Normally the system detects tokens and touches in tabletop systems with a rear projection with the help of reflected infrared light. As it was not possible to use infrared diodes in the setting of *Integrative Workplace*⁴⁹, the marker detection was instable and highly depended on the lighting conditions of the environment. The implementation of a computer vision based system (like e.g. in *LivePaper* [49]) to detect documents on table would result in higher user experience and would offer the benefit that no more markers would be needed to be imprinted on documents used in the system.

The second component which reduced the user experience is the capacitive foil. The foil has major problems regarding the accuracy of detected touches and sometimes it fires events for touches which did not occur. A conceivable solution for this problem is to replace the table with a screen having a sophisticating pen and touch detection (like e.g. *Perceptive Pixel* by Microsoft⁵⁰) and use the projector only for the augmentation of printed documents.

A positive lesson learned was the usage of a case study for evaluation. The case study gave in-depth insights into the domain of writing

Detection of printed documents

Capacitive foil

Case study for evaluation

⁴⁹ The camera needed to be mounted high above the tabletop so as the use of an infrared filter caused the edges of the markers to blur. As a result markers no longer have been recognized by *reactIVision*.

⁵⁰ <http://www.microsoft.com/office/perceptivepixel/default.aspx>

a jurisprudential seminar paper which built the base for many of the presented design ideas. In addition the findings of the study formed a foundation for the suggestion of a research question for further examinations.

Development of systems for knowledge work

Another lesson learned addresses the development of systems for knowledge work in general. The examination has shown that you should not force knowledge workers to use a certain tool or function. Unfortunately this is done by Integrative Workplace, with the mind map being the only method to build a solution sketch for a legal record. This shortcoming was also perceived by two participants, who complained about the attachment to the structure of the mind map. They stated that the system is not able to adjust to their individual way of working. If you design a visualization or a tool which aims to support knowledge workers, it should always be integrable in their usual way of working and in the common tools to perform their work. This is emphasized by the desire of a participant for a connection between Integrative Workplace and a laptop. Other examples which underline this statement are wishes for a text editor and the possibility to be able to just paste excerpted text into continuous text.

In this context the complaints about the pen and fingers not being fast enough when excerpting text can be explained with not having the possibility to use PC's common tool to perform such an operation, the mouse. When choosing a reality-based design approach to develop a system which simplifies excerption of text from printed documents a mouse must be considered as part of reality ("well established digital concept" [32]), because knowledge workers use it every day to excerpt text. And therefore it needs to be integrated into the system.

As knowledge workers are highly skilled using common applications of their domain, new tools should provide functionality which can be used within these applications. You should not try to reinvent working methods, but to offer alternative ways or functions which are not possible to execute with state-of-the-art tools. A system which aims to support knowledge workers must offer new functionality in addition to common functionality to go beyond the working practices of a certain domain.

7.3 FUTURE WORK

Design of the new system

One part of future work is to implement the insights obtained by the study in Integrative Workplace. Therefore a visualization is designed which depicts the linear way a legal case normally is solved. This solution sketch visualization is provided on the information landscape additionally to the mind map. To add an item into the solution sketch you can just drag a mind map item at the desired position on the visualization and drop it (see [Figure 54a](#)). The sequence of items inside the

visualization also can be changed using drag'n'drop (see [Figure 54b](#)). If you touch an item of the visualization, its detail view is opened. This detail view is a text editor, which allows users to process text as usual and to paste excerpted passages (from printed documents or web pages) directly in continuous text (see [Figure 54d](#)). If a hold gesture is performed on an item of the solution sketch the reference backtracking function known from this version of Integrative Workplace is executed. On a vertical display a desktop is shown, which offers all functionality of a default operating system (see [Figure 54c](#)). User can drag contents from the information landscape on the desktop and vice versa. Conclusively it should be stressed that the new system is based on the guidelines for mind mapping and the division of labor between pen and finger in pen and touch user interfaces presented in [Section 6.4](#).

Another part of future work concerns pen and touch user interfaces in general. In literature there are different opinions about using pen and touch for context-switching between different kinds of tasks. Matulic et al. name the "seamless and almost instant context switches between the two modes" [[44](#), p. 1] as one of two main advantages of pen and touch being available together⁵¹. In contrast Frisch et al. detected in a study about editing node-link diagrams on interactive tabletops that users hardly distinguish between fingers and pen ([[17](#)]. For that reason they refused to use the distinction of input modalities to switch between moving and tracing tasks in an own prototype and instead relied on graphical context switching [[18](#)]. The case study of this thesis revealed that users have serious problems with the use of pen and finger for switching between tracing and moving tasks. As clear cut as it might seem applying a reality-based design approach this context-switch caused numerous misappropriations of pen and finger and two participant to complain about their uncertainty on when to use a finger and on when to use the pen. The discord in literature and the findings conducted in this thesis' study suggest the following research question:

Is it reasonable to use the distinction between pen and finger as a context-switch between tracing and moving tasks if the execution of a task does not require any accuracy?

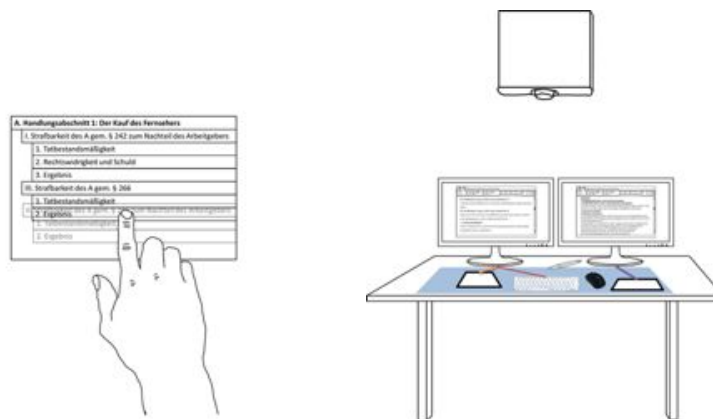
This question belongs to the topic of the division of labor in pen and touch interfaces in general, which was defined as an interesting direction for future research by Matulic et al. [[44](#), p. 10].

Pen and touch for context-switching

⁵¹ The second main advantage of pen and touch according to Matulic et al. is that "in coupled bimanual operations, one modality can serve to modify the functional context of the second through parallel activation or gestural actions" [[44](#), p. 1].

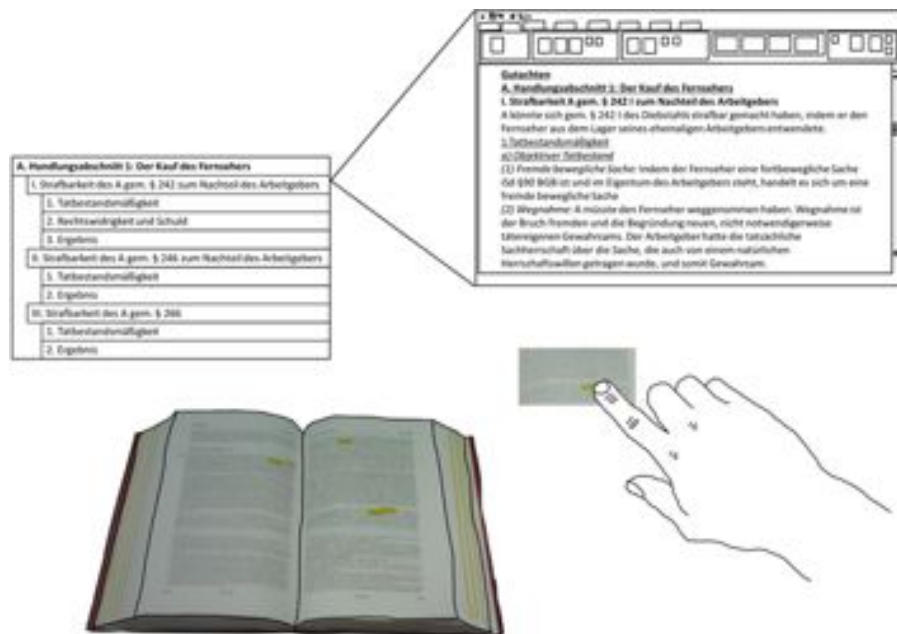


(a) Dragging an item into the solution sketch visualization



(b) Changing the sequence of items inside the solution sketch visualization with drag'n'drop

(c) New hardware setting



(d) Dragging text in to the detail view of the solution

Figure 54: New design of Integrative Workplace

NARRATIVE STORYBOARD

The narrative storyboard of this thesis was designed to get a deeper understanding on how the system will work. Therefore it pictures the system's environment and it tells the thoughts and the intention of a user. The narrative storyboard of this thesis tells the story of a law student who solves a legal record using Integrative Workplace. It was designed to motivate discussions with usability and domain experts.



<p>Der Student wählt die markierte Passage mit dem Finger aus und dragged sie auf die Tischfläche.</p>	<p>Anschließend lässt er sie los. Dadurch bildet sich eine Mindmap-Wolke, die den exzerpierten Text repräsentiert.</p>
<p>Nachdem der Student verschiedene Wolken durch Exzerpieren und manuelles Anlegen auf seiner Tischplatte verortet hat, möchte er den Begriff Kausalität definieren.</p>	
<p>Er sucht nach einer Definition des Begriffes in einem Kommentar des StGBs und markiert die Stelle mit dem Stift.</p>	<p>Er wählt den Text mit dem Finger aus und dragged ihn..</p>



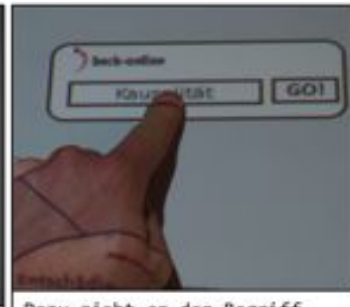
...auf die Definition.



Nach dem Loslassen wird auf dem Tisch die entsprechende Referenz dargestellt.



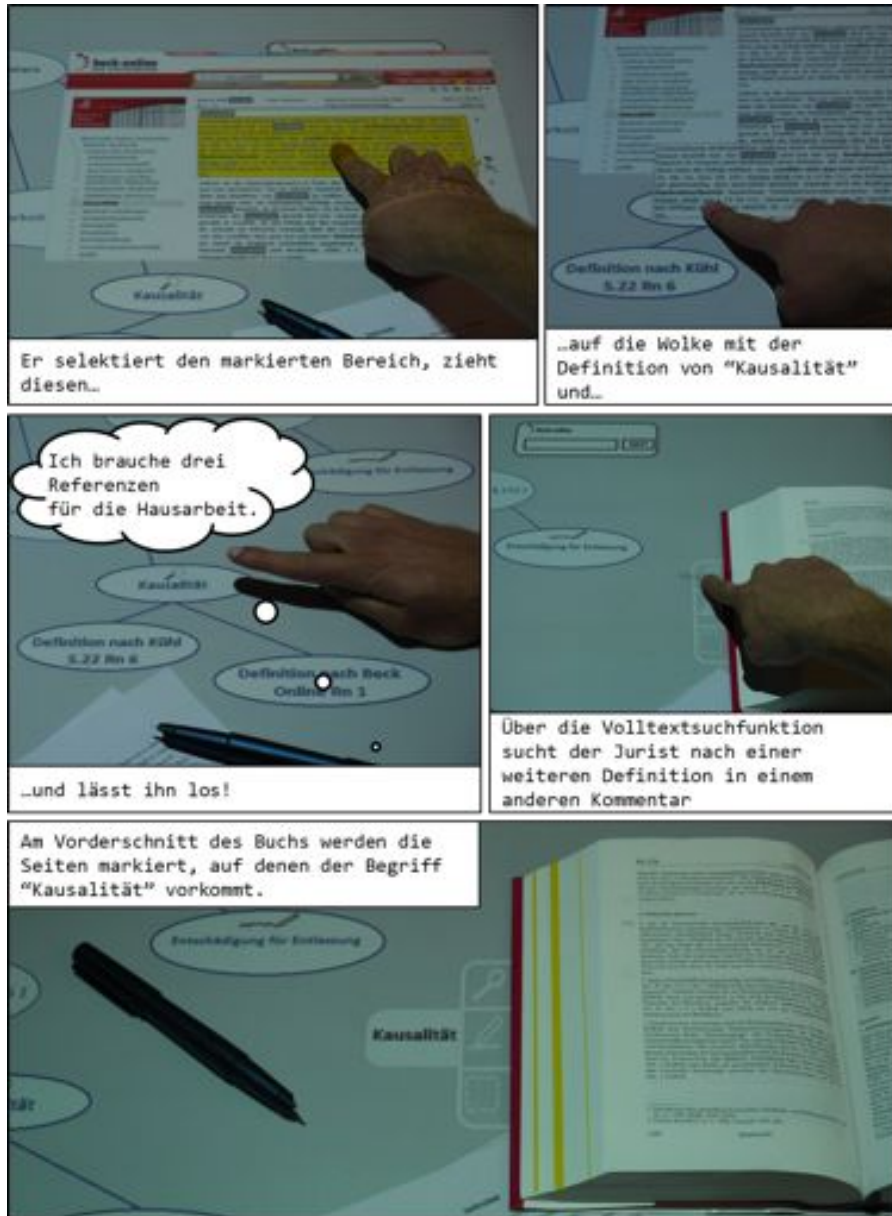
Der Student sucht online nach weiteren Referenzen, um die Definition in seiner Hausarbeit verwenden zu können.



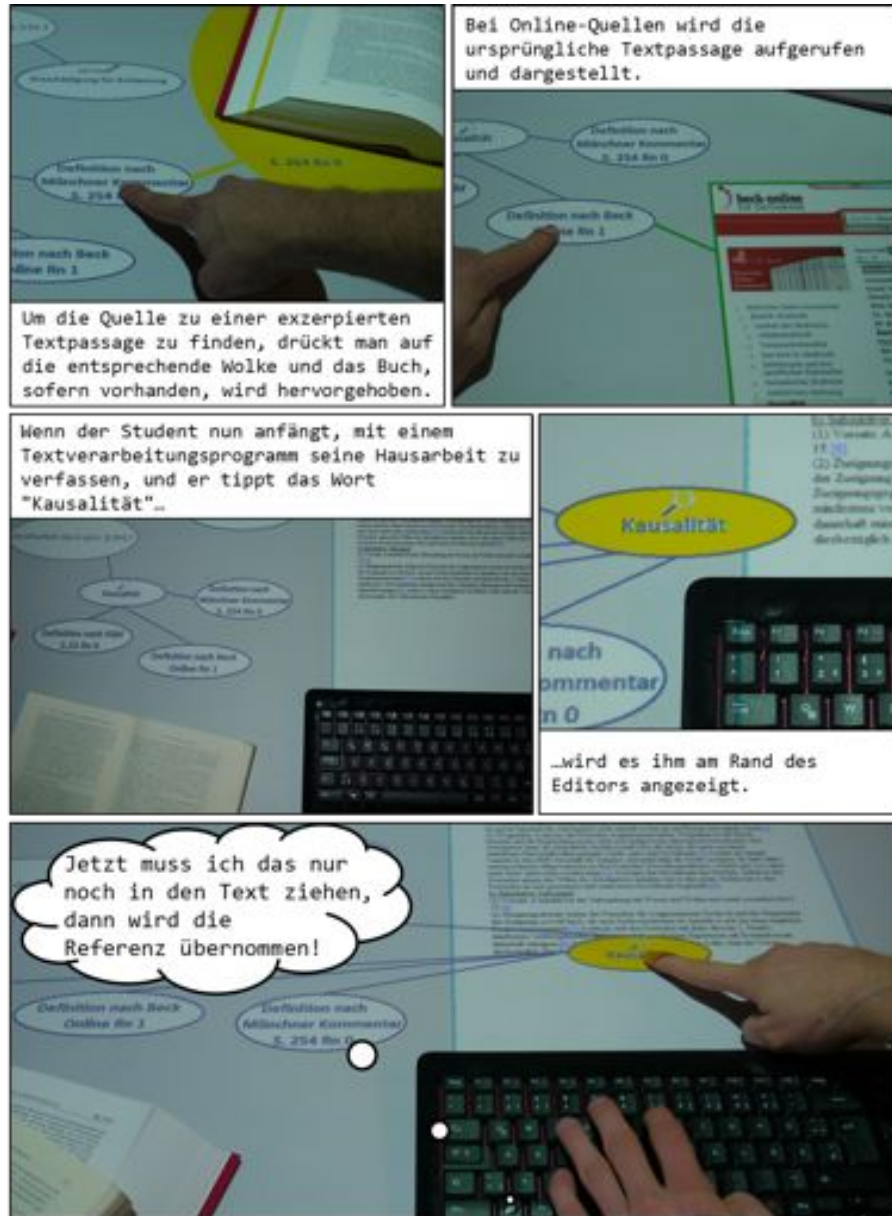
Dazu zieht er den Begriff "Kausalität" in das Such-Widget einer Online-Fachdatenbank.

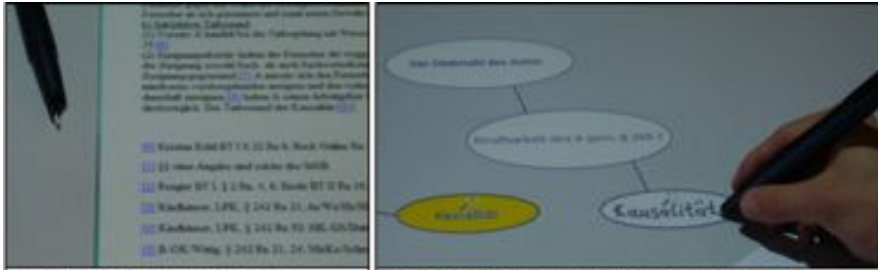


Diese Definition ist aber gut...





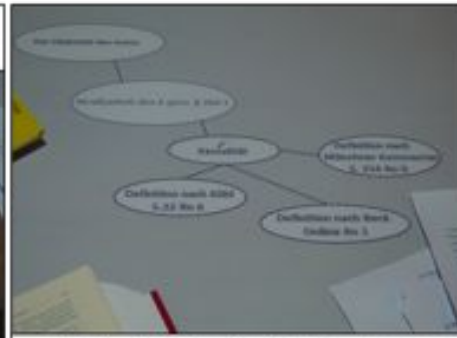
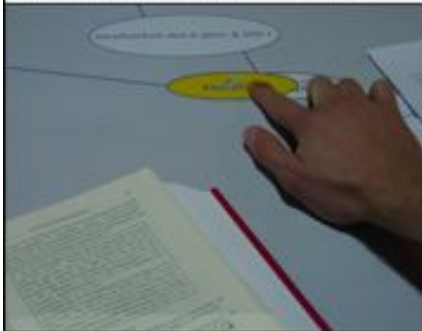




Nachdem der Student die Definition in den Text gezogen hat, werden die zugehörigen Referenzen als Fußnote eingefügt.

Wenn der Student an einem neuen Fall arbeitet und wieder den Begriff "Kausalität" benötigt, wird die angelegte Definition des schon bearbeiteten Sachverhalts aus dem Off-Bereich der Landschaft angezeigt.

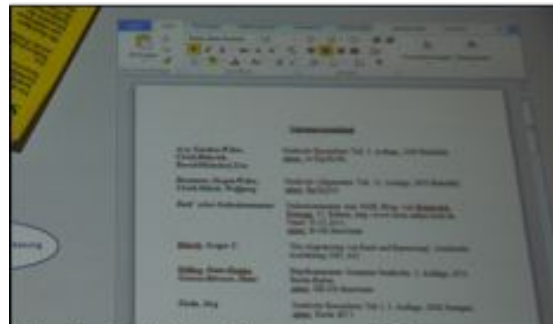
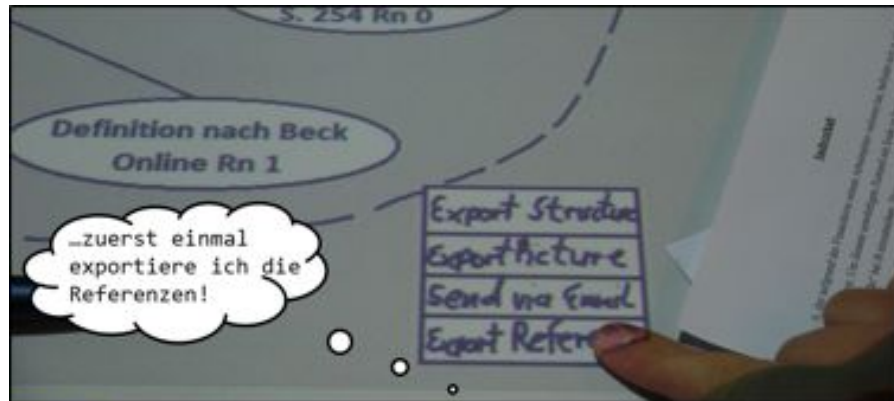
Anschließend muss der Benutzer die Definition nur noch auswählen..



...und sie wird für die Mindmap des neuen Falls übernommen.

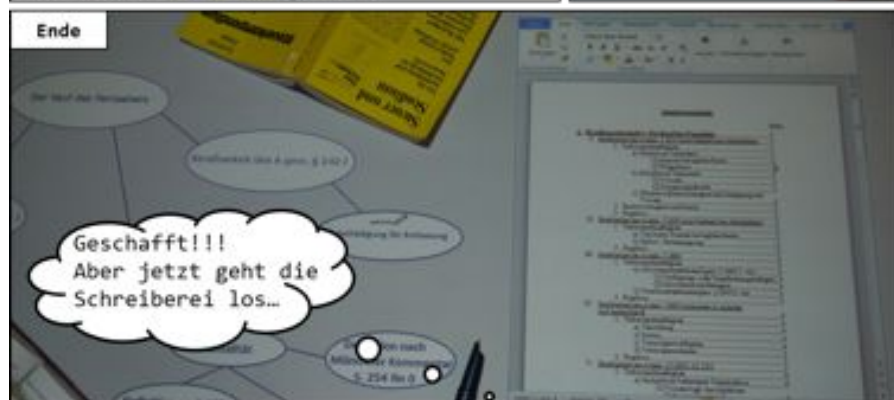
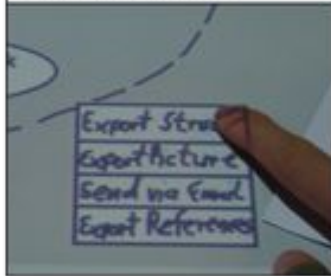


Puhh, Literaturlauswertung abgeschlossen. Jetzt nur noch die Ergebnisse exportieren!



Der Jura-Student exportiert im letzten Schritt die Struktur der Mindmap als vorläufiges Inhaltsverzeichnis.

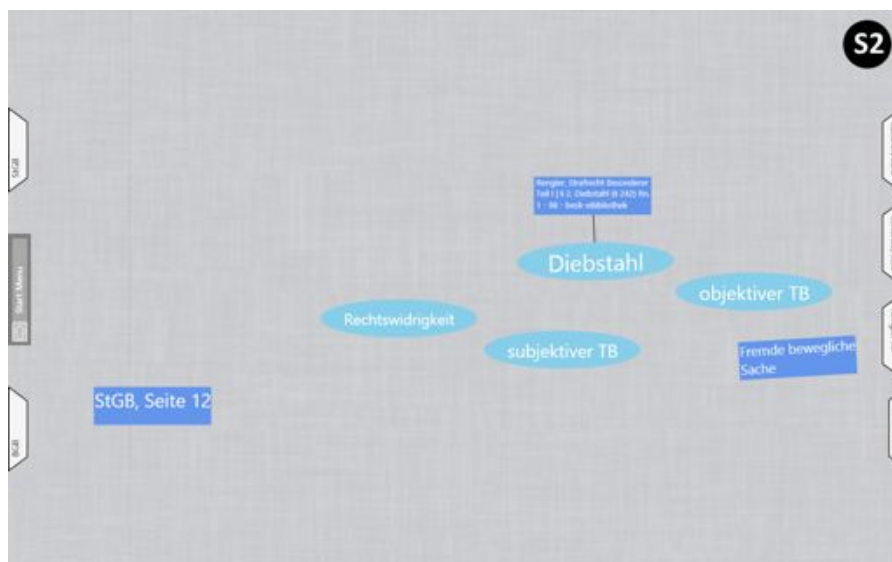
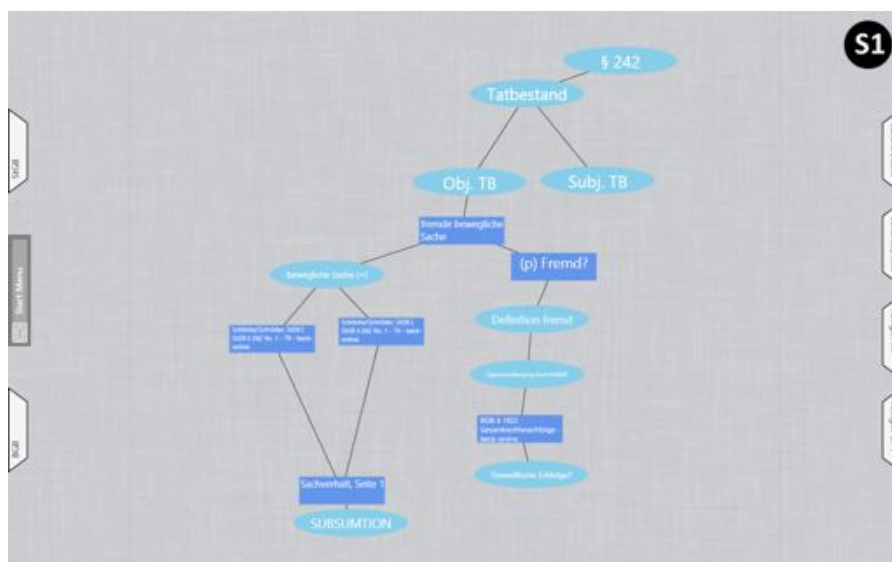
Die in der Mindmap hinterlegten Referenzen werden im korrekten Format in einem Literaturverzeichnis dargestellt.

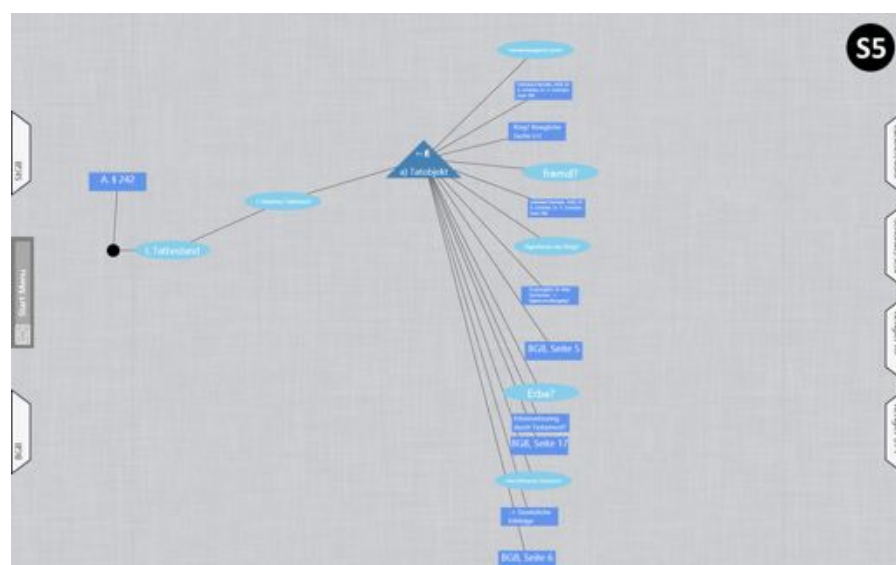
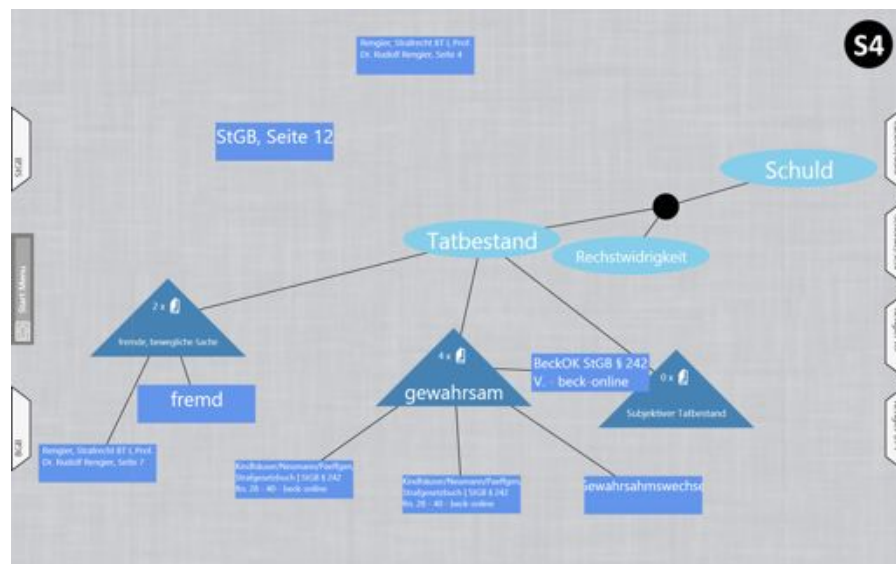
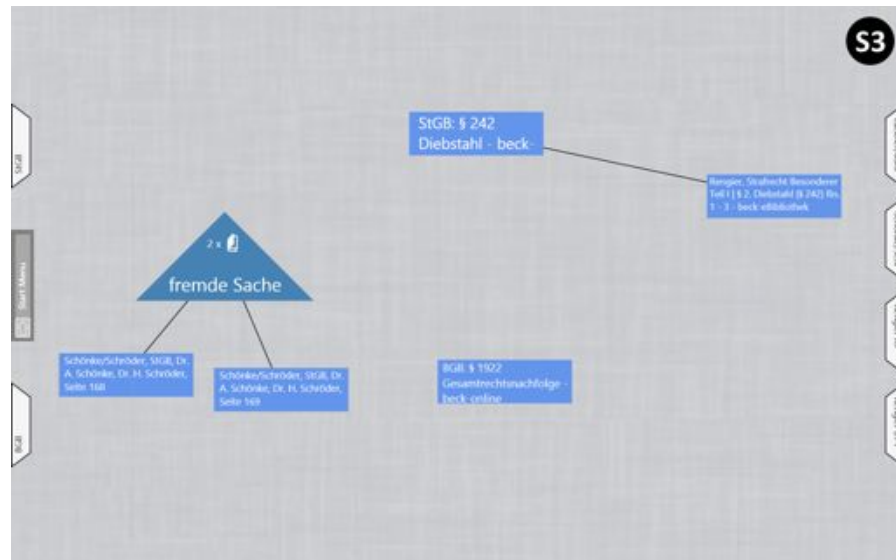


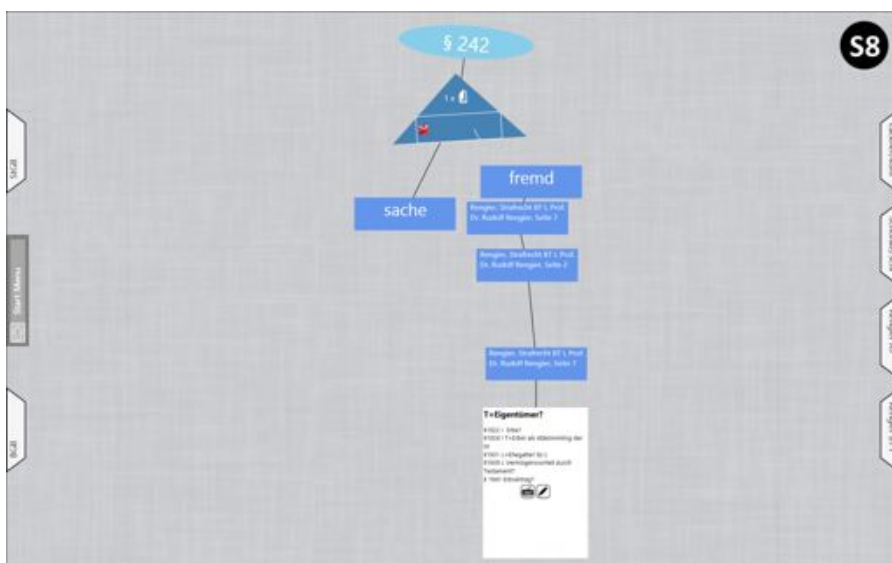
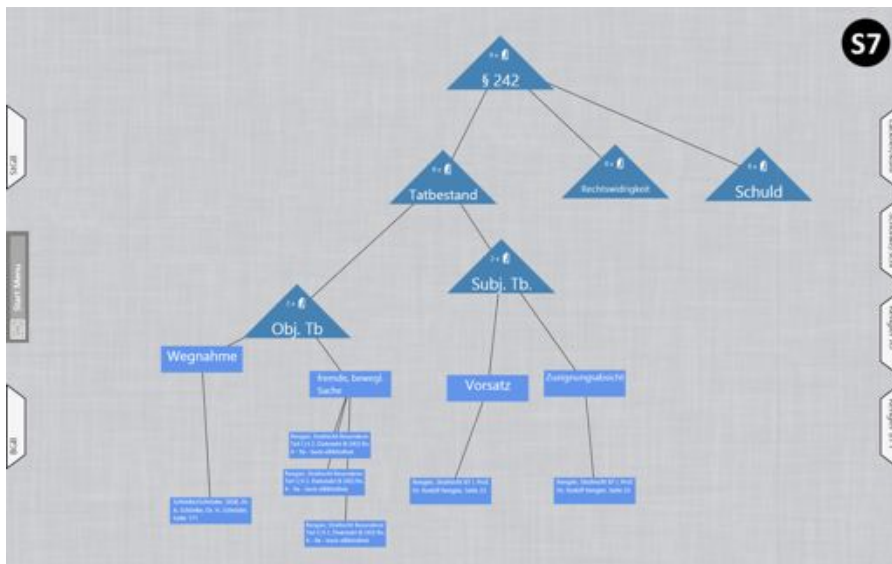
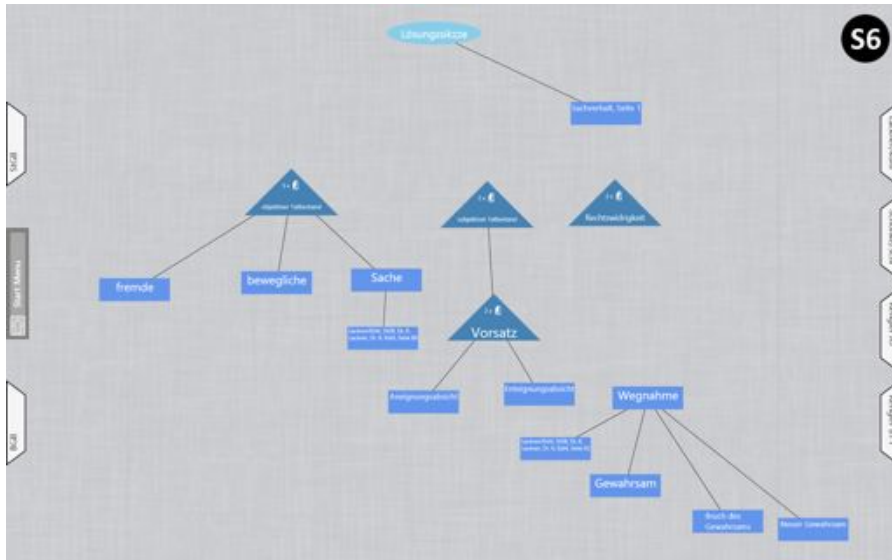
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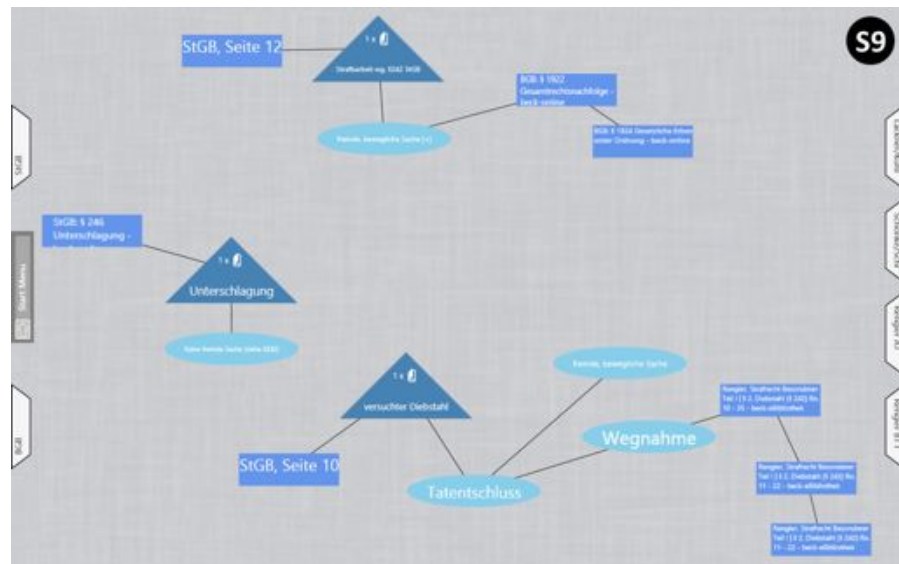
SOLUTION SKETCHES

This appendix shows the solution sketches which have been designed by the participants of the case study. The solution sketches show the way the legal record, which was the task of the study, can be solved.









STUDY OUTLINE

This appendix contains the outline of the study. The outline operationalizes the hypotheses in an informal way.

Outline Integrative Workplace

Eckdaten

Projekt

Integrative Workplace - Sense-making on Digital Tabletops employing Reality-based Interaction
Master-Arbeit von Christoph Gebhardt

Kernmethode

Fallstudie

Personen und Aufgaben

Christoph Gebhardt: Studienplanung und Durchführung, Konzeption und Implementation des Prototyps

Zeitraum

Juni/Juli 2013

Abschluss

Abgabe und Präsentation der Master-Arbeit

Zusammenfassung

Das Projekt Integrative Workplace hat die allgemeine Zielsetzung die Kluft zwischen digitalen und analogen Medien zu überbrücken bzw. zu verringern. Der spezielle Fokus liegt dabei auf der Bearbeitung von digitalen und analogen Texten mit gleichartigen Interaktionstechniken und Eingabegeräten sowie dem lückenlosen Transferieren von Inhalten zwischen Büchern und elektronischen Texten. Als Anwendungsdomäne hat man das Verfassen einer rechtswissenschaftlichen Hausarbeit gewählt. Dieser Prozess wurde auf das Model von O'Hara et al. übertragen und auf gewisse Teilbereiche des Modells eingeschränkt.

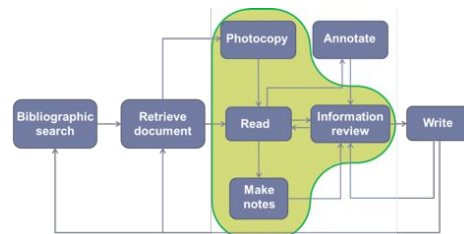


Abbildung 1: In Anlehnung an das Model von O'Hara et al. über "Student Readers' Use of Library Documents: Implications for Library Technologies"

Wie in der Abbildung dargestellt, ist das Projekt innerhalb des Modells um den Aspekt "Information review" verortet. In einer Anforderungsanalyse wurden Erfordernisse erarbeitet, die Jura-Studenten an ein solches System haben. Sowohl die Anforderungen des Anwendungsfalls als auch der Fokus der allgemeinen Zielsetzung wurden in einem Prototyp umgesetzt. In der Studie soll überprüft werden inwiefern der Prototyp Studenten beim Verfassen einer rechtswissenschaftlichen Hausarbeit unterstützt. Darüber hinaus soll überprüft werden inwiefern die die Kluft zwischen digitalen und analogen Medien geschlossen werden konnte. Das heißt es wird untersucht ob sich die Unterschiede beim Arbeiten mit digitalen und analogen Quellen verringert haben, oder sogar die Vorteile der jeweiligen Quellen im Prototyp zusammengeführt werden konnten.

Ziele, Forschungsfragen & Hypothesen

Ziele

- Ein Ziel ist es zu untersuchen ob Integrative Workplace die unterschiedlichen Arbeitsweisen mit digitalen und analogen Medien an einander annähern und erfolgreich in ein System integrieren konnte (Empfindet der Benutzer den Wechsel zwischen digitalen und analogen Medien immer noch als störend). Dabei wird der Fokus auf den Teilbereich des Modells von O'Hara et al. beschränkt, in dem Integrative Workplace verortet wurde.
- Das zweite Ziel dieser Fallstudie ist es herauszufinden, inwiefern der Prototyp Studenten beim Verfassen einer rechtswissenschaftlichen Hausarbeit unterstützt. Da der Prototyp nicht den gesamten Prozess des Verfassens einer Hausarbeit abdeckt, soll insbesondere untersucht werden ob Studenten den Prototyp in ihre eigene Arbeitsweise integrieren können.

Forschungsfragen

F1: Ist es Integrative Workplace gelungen Printmedien in das System und die digitale Arbeitsweise mit Text zu integrieren?

F2: Unterstützt Integrative Workplace Jurastudenten beim Verfassen einer rechtswissenschaftlichen Hausarbeit?

F3: Gelingt es den Benutzern mit Integrative Workplace problemlos zu interagieren? Welche Benutzungsprobleme tauchen auf?

- F3 wird anhand von Beobachtungen und der Beantwortung des Standardfragebogens SUS beantwortet.

Hypothesen

Da es sich in dieser Studie um eine Fallstudie handelt, werden die im Folgenden aufgestellten Hypothesen nicht formal getestet. Sie dienen vielmehr als Anhaltspunkt für die spätere Auswertung der Studie und definieren die zu untersuchenden Aspekte (siehe S. 161 in "Research Methods in Human-Computer Interaction").

H1: Das Verhältnis der exzerpierten Passagen aus digitalen und analogen Quellen verändert sich zugunsten von analogen Quellen, wenn man die normale Arbeitsweise mit dem Arbeiten unter Integrative Workplace vergleicht.

→ Abgeleitet aus der Anforderung "Exzerpieren". Bezieht sich auf F1.

→ Quantitative Auswertung: Gibt es signifikante Unterschiede zwischen der Häufigkeit von exzerpierten Textpassagen aus digitalen und analogen Quellen?

→ Abfragen in Pre-Fragebogen:

- Schreiben Sie Textpassagen bewusst ab, da durch den Prozess des Schreibens Wissen besser verinnerlicht wird?
- Aus welcher Art von Quelle exzerpieren Sie häufiger Textpassagen? Begründen Sie Ihre Antwort.

→ Abfragen in Fragebogen:

- Wie viele Textpassagen haben Sie aus analogen Quellen extrahiert im Vergleich zu Ihrer normalen Arbeitsweise bei einem Sachverhalt mit einem ähnlichen Umfang?
- Wie viele Textpassagen haben Sie aus digitalen Quellen extrahiert im Vergleich zu Ihrer normalen Arbeitsweise bei einem Sachverhalt mit einem ähnlichen Umfang?

→ Abfragen in Interview:

- Wie empfinden Sie das Extrahieren von Text aus digitalen und analogen Quellen mit Finger und Stift?
- Hat sich Ihr Verhalten in Bezug auf die Häufigkeit des Exzerprierens von digitalen und analogen Quellen verändert?
- Würden Sie das System auch verwenden, obwohl die Gefahr besteht, dass Sie später weniger wissen würden, als durch handschriftliches Zusammenfassen? In welchem Kontext würden Sie noch handschriftlich Zusammenfassen?

H2: Unter Verwendung von Integrative Workplace unterstützen digitale Quellen das Arbeiten von Juristen genauso gut wie Bücher.

→ Bezieht sich auf F1.

→ Quantitative Auswertung: Wie viele Webpages wurden angeschaut? Wie viele Seiten wurden aufgeschlagen?

→ Beobachtung des Teilnehmers: Gibt es wesentliche Unterschiede bei der Arbeit mit digitalen oder analogen Quellen? Hat der Teilnehmer eine Präferenz zu digitalen oder analogen Quellen? Gibt es konkrete Situationen in denen Nachteile bzw. Vorteile von digitalen/analoge Quellen erkennbar sind?

→ Abfragen in Pre-Fragebogen:

- Mit welcher Art von Quellen arbeiten Sie lieber beim Verfassen einer rechtswissenschaftlichen Hausarbeit?

→ Abfragen in Interview:

- Sind Vorteile von digitalen/analoge Medien verloren gegangen?
- Sind Nachteile von digitalen/analoge Medien weniger geworden?
- Würde Sie Ihr Verhalten in Bezug auf die Verwendung von digitalen und analogen Medien beim Verfassen einer Hausarbeit ändern?

H3: Qualitative Daten zeigen, dass Teilnehmer analoge Medien als gut in Integrative Workplace integriert empfinden.

→ Abfragen in Interview:

- Sind Vorteile von digitalen/analoge Medien verloren gegangen?
- Sind Nachteile von digitalen/analoge Medien weniger geworden?
- Was ist der größte Vorteil von Integrative Workplace?
- Was ist der größte Nachteil von Integrative Workplace?
- Gibt es für Sie immer noch Unterschiede in der Benutzung von digitalen und analogen Medien? Welche?

H4: Jura-Studenten können Integrative Workplace beim Verfassen einer Hausarbeit anwenden.

→ Bezieht sich auf F2.

→ Abfragen in Fragebogen:

- Ich kann Integrative Workplace in meinem Arbeitsprozess beim Verfassen einer Hausarbeit verwenden (Stimme zu/Stimme nicht zu).

→ Abfragen in Interview:

- Warum können Sie Integrative Workplace in Ihrem Arbeitsprozess beim Verfassen einer Hausarbeit verwenden/nicht verwenden?
- Wie kann man das System verbessern, damit es ihre Arbeitsweise beim Verfassen einer Hausarbeit unterstützt?
- Was gefällt Ihnen besonders gut bei Integrative Workplace? Was ist eine besondere Unterstützung für Ihre Arbeit?

H5: Unter Verwendung von Integrative Workplace werden Studenten die Mindmap nutzen, um eine Lösungsskizze für den zu bearbeitenden Fall zu erstellen.

→ Abgeleitet aus der Anforderung "Wissensarchivierung". Bezieht sich auf F2.

→ Beobachtung des Teilnehmers: Verwendet der Teilnehmer die Mindmap zur Erstellung einer Lösungsskizze?

→ Vergleich der des Teilnehmers erstellten Lösungsskizze mit der Mindmap: Ist die Lösungsskizze in der Mindmap wiedererkennbar?

→ Abfragen in Fragebogen:

- Ich konnte die Mindmap nutzen um eine Lösungsskizze zu erstellen.
- Die Mindmap ist eine geeignete Visualisierung zur Wissensarchivierung im Kontext des Verfassens einer rechtswissenschaftlichen Hausarbeit.

→ Abfragen in Interview:

- Was für eine Visualisierung würden Sie für Integrative Workplace vorschlagen, um eine Lösungsskizze abbilden zu können?

H6: Die Teilnehmer werden die Referenzrückverfolgungsfunktion von Integrative Workplace intensiv verwenden.

→ Abgeleitet aus der Anforderung "Rückverfolgung von Referenzen". Bezieht sich auf F2.

→ Quantitative Auswertung: Wie häufig wird die Referenzrückverfolgungsfunktion verwendet?

→ Abfragen in Fragebogen:

- Wie häufig haben Sie durch die Referenzrückverfolgungsfunktion Textpassagen nochmals in der originalen Quelle nachgelesen im Vergleich zu Ihrer normalen Arbeitsweise bei einem Sachverhalt mit einem ähnlichen Umfang?

→ Abfragen in Interview:

- Wie unterstützt die Referenzrückverfolgungsfunktion Ihre Arbeit?

H7: Die Teilnehmer werden die Volltextsuche in Büchern intensiv verwenden.

→ Bezieht sich auf F2.

→ Quantitative Auswertung: Wie häufig wird die Volltextsuche in Büchern verwendet?

→ Beobachtung des Teilnehmers: Wird die Volltextsuche verwendet um Gelesenes wieder zu finden? Wird die Volltextsuche verwendet um mit Signalwörtern passende Passagen zu finden?

→ Abfragen in Fragebogen:

- Haben Sie das Gefühl durch die Volltextsuche häufiger eine Stichwortsuche durchgeführt zu haben als normalerweise? Unterstützt die Volltextsuche Ihre Arbeit

→ Abfragen in Interview:

- Wie unterstützt die Volltextsuche Ihre Arbeit?

Untersuchungsgegenstand

Integrative Workplace

Ziel ist es die Usability von Integrative Workplace in Bezug auf das Verfassen einer rechtswissenschaftlichen Hausarbeit zu untersuchen. Aspekte der Studie sind:

- Integrierbarkeit in das normale Vorgehen des Verfassens einer juristischen Hausarbeit
- Annäherung der Arbeitsweisen mit digitalen und analogen Medien
- Allgemeine Benutzbarkeit des Prototyps

Studiendesign und Erhebungsmethoden

Erhebungsmethoden

Fallstudie:

Haupterhebungsmethode ist eine Fallstudie, in welcher Jura-Studenten einen vorgefertigten Sachverhalt mit dem Prototyp lösen müssen.

Thinking Aloud:

VP und VL schauen sich gemeinsam die Videoaufzeichnung der Fallstudie an. Spezieller Fokus ist hierbei auf den Unterschieden zwischen der normalen Arbeitsweise und dem Arbeiten mit Integrative Workplace gelegt. Des Weiteren werden die Verwendbarkeit von Integrative Workplace und die Interaktion mit digitalen und analogen Medien diskutiert. Wenn Retrospective Testing auf Grund der Länge der Studie nicht durchführbar ist, wird die Studie mit Thinking Aloud im klassischen Sinne durchgeführt.

Fragebogen:

- Pre-Questionnaire:
Erhebung demografischer Daten der Versuchspersonen. Evtl. Fragen bezgl. normaler Arbeitsweise und bezgl. Präferenz von digitalen oder analogen Medien
- Post-Questionnaire:
Subjektive Einschätzungen der Benutzer aufnehmen. Zusätzlich Fragen die anhand von Skala beantwortet werden müssen.
- SUS:
Fragebogen der das System bezgl. Effizienz und Benutzerzufriedenheit (SUS) untersucht.

Videoaufzeichnung:

Die Fallstudie wird mit einer Videokamera erfasst, die zudem spontane Kommentare der Versuchsperson aufnehmen soll. Die Kamera wird so platziert, dass sowohl die Versuchsperson als auch der Tisch gut zu sehen sind. Ist dies nicht möglich wird eine zweite Kamera verwendet.

Logging & Abspeichern:

Die erarbeitete Mindmap jedes Probanden wird im Databackend der Anwendung abgespeichert. Ein Logger erfasst im Prototyp für die Studie interessante quantitative Daten. Die folgende Auflistung beinhaltet die zu loggenden Daten:

- Verwendung der Volltextsuche
- Verwendung der Referenzrückverfolgungsfunktion
- Exzerpieren aus digitalen Quellen
- Exzerpieren aus analogen Quellen

- Finger-Interaktion (Viewport und Landscape)
- Stift-Interaktion (Viewport und Landscape)
- Tag-Bewegung (Viewport)
- Anlegen eines Mindmap-Controls
- Löschen eines Mindmap-Controls
- Geöffnete Webpages im BeckBrowser
- Geöffnete Seiten in Büchern (verwendete Bücher)

Studiendesign

Studientyp:

Die Studie ist qualitativ und nicht vergleichend. Damit ist es nicht notwendig die abhängige und unabhängige Variable festzulegen.

Längsschnitt oder Querschnitt:

Querschnittstudie

Teilnehmer:

- 5-10 Probanden (abhängig von Verlauf und Akquise)
- Studenten aus dem Fachbereich Rechtswissenschaften
- VP müssen im Verlauf ihres Studiums 2-3 rechtswissenschaftliche Hausarbeiten verfasst haben (genauer Faktor wird in Abhängigkeit der sich meldenden VPs bestimmt)
- Alter der Probanden ist egal

Aufgabe

Eine Versuchsperson löst während der Fallstudie einen Sachverhalt mit Hilfe von Integrative Workplace. Dabei wird der Sachverhalt so konstruiert, dass er im Rahmen der Studie lösbar ist. Die verfügbaren Kommentare und Gesetzestext sind an den Sachverhalt angepasst. Wichtig ist, dass alle Quellen sowohl digital als auch analog verfügbar sind. Der Proband soll den Sachverhalt auf der im Studium gelernten Art und Weise lösen. Als Arbeitsertrag soll der Proband eine Lösungsskizze für den Sachverhalt erstellen (nur Überschriften).

Wenn es auf Basis des Interviews, der Fragebögen und der Pre-Studie nicht möglich ist das System mit der normalen Arbeitsweise von Juristen in einer hinreichenden Art zu vergleichen, wird die gleiche Studie zusätzlich mit den normalen "Werkzeugen" von Jura-Studenten durchgeführt.

Durchführung

Während der Studie sind eine Versuchsperson und ein Versuchsleiter anwesend. Der Versuchsleiter leitet die Versuchsperson durch die Fallstudie. Er gewährleistet die einwandfreie Funktionalität des Prototyps und schaltet die notwendigen Hilfsanwendungen an.

Der folgende Zeitplan beschreibt exemplarisch den Ablauf der Studie mit einer einzelnen Versuchsperson.

Zeitplan der Studie (ca. 1.5 h)

Aktion	Thinking Aloud
Begrüßung	5 min
Fragebogen	5 min
Einführung	10 min
Training	10 min
Lösen des Sachverhalts	30 min
Fragebogen	5 min
SUS	5 min
Interview	15 min
Verabschiedung	5 min
Gesamte Zeit	90 min

Auswertung**Quantitativ durch Logging-Daten**

Die gespeicherten Logging-Daten werden in Bezug auf die entsprechenden Hypothesen untersucht. Des Weiteren werden die Daten nach weiteren interessanten Erkenntnissen durchsucht.

Qualitativ durch SUS

Die Auswertung des System Usability Scale (SUS) zeigt die subjektive Meinung der Versuchsperson zu Integrative Workplace.

Qualitativ durch eigene Fragebögen

Mit Hilfe der eigenen Fragebögen werden die verschiedenen operationalisierten Faktoren der Hypothesen evaluiert.

Qualitativ durch Thinking Aloud/Retrospective Testing

Offene Fragen, die nicht in einer Skala abgebildet werden können, werden während oder im Anschluss der Betrachtung des Videos mit dem Probanden besprochen.

D

EVALUATION DOCUMENTS

This appendix contains the documents (questionnaires, etc.) that were handed to the participants and filled out by the study conductor. As all participants were German, the documents are written in German.

D.1 DOCUMENTS FOR PARTICIPANTS

D.1.1 *Task*

Aufgabenstellung

Die Aufgabe dieser Studie ist es, den vorgelegten Sachverhalt mit dem System Integrative Workplace zu lösen. Das Ziel ist es, die Lösungsskizze anhand der Mindmap von Integrative Workplace abzubilden. Zusätzlich sollen zu den erkannten Problemen des Sachverhalts in allen verfügbaren Kommentaren und Lehrbüchern nach gängigen Meinungen und Lösungen gesucht werden. Die entsprechenden Passagen sollen extrahiert und in der Mindmap hinterlegt werden. Sie haben dafür eine halbe Stunde Zeit. Ob Sie am Ende der Zeit den Fall komplett lösen konnten, ist für die Studie nicht von Bedeutung.

Wichtig ist, dass nicht Sie getestet werden, sondern das System!

D.1.2 *Legal Record***Sachverhalt**

T ist bei L zu Gast, um nach dem plötzlichen Tod der M vor einer Woche den weiteren Gang der Dinge zu besprechen. M, die Mutter der T, hatte kurz vor ihrem Tod L kennengelernt und war sofort bei diesem eingezogen. Auch ein baldiges Verlöbnis stand zur Diskussion.

L teilt T mit, dass ihre Mutter in einem Gespräch erwähnt hatte, dass er im Falle ihres Todes "alles bekommen soll". Deswegen sehe er keinen Grund die T am Nachlass ihrer Mutter zu beteiligen.

T ist über diese Mitteilung entsetzt. Besonders der Verlust eines alten Rings, der schon immer in Familienbesitz war, schmerzt sie besonders. Als L in die Küche geht, bemerkt T den Ring auf einer Kommode. Sie steckt den Ring ein und geht nach Hause.

Wie hat sich T strafbar gemacht?

D.1.3 *Pre-Questionnaire*

ID: ____

Fragebogen zur Person und der üblichen Arbeitsweise beim Verfassen einer Hausarbeit

1) Was ist Ihr Geschlecht?
<input type="checkbox"/> Männlich <input type="checkbox"/> Weiblich

2) Wie alt sind Sie?
_____ Jahre

3) Mit welcher Hand schreiben Sie?
<input type="checkbox"/> Rechte Hand <input type="checkbox"/> Linke Hand

4) In welchem Fachsemester sind Sie?
_____ Fachsemester

5) Wie viele rechtswissenschaftliche Hausarbeiten haben Sie im Verlauf Ihres Studiums verfasst?
_____ Hausarbeiten

6) Wie verfahren Sie mit interessanten Textpassagen?		
<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Ich extrahiere die Textpassage in ein separates Dokument und schreibe sie zu einem späteren Zeitpunkt in die Hausarbeit.	Ich schreibe die Textpassage direkt in die Hausarbeit.	Sonstiges:

ID: ____

7) Schreiben Sie Textpassagen bewusst ab, da durch den Prozess des Schreibens Wissen besser verinnerlicht wird?		
<input type="checkbox"/> Ja	<input type="checkbox"/> Nein	<input type="checkbox"/> Manchmal

8.a) Mit welcher Art von Quellen arbeiten Sie lieber beim Verfassen einer rechtswissenschaftlichen Hausarbeit?		
<input type="checkbox"/> Digitalen Quellen	<input type="checkbox"/> Analogen Quellen	<input type="checkbox"/> Keine Präferenz

8.b) Begründen Sie Ihre Antwort.		

ID: ____

9.a) Aus welcher Art von Quelle exzerpieren Sie häufiger Textpassagen?		
<input type="checkbox"/> Digitalen Quellen	<input type="checkbox"/> Analogen Quellen	<input type="checkbox"/> Keines von beiden
9.b) Begründen Sie Ihre Antwort.		

D.1.4 *Post-Questionnaire*

ID: ____

Fragebogen zum Verfassen einer Hausarbeit mit Integrative Workplace

1) Ich kann Integrative Workplace in meinem Arbeitsprozess beim Verfassen einer Hausarbeit verwenden.					
Stimme zu	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	Stimme nicht zu

2) Die Mindmap hat mir dabei geholfen eine Lösungsskizze zu erstellen.					
Stimme nicht zu	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	Stimme zu

3) Die Mindmap ist eine geeignete Visualisierung zur Wissensarchivierung im Kontext des Verfassens einer rechtswissenschaftlichen Hausarbeit.					
Stimme zu	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	Stimme nicht zu

4) Der Stift ist ein geeignetes Eingabegerät um Integrative Workplace zu bedienen.					
Stimme nicht zu	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	Stimme zu

5) Der Finger ist ein geeignetes Eingabegerät um Integrative Workplace zu bedienen.					
Stimme zu	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	Stimme nicht zu

6) Ich empfinde die mit dem Stift verbundene Funktionalität als natürlich.					
Stimme nicht zu	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	Stimme zu

7) Ich empfinde die mit dem Finger verbundene Funktionalität als natürlich.					
Stimme zu	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	Stimme nicht zu

ID: ____

8) Ich habe mehr Textpassagen aus digitalen Quellen extrahiert, als wenn ich die Aufgabe ohne die Verwendung von Integrative Workplace gelöst hätte.						
Stimme nicht zu	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	Stimme zu

9) Ich habe mehr Textpassagen aus analogen Quellen extrahiert, als wenn ich die Aufgabe ohne die Verwendung von Integrative Workplace gelöst hätte.						
Stimme zu	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	Stimme nicht zu

10) Wie häufig haben Sie durch die Referenzrückverfolgungsfunktion Textpassagen nochmals in der originalen Quelle nachgelesen im Vergleich zu Ihrer normalen Arbeitsweise bei einem Sachverhalt mit einem ähnlichen Umfang?						
Weniger	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	Häufiger

11) Wie häufig haben Sie durch die digitale Volltextsuche nach Stichworten gesucht im Vergleich zu Ihrer normalen Arbeitsweise bei einem Sachverhalt mit einem ähnlichen Umfang?						
Häufiger	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	Weniger

D.1.5 *System Usability Scale*

ID: ____

System Usability Scale

	Stimme überhaupt nicht zu	Stimme voll zu
1. Ich denke, dass ich das System gerne häufig benutzen würde.	<input type="checkbox"/>	<input type="checkbox"/>
2. Ich fand das System unnötig komplex.	<input type="checkbox"/>	<input type="checkbox"/>
3. Ich fand das System einfach zu benutzen.	<input type="checkbox"/>	<input type="checkbox"/>
4. Ich glaube, ich würde die Hilfe einer technisch versierten Person benötigen, um das System benutzen zu können.	<input type="checkbox"/>	<input type="checkbox"/>
5. Ich fand, die verschiedenen Funktionen in diesem System waren gut integriert.	<input type="checkbox"/>	<input type="checkbox"/>
6. Ich denke, das System enthielt zu viele Inkonsistenzen.	<input type="checkbox"/>	<input type="checkbox"/>
7. Ich kann mir vorstellen, dass die meisten Menschen den Umgang mit diesem System sehr schnell lernen.	<input type="checkbox"/>	<input type="checkbox"/>
8. Ich fand das System sehr umständlich zu nutzen.	<input type="checkbox"/>	<input type="checkbox"/>
9. Ich fühlte mich bei der Benutzung des Systems sehr sicher.	<input type="checkbox"/>	<input type="checkbox"/>
10. Ich musste eine Menge lernen, bevor ich anfangen konnte das System zu verwenden.	<input type="checkbox"/>	<input type="checkbox"/>

ID: ____

Nach Ende der Studie:

7. Welche Funktionen des IW-Prototyps wurden nicht verwendet?

8. Hat der Teilnehmer eine Präferenz zu digitalen oder analogen Quellen?

Digitalen Quellen

Analogen Quellen

D.2.2 *Interview*

ID: ____

Interview-Leitfaden

1. Warum können Sie Integrative Workplace in Ihrem Arbeitsprozess beim Verfassen einer Hausarbeit verwenden/nicht verwenden? Bezieht sich auf 1) in Post-Fragebogen.

2. Empfinden Sie dass das Ablegen von Textpassagen in der Mindmap als vorteilhaft? Wenn ja warum? Was sind die Vorteile?

3. Gibt es eine andere Visualisierung mit der man eine Lösungsskizze besser abbilden kann als mit einer Mindmap?

4. Wie empfinden Sie das Extrahieren aus digitalen und analogen Quellen mit Stift und Finger?

5. Würden Sie mit Integrative Workplace immer noch handschriftlich Zusammenfassen? Muss ein solches System das handschriftliche Zusammenfassen unterstützen? Warum?

ID: ____

6. Unterstützt die Referenzrückverfolgungsfunktion Ihre Arbeit? Warum?

7. Unterstützt die Volltextsuche Ihre Arbeit? Warum?

8. Sind Vorteile von digitalen/analogen Medien verloren gegangen? Welche?

9. Sind Nachteile von digitalen/analogen Medien weniger geworden? Welche?

10. Wie empfinden Sie die Interaktion mit Finger, Stift und Tastatur? Ist sie natürlich? Ist sie schlüssig/konsistent? Würden Sie eine andere Interaktionstechnik (Maus, etc.) bevorzugen?

ID: ____

11. Warum haben Sie hauptsächlich digitale/analoge Medien verwendet?

12. Würde sich ihr Verhalten in Bezug auf die Verwendung von digitalen und analogen Medien ändern (in Bezug auf Exzerpieren, paralleles Lesen, etc.)? Warum? Bezieht sich auf 8) in Pre-Fragebogen.

13. Wie kann man das System verbessern, damit es Sie besser in Ihrer Arbeitsweise beim Verfassen einer Hausarbeit unterstützt?

14. Was ist Ihrer Meinung nach der größte Vorteil bei der Verwendung von Integrative Workplace beim Verfassen einer rechtswissenschaftlichen Hausarbeit?

15. Was ist Ihrer Meinung nach der größte Nachteil bei der Verwendung von Integrative Workplace beim Verfassen einer rechtswissenschaftlichen Hausarbeit?

DVD CONTENT

The DVD contains the documents, data recordings and analyzed data of the study. In addition this thesis' digital copy and a video showing the functionality of Integrative Workplace is included.

Study documents	All documents which were needed beforehand and during the study
Data recording	Video recordings for each participant as well as the XML-file containing log data and the final mind map picturing the solution sketch
Analyzed data	Analyzed data from questionnaires, observations, interview and log data
Thesis	PDF-file of this thesis
Video	A video showing all features of Integrative Workplace

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