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**Research Line: a new design for better information
sharing and storage between mentors and students
in the E-mentoring process**



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Abstract

As one of the major publishing companies, Elsevier wants to enhance the mentor-student relationship through the Mendeley Group to attract more users and increase its impact in academia. One kind of mentor-student relationship is mentoring. Mentoring is a process for the informal transmission of knowledge, social capital, and the psychosocial support as relevant to work, career, or professional development. Advances in Information Communication Technology are bringing new opportunities to the mentoring process. E-mentoring, the mentoring relationship via online software is gradually playing an important role. Various tools have been used to share and store information in the E-mentoring process. But the delayed updating of the student's research progress, the missing of important information, and other challenges exhibit the inefficient and ineffective information sharing and storage, affecting the mentor-student relationship.

Aiming at reaching better information sharing and storage in the E-mentoring process, we conduct this study in three steps. First, we identify the challenges mentors and students have in the current E-mentoring process through the user interviews. Second, we propose a new design based on the challenge and develop the hi-fi prototypes. Third, we evaluate the new design using both quantitative studies and qualitative studies. The results of the evaluations suggest that the new design has potential in providing the better information sharing and storage process. We recommend a long-term evaluation with bigger sample size, explicit benchmark and objective measurements in the future.

Keywords: E-mentoring, information sharing and storage, Mentor-student relationship, timeline, design

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Chapter 1. Introduction

Elsevier wants to enhance the mentor-student relationship through the Mendeley Website to attract new users and increase its impact in academia. As one kind of mentor-student relationship, mentoring is about the informal transmission of knowledge and psychosocial support between mentors and students. Mentoring via online software is defined as E-mentoring. Mentors and students share information through the E-mentoring process.

To enhance the mentor-student relationship, we focus on improving current information sharing and storage in the E-mentoring process. We conduct this study from the following three steps:

1. Identify the challenges in current information sharing and storage process.
2. Design a new solution to solve the challenges.
3. Evaluate the new solution's performance.

1.1 Background

1.1.1 Elsevier and mentor-student relationship

Elsevier is an information and analytics company and one of the world's major providers of scientific, technical, and medical information. Elsevier provides information service in multiple areas, and academia is one of the fields that Elsevier focuses on. One of Elsevier's leading products is Mendeley. Mendeley is a desktop and web program for managing and sharing research papers, discovering research data and collaborating online. Mendeley website, as part of Mendeley, is an online social network for researchers. Millions of users have registered on the Mendeley website.

Professors and students are Mendeley's target users. Professors and students build their personal profile, share research work and discuss on the Mendeley website. Not just for

sharing research papers and discovering research data, Mendeley also wants to enhance the collaborations between professors and students. One kind of professor-student collaboration is mentoring. Mentoring is the process for the informal transmission of knowledge, social capital, and the psychosocial support as relevant to work, career, or professional development between mentors and students.

To enhance the mentoring relationship, Elsevier provides mentors and students with the opportunity for creating shared groups on the Mendeley website. By forming such groups, Elsevier hopes Mendeley bring benefits for users to increase their academic impacts, keep track of each other and stimulate the online discussions.

1.1.2 Mentoring

Mentoring is one kind of collaboration between professors and students. More than just advisor, as [1] said: "the role of the mentor is centered on a commitment to advance student's career through an interpersonal engagement that facilitates sharing guidance, experience, and expertise". Mentoring is a process for the informal transmission of knowledge, social capital, and the psychosocial support as relevant to work, career, or professional development.

1.1.3 ICT technology and E-mentoring

The advancements in ICT technologies increase options and opportunities for mentoring. E-mentoring, as defined in [2], is "the merger of mentoring with electronic communications to develop and sustain mentoring relationships linking a senior individual and a lesser skilled or experienced individual independent of geography or scheduling conflicts", is gradually playing an important role in the mentoring process. Mentors and students benefit from online discussions and file sharing. The combination of online and offline increases the accessibility and traceability of mentoring process. As mentioned in [3], "In this age of the Internet, innovative educators are combining the concept of mentoring with the reach and convenience

of new telecommunications technology”.

1.2 Information sharing and storage in E-mentoring process

In the E-mentoring process, mentors and students share information with each other and store important resources. Mentors and students share student’s research progress and mentor’s feedback regularly. Usually, based on students’ regular updates of their research work, mentors give them instructions and feedback in time to help them stay on the right track and keep making progress. The information sharing and storage experience affects the quality of the mentoring relationship.

The sharing needs to be efficient so that mentors can get instant update of student’s research progress and students can get instant feedback. Any problems and delay in student’s research work can be recognized earlier to prevent delay and errors in later stage. The sharing also needs to be effective. The shared information should be what mentors and students care about most and should be presented succinctly, to reduce extra communications between mentors and students.

The storage also needs to be efficient and effective. Both mentors and students can store the important information efficiently so that they don’t lose the important information. The effective storage can help mentors and students to save time on searching and management.

Since most sharing and storage in the E-mentoring are completed by online software, the quality of mentoring heavily depends on the capability of the online software.

1.3 Problem statement

Existing tools have limitation in sharing and storing information efficiently and effectively. For example, students use blogs to record their research progress, but blogs can’t visualize

the overview of student's research progress. Messaging tool, such as email, has limitations in providing the effective information sharing since discussions through email usually takes several times. And some tools have limitations in providing mentors with the instant updating of the student's research progress, which results in inefficient information sharing. Those limitations may cause the delay of the student's research work and miscommunications between mentors and students. The mentoring relationship is therefore affected.

1.4 Research question

To solve the challenges found in the current E-mentoring process, we conduct this study to build better information sharing and storage process. Therefore, we propose one research question for the study:

What could be a solution for better information sharing and storage between mentors and students in the E-mentoring process? Can it help improve the efficiency and effectiveness of current information sharing and storage process?

1.5 Thesis overview

The way the rest of the dissertation is organized is as follows: Chapter 1 briefly introduces the whole study to give the readers a general idea of the research project. Chapter 2 is the investigation of studies in similar areas. In Chapter 3, the user study and the findings are presented. The new design is introduced in chapter 4, including the presentation of the design outputs. Chapter 5 is the evaluation of the new design. The methodologies and the experiment results are presented. In chapter 6, experiment results from chapter 5 are further analysed and discussed. The research question is discussed through the experiment results. Chapter 7 is the exhibition of the conclusions, limitations and the future work.

Chapter 2. Literature study

We review the related literature to investigate the possible solutions in other studies. We want to investigate what roles the social networks, blogs, and other platforms play in the E-mentoring process.

2.1 Academic social networks and researchers

The academic social network is one of the platforms where the mentors and students collaborate very often. The academic social networks, as the platform for exchanging information, have rapidly developed after the widespread of social networks. Some studies [4][5][6] discussed how scholars and students benefit from those academic social networks.

A study by Nature in [7] and the study in [4] analyzed the scientists' online social behaviors. It revealed that those social networks, such as ResearchGate, Academia or Mendeley, could help researchers and scientists maintain their professional profiles, stimulate online discussions, and interact with other researchers. The study in [5] revealed that social networks help scientists improve the research efficiency, enhance their networks and increase their professional impacts.

Those studies revealed how researchers benefit from the online social networks, but they are more focused on researcher's personal benefits rather than the mentor-student relationship. As one of the academic social network, Mendeley already provides a platform for users to build their professional profile and interact with other researchers. To further enhance the mentor-student relationship, a narrowed and focused study targeting at the E-mentoring process is expected.

2.2 Blogs and E-mentoring

Different from the academic social networks, blogs are often used in the E-mentoring process. As a simple and efficient way of recording and commenting, blog plays an important role in the mentoring process. The good combination of “solitary reflection and social interaction” makes blogs a good way of recording and sharing the research progress [8].

Several studies [8][9][10][11] discuss how blogs were used in the research process to enhance the mentor-student communications in the E-mentoring process.

The advantages of using blogs in research and mentoring are widely discussed. It's time-saving, convenient and it can provide equally learning effects as the traditional approaches [9]. It could enhance the exchange of ideas between mentors and students compared with the traditional communication avenue [10][12]. The study about three students' research process in [8] argued that the chronicling nature of blogs help mentors and students trace their thoughts and the research process. By providing a “framework for disciplines”, the blogs help students develop the academic skills as well as “cultivate a term paper”. The study in [11] found that Ph.D. students use blogs for recording their research progress and receiving feedback. The free-flowing, informal and often fragmentary nature of blog maybe not the ideal academic writing style, but it reflects the nature of the research process [8].

On the other hand, some studies argued about blogs' drawbacks in the researching process. Lacking mentors' involvements affect the immediacy of feedback. Lacking the systematic “big picture” and the disciplined plan brings chaos to research process recording. The study in [9] recommended that the future online mentoring should have proper time arrangement and better privacy protection.

Those studies revealed blog's limitations in the mentor-student communication in E-mentoring process but they don't provide the solutions, which leaves the exploration for the future studies.

2.3 Other Tools and E-mentoring

Some studies discussed from a broader range that how ICT technologies enhance the E-mentoring process. The common E-mentoring tools include email, online chat, forums, and other tools.

Through several examples, the study in [13] demonstrates how computer-mediated communication help mentors and students increase their scholastic performance, networking, and develop their professional knowledge and skills. There are some challenges in using those tools in E-mentoring process. The miscommunication in the E-mentoring process, the slower development of the online relationship, the required competency in written communication, and privacy issues are widely discussed, which provides good hints to the future studies on the E-mentoring process.

In the study in [14], an E-mentoring system is developed to complement the traditional face-to-face mentoring. Qualitative studies showed that E-mentoring has the good accessibility and availability. Feedback of the E-mentoring system is generally positive, but the feedback reveals that the system has usable constraints and functional constraints.

In [15], a qualitative investigation was conducted to learn mentor's opinions and student's opinions on a formal mentoring program. The future recommendations of the program are interesting, including clearer communication of the program objectives (e.g., timeline, goals and expected outcomes, interaction frequency, general guidance), better monitoring and follow-up with program participants (e.g., periodic check-ins, formal feedback on the program), and clarification of roles (e.g., training, expectation setting, suggested activities).

The study in [16] investigates how online mentoring encourage girls in the STEM(Science, Technology, Engineering, and Mathematics). The results showed that E-mentoring helps in finding effective role modal, discussing, sharing knowledge and counseling. But it can be improved in planning and monitoring the research process to increase the contact frequency between mentors and students.

Through the qualitative study, [17] investigated master students' perceptions on the impact and role of online mentoring. This study gave several good recommendations on the future E-mentoring, including careful planning of the online mentoring process and proper interaction between mentors and students. Studies in [18] [19] also investigate students' attitudes toward the E-mentoring and validate the importance of students' attitudes.

2.4 Summary

The above studies investigate how ICT technologies enhance the current E-mentoring process from different perspectives. Social network, blogs and other platforms indeed bring new opportunities to the E-mentoring process. However, the worse planning and scheduling, the involvement of mentors and privacy issues are repeatedly mentioned in those studies. No better solution is proposed for those problems. On the other hand, those studies proposed some common expectations for the future e-mentoring process: the better planning of the mentoring process, better monitoring, and follow-up with students, increasing contact frequency and setting clear mentoring goals.

Those limitations and future expectations point out the planning and monitoring problem of the current E-mentoring process, which is closely related to the information sharing and storage between mentors and students. Therefore, building a better information sharing and storage in the E-mentoring process could be possible exploration.

Chapter 3. User study

The first step of building better information sharing and storage in the E-mentoring process is to figure out the limitations of current information sharing and storage process. We conduct a user study to find out the user insights.

In this chapter, we first introduce the user study objectives in 3.1. Then we discuss the methodology in 3.2. Then the findings of the user study and the related analysis are presented in 3.3. A short summary is given in 3.4.

3.1 User study objectives

The ultimate goal of the user study is to find out the challenges users have in the E-mentoring process, we propose four research objectives below.

1. **To find out how is information shared and stored in E-mentoring process:** This objective is to understand the steps of the information sharing and storage process. This is also helpful to find out which step is most likely to produce the problems.
2. **To find out users' understandings of the E-mentoring process:** This objective is to find out the mentors' understanding of the E-mentoring process and students' understanding of the E-mentoring process respectively, which may relate to their requirements on the information sharing and storage process.
3. **To find out the challenges users have in the current E-mentoring process:** this objective is to find out the challenges users have when they share or store information with each other in the E-mentoring process.
4. **To find out users' opinions on existing tools for sharing and storing information:** this objective is to understand user' opinions on the existing tools they use for sharing and storing information in the E-mentor process.

3.2 User study methodology

3.2.1 User interview

User interview, as a useful tool in user research, is an efficient way to directly speak to users and get answers to specific questions. To quickly understand the users and extract the information from users' personal experience, this study uses the user interview to obtain the user insights. The interview questions are based on the four research objectives. Interviews for mentors and students are conducted respectively.

3.2.2 Participants

There are two types of participants:

1. Researchers with mentoring experience
2. Students with experience of research work, including bachelor students, master students and Ph.D. students

Researchers and students are the main roles in the E-mentoring process. With the restriction of time and location, this study only access researchers and students at the University of Twente. To reduce the influence of users' research backgrounds, we recruited six researchers and five students of different backgrounds at the University of Twente. Participants' profiles are summarized separately into two tables below.

Table 3.2.2-1 Mentors' profiles

Index	Gender	Title	Background
M01	F	Assistant Professor	Human Media Interaction
M02	F	Full Professor	Human Media Interaction
M03	M	Assistant Professor	Psychology
M04	F	Assistant Professor	Industrial Design
M05	M	Ph.D. student	Human Media Interaction
M06	M	Assistant Professor	Mathematics

Table 3.2.2-2 Students' profiles

Index	Gender	Background	Research Project Period
S01	F	Human-Computer Interaction	6 month
S02	M	Machine Learning	6 month
S03	M	Creative Technology	9 month
S04	F	Industrial Design	3 month
S05	F	Industrial Design	3 month

3.3 User study findings and the analyses

3.3.1 “How is information shared and stored between mentors and students”

Based on the collected answers, the whole E-mentoring process can be summarized as: in the beginning, the mentor and the student discuss together to make a rough plan for the whole research project. During the research, mentor and student hold the regular face-to-face meetings to discuss the research work. Student makes adjustments on his research work based on mentors' feedback.

Mentors and students share the student's research work and mentor's feedback regularly. The process can be summarized as follows: before the meeting, the student sends his recent work to the mentor in advance. Mentor gives his feedback on the research work. During the meeting, the mentor and the student discuss the research work. After the meeting, the mentor gives the commented work to the student. Various tools are used in the process. Email or weTransfer are used for sending the report. The physical paper, Notability or DrawBoard on iPad (both are PDF editor software on iPad) are used for presenting the paper at the meetings and sharing papers and documents. The process is visualized in figure 3.2.1-1:

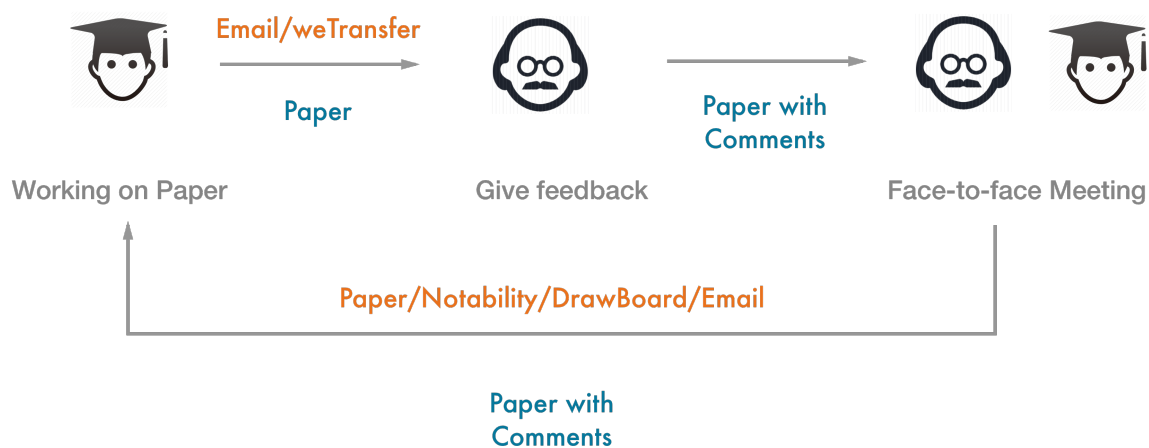


Figure 3.2.1-1 The information sharing process

3.3.2 “Users’ understandings of the E-mentoring process”

According to the collected answers, mentors and students have similar understandings of the E-mentoring process but with the different focus.

Both mentors and students agreed that *the student’s research progress* is one important message that is shared between them. The mentor needs to keep up-to-date with the student’s research progress in order to give proper instruction in time. The student needs to record his progress timely and share it with his mentor timely so that he can keep on the right track. Both of them require the instant sharing of the student’s research progress.

However, mentors and students have the different focus of the student’s research progress. The three aspects that mentors care about most are:

1. **The big picture:** the general image or the overview of the student’s research progress.
2. **The next step:** what is the next step of the research work.
3. **The materials:** literature, articles or all related materials the student needs in the research work.

Students care about the project plan and the next step most. A flexible project plan can help students record their progress flexibly and adjust their directions timely. Explicit deadlines

can motivate students to keep moving on.

In a good E-mentoring process, the shared information should indicate the aspects that users care about most, which requires an effective information sharing process.

3.3.3 “Challenges in the current E-mentoring process”

Mentors’ challenges and students’ challenges are summarized in the two figures below. In the two figures, some users’ quotes were selected and grouped into different categories. Detailed analyses can be found below.

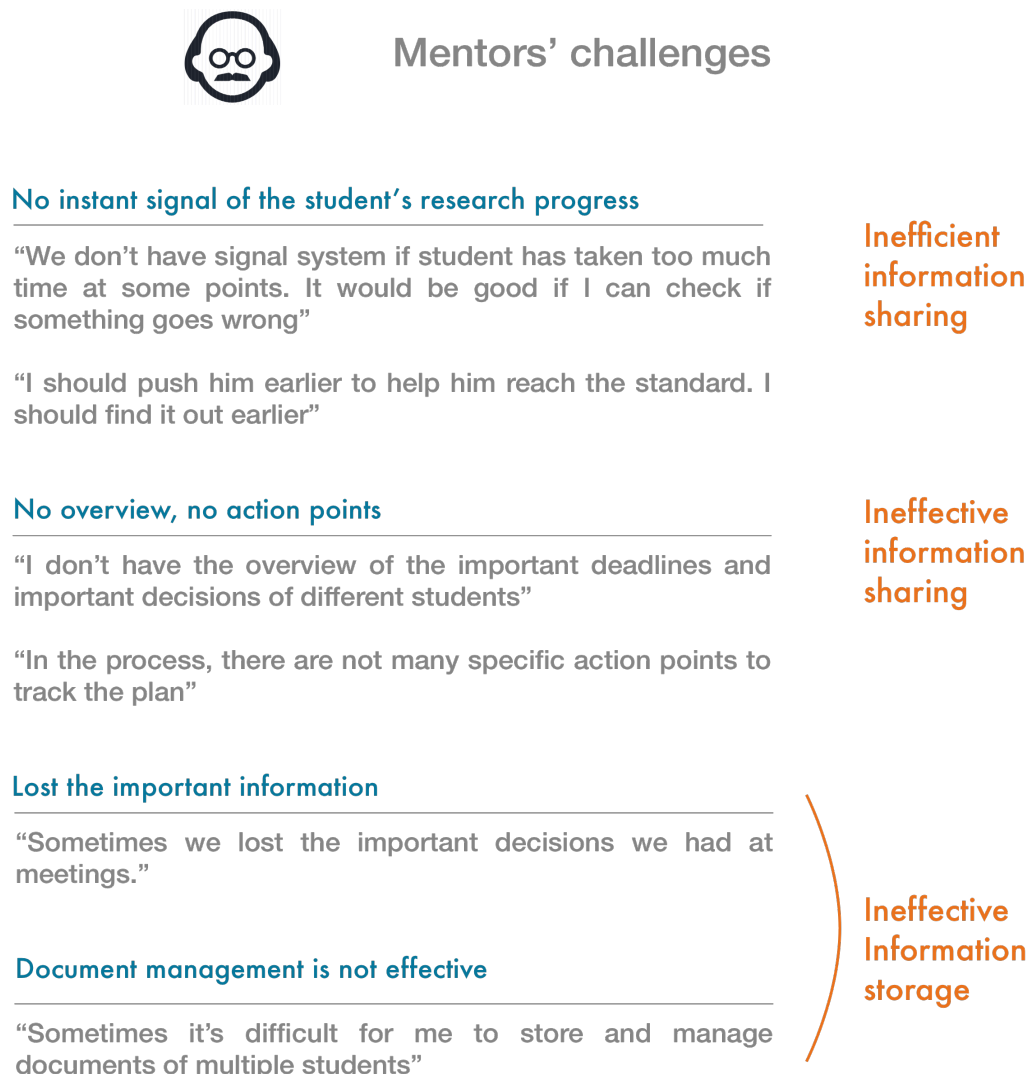


Figure 3.3.3-1 Mentors’ challenges in E-mentoring process

Mentors' challenges are summarized in figure 3.3.3-1. The blue texts represent the issues. The grey texts are the related quotes. The orange texts on the right are the underlying problems behind those issues.

As can be seen from the figure, mentors' challenges can be grouped into four main issues:

1. No instant signal of the student's research progress

This refers to that mentors cannot get an instant reflection of the student's research progress, especially when they are distant from students. Students may get stuck, encounter a problem or go in the wrong direction in the research process. When those situations happen, if mentors cannot get the instant signal from students and give proper feedback in time, worse problems and errors can happen in the later research work. This results from inefficient information sharing in the E-mentoring process.

2. No overview and action points of student's research progress

The "no overview" refers to that mentors don't have an overview of the important deadlines of student's research work. The "no action points" refers to that mentors can't track the action points of student's research work. As discussed in 3.3.2, mentors care about the big picture, the next step and the materials most. Lacking the overview and action points means that mentors cannot get the information that they want, which reveals ineffective information sharing between mentors and students.

3. Lost the important information at meeting

The third issue refers to that mentors sometimes lose the important decisions and feedback they made at the meetings. This reveals ineffective information storage in the E-mentoring process.

4. Document management is not effective

The last issue is a common challenge for mentors. Since one mentor could supervise several

students at the same time, managing documents of multiple students requires much discipline and effort from mentors, which reveals ineffective information storage in the E-mentoring process.

Therefore, mentor's challenges can be attributed to the *inefficient and ineffective information sharing and storage* in the E-mentoring process.



Figure 3.3.3-2 Students' challenges in the E-mentoring process

Figure 3.3.3-2 presents students' challenges. Similarly, each blue text represents an issue. The orange texts are the underlying problems behind those issues.

Students' challenges are different from mentors' challenges. We found two main issues:

1. Lost the important information at meeting

Same as mentors, students sometimes also lose the important decisions at the meetings. Three students mentioned that they could not quickly write down all the notes at the meetings so they lost them at the end. This reveals inefficient information storage in the E-mentoring process.

2. Have barriers to reporting the progress to his mentor in time

Only two students mentioned this issue. They could not report their research progress to their mentors when their mentors are far away from them because they did not want to disturb their mentors through email. This reveals the inefficient information sharing in the E-mentoring process.

By interpreting those quotes into more general issues, we found a fundamental challenge: *The information sharing and storage is not efficient and effective in the E-mentoring process.*

3.3.4 “Existing tools discussions”

In the last section of the user interview, participants discussed existing tools they used in the E-mentoring process.

Since E-mentoring is a complex process and various tools are used, our analyses are mainly focused on existing tools’ capabilities in completing one of the most important tasks—*sharing and storing the student’s research progress*. The previous section has demonstrated that student’s research progress is one important message that is shared between mentors and students. It should be efficient to help mentors and students take the right action in time. It should be effective to give users the information that they care about most to reduce the unnecessary communications. Therefore, the following discussions are given from the efficiency and the effectiveness.

According to their functions, the existing tools are grouped into three categories:

1. **Messaging tools:** mentors and students use them for general messages and direct communication.
2. **Notes-taking tools:** mentors and students use them for writing down the discussions and decisions at meetings.
3. **Project management tools:** students use them for planning and managing their research

project.

Email and WhatsApp are the most popular messaging tools. They are mainly used for the general communications between mentors and students, including scheduling a meeting, submitting papers or discussing general problems. *The information sharing through those tools are efficient but not effective.* Those messaging tools are good at sending instant messages and get the instant replies, which provide efficient information sharing. However, the shared information through those applications is in the text, which can't clearly and succinctly visualize the big picture and action points of the student's research progress, which may take mentors' extra effort to understand student's research work. It is an ineffective sharing of the student's research progress.

For note-taking tools, different types have different pros and cons. There are three types of note-taking tools: physical papers or notebooks, applications on iPad and applications on PC.

Physical papers or notebooks are generally efficient but ineffective in storing information. The intuitiveness and promptness of taking notes on physical papers make recording information very efficient. However, the storage is not so effective. First, physical paper is hard to conserve and easily lost. Second, searching for previous notes or specific information on physical notes is very difficult, sometimes even impossible. The two inevitable problems make physical paper store information ineffectively.

The applications on iPad and the applications on PC share the similar advantages. Compared with the physical notes, they are more effective but inefficient. Information storage via software is easy and reliable. Sharing notes or searching for previous notes via software is also effective. But those applications are not as efficient as physical paper. Considering taking notes at the meeting, whether writing on iPad or typing on PC is not as fast as on the physical paper. Typing on the PC is even worse since it's distracting and not intuitive. The

inefficiency and inconvenience of taking notes at meeting affect the efficiency of information storage.

In general, most note-taking tools cannot store information both efficiently and effectively.

Project management tools are mainly used by students to track their progress and share the progress with their mentor, especially when the mentor is distant from them. *Most of those tools are efficient but ineffective in sharing the student's research progress.* Taking Trello as an example, Trello allows students to update their research progress instantly and share it with mentors. This ensures the efficiency of the information sharing. However, Trello can't present the overview of the student's research progress and the connections between action points. A screenshot of Trello in Figure 3.3.4-1 demonstrates the problem. The action points are present in the cardboard. In the user interview, participants said it's difficult for them to get an overview of the research process at a glance.

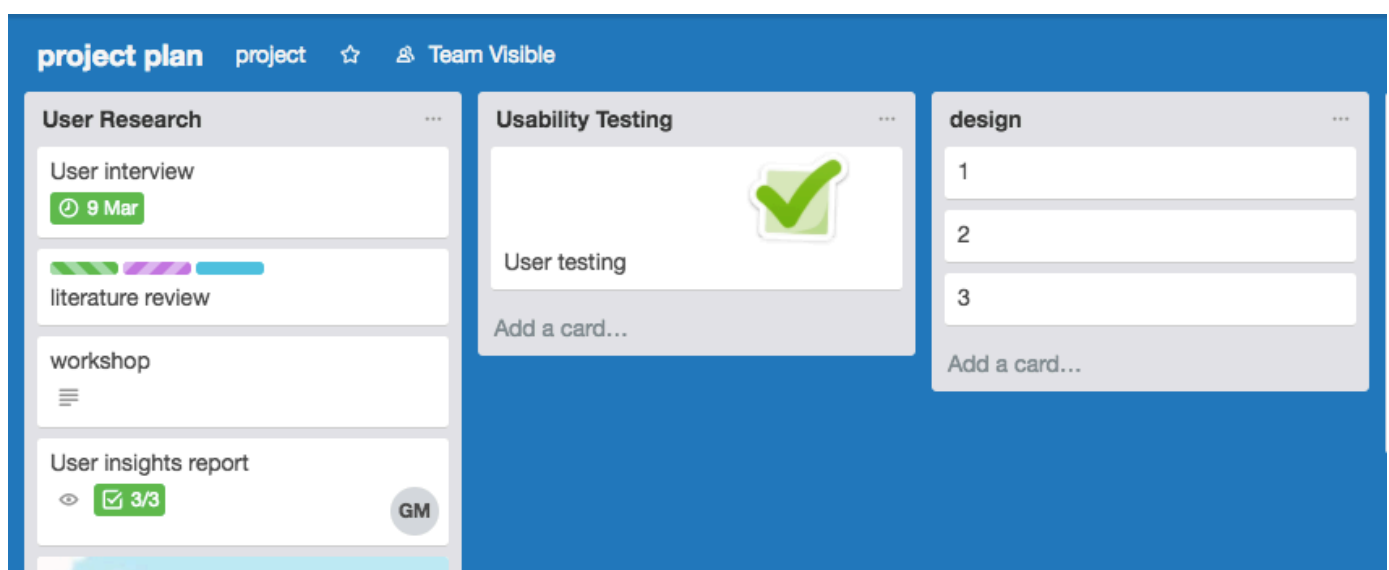


Figure 3.3.4-1 Screenshot of Trello

As discussed earlier, mentors care about the overview and action points in student's research progress most. Lacking this information may cause mentor's confusing or misunderstanding on the research work, and even bring extra communications between mentors and students. This reveals the ineffectiveness of Trello in sharing the student's research progress.

Therefore, it can be found that different tools do have their advantages in completing different tasks in the e-mentoring process, but most of them are not good at sharing and storing the student's research progress efficiently and effectively.

3.4 User study summary

In this chapter, we present the user study findings. We conducted user interviews to find out how is the information shared and stored in the E-mentoring process, users' understandings and challenges in the E-mentoring process, and their opinions on existing tools. From the four aspects, we gradually uncover one problem that commonly exists in the E-mentoring process:

Existing tools cannot share or store the student's research progress efficiently and effectively between mentors and students in the E-mentoring process, which may affect the mentor-student relationship.

Based on this problem, a new design for improving the information sharing and storage between mentors and students is proposed in the next chapter.

Chapter 4. The design solution

In the previous chapter, we learned from the user study that the information sharing and storage through existing tools is not so efficient and effective. To tackle this challenge, we propose a design solution in this chapter.

This chapter is organized as follows: the design inspiration is first introduced in 4.1; then the design methodology is discussed in 4.2; the design outputs, including the personas and the scenarios, the user requirements, the design options and hi-fi prototypes are exhibited in 4.3. A short summary of this chapter is given in 4.4

With the limited space, the detailed design process is omitted in this paper, but the design outputs are presented below.

4.1 Design inspiration: Research Storyline

The design inspiration can help the readers understand how the new solution was produced. The design solution is inspired by a concept called *Research Storyline*.¹ Research Storyline is a visual model that depicts the research process. The model visualizes the different phases in the research progress and the connections between the phases. This model is to help students understand the expectations of their research work and give students a general idea of their research process at the beginning of their research.

The Research Storyline inspires the new solution from two aspects. On the one hand, it vividly depicts the phases in the research process. From conducting background research to literature study and to data collection, this model provides a direction for students to do the research. It makes the research progress more attractive and understandable for students. On

¹ A professor in the user interview proposed Research Line, which is a visual model that is used in her mentoring work.

the other hand, however, this model is not flexible and it only provides a still structure of the research progress, which cannot adapt to changes in the real research progress. Therefore, a flexible and interactive visual model of the research process is inspired by Research Storyline.

4.2 Design methodology

To propose a reasonable design solution, this study mainly refers to the design methodology in [20]: first, we construct the personas and the scenarios based on the Persona-based Scenario method (this method is introduced below). Then, we identify the user requirements through the personas and scenarios. Third, we explore the design solutions. Finally, we develop the hi-fi prototypes.

Persona-based-scenario is the method that was proposed in chapter 6 of [20]. It is a concise narrative description of one or more personas using a product to achieve specific goals. It is an improved version of the Scenario-based Design that adds the persona into the scenarios. Like what is said in [20], “a persona provides a tangible representation of the user to act as a believable agent in the setting of a scenario”. The persona-based-scenario helps designers to start the designs from a story by describing an ideal experience from the persona’s perspective.

By referring to the Persona-based Scenario, the design process follows the six steps:

1. **Construct the personas and scenarios:** identify the persona expectations and construct the context scenarios.
2. **Extract the user requirements and functional requirements:** extract the user requirements from the personas and scenarios. Transfer the user requirements into the functional requirements.
3. **Ideation:** explore the possible idea.
4. **Explore design options:** propose the possible design options.

5. **Define the visual style:** define the color theme, icons, and buttons.
6. **Define the information architecture:** develop the information architecture.
7. **Build Hi-fi prototypes:** based on all the previous work, develop the interactive hi-fi prototypes.

4.3 Design output

4.3.1 The personas and scenarios

Based the Persona-based-scenario, the Personas and Scenarios have been constructed.

Personas

The personas are developed based on the data collected in the user study. Mentor personas and student persona are built separately. The user study reveals two types of mentor: the intermediate mentors and the expert mentors. Intermediate mentors are the mentors with few supervised students and a relatively plain calendar. Expert mentors are the busy mentors with more than 10 supervised students and a relatively busy calendar. Intermediate mentors and expert mentors have different user requirements. Expert mentors have higher requirements on the document management and working efficiency. Students' behaviors are not obviously distinguishable even though they have different education level.

Therefore, two mentor personas and one student persona are constructed. The target students include the bachelor students, master students, and Ph.D. students. Here we take the Ph.D. student as an example because a Ph.D. student usually has a long research project. Detailed descriptions are presented below.

Josie Hernandez

Josie is an intermediate mentor with few students and a relatively plain calendar.

Mentor Persona 1: Assistant Professor



Josie Hernandez
Assistant professor

35 years old
Enschede, Netherlands

Josie uses the research model to guide her student's research work. She cares about the big picture and the next step of the student's research progress. She wants to get a signal if students have any problems with their research work

Her goals

- To track student's research progress
- To read student's report and give feedback
- To have face-to-face meetings with students
- To provide help if students have any problems
- To share useful materials with students

Figure 4.3.1.1-1 Mentor persona 1

Seth Bush

Seth is an expert mentor with many students and a busy calendar.

Mentor Persona 2: Full Professor



Seth Bush
Full professor

45 years old
Amsterdam, Netherlands

Seth has multiple roles at the University. He supervises more than 10 students at the same time. He wants his students to develop their skill sets in various aspects.

He uses software on iPad to read and comment on students' papers. He is used to taking notes at the face-to-face meetings.

He has a research meeting every two weeks in which his students and other supervisors present their research work.

His goals

- To track student's research progress
- To read students' papers and give feedback
- To have face-to-face meetings with students
- To share useful materials with students
- To help students develop their various skills as a researcher
- To manage and supervise multiple students

Figure 4.3.1.1-2 Mentor persona 2

Phillip Cobb

Phillip is a Ph.D. student who works on several research projects at the same time

Student Persona: PhD student



Phillip Cobb
PhD student

25 years old
Netherlands

Phillip is a PhD student. He usually works on several projects at the same time. He likes to record the milestones in his research work. He likes to keep a flexible project plan.

His goals

- To plan his research projects flexibly
- To record the milestones in his research progress
- To communicate with his mentor on his work regularly.
- To have face-to-face meetings with his mentors
- To manage his research projects

Figure 4.3.1.1-3 Student persona

Scenarios

The scenarios describe the broad contexts in which usage patterns of different personas are exhibited. A virtual agent is put in the scenarios to help personas to complete their tasks.

#Scenario 1 Josie's story

On Tuesday, Josie attended a conference in San Francisco. At 10 am, she received an alarm email. It showed Bob, one of her Ph.D. students, was behind his schedule. How did it happen?

She opened his research project. It showed that Bob has done well in conducting the experiments but he had spent two weeks on summarizing the experiment results and had almost no progress. “He needs help.” Josie added some reading materials under Bob’s experiment section to help him understand how to organize the experiment results. Josie also added a temporary meeting with Bob.

At 12 pm, Josie got a notification that Lily has completed her literature summary and had uploaded it to the unread list. During the lunch, Josie read the literature summary and left some comments on it.

One week later, Josie had a meeting with Bob and his second supervisor. During the meeting, Josie retrieved Bob’s research progress and presented it to the second supervisor. Looking at the research project together, they discussed the rough plan of the research project and what Bob could do for the next month.

#Scenario 2 Seth’s story

Before the research meeting, Seth checked the overview status of his students and other supervisors. Most Ph.D. students were doing well. He also checked the skill sets of his Ph.D. students. He wanted to help them develop the various skills as a Ph.D. student. There were some unusual situations on the overview:

1. One Ph.D. student delayed his draft paper
2. One student went faster than his schedule
3. One Ph.D. student didn’t have enough communications with his first supervisor in the last month

At the research meeting, Seth discussed the problems he found in the overview. He gave some suggestions to their problems. He also wrote down the notes of the discussions. After the meeting, Seth shared his notes with his students.

#Scenario 3 Phillip's story

Phillip just started his research project. At the first meeting with his mentor, Phillip created a new research project. Then he discussed with his mentor about the rough plan of this research project. They created several deadlines for the next two weeks.

After creating the research project, Phillip kept adding his milestones to the project. The updates of his research progress were constantly sent to his mentor automatically. Even when his mentor was in a distant conference, he could still get the updates.

One day, Phillip had a video meeting with his mentor online. They had a long discussion on the research methodologies. The discussion was recorded and kept in the system.

Phillip also built a central library to manage several research projects at the same time.

4.3.2 From the user requirements to the functional requirements

User requirements

The constructions of the personas and scenarios depict users' expectations and their behaviors under different contexts, based on which, Mentors' requirements and students' requirements are extracted and summarized here.



Mentors' Requirements

- Get signals on student's research progress when unusual situations happen
 - Check the overview of a group of students' research work
 - Check the student's research progress at any place
 - Read student's papers and give feedback
 - Share useful materials with students
 - Write down the meeting notes
 - Plan meetings with students
-



Students' Requirements

- Plan my research work
- Record my research progress
- Manage multiple research projects at the same time
- Present my research progress to my mentor
- Write down the meeting notes
- Plan meetings with my mentor

Figure 4.3.2-1 User requirements

Then the requirements are further grouped into the following four aspects:

1. Reflection of the student's research progress
2. Record and manage the research progress
3. Document sharing and management
4. Meeting planning

Sharing of the student's research progress

Get signals on student's research progress when unusual situations happen
Check the overview of a group of students' research work
Check student's research progress at any place
Present the research progress to the mentor

Record and manage the research projects

Plan the research project
Record the research progress
Manage multiple research projects at the same time
Write down the meeting notes

Documents management and sharing

Read student's paper and give feedback
Share useful materials with students
Manage documents of multiple students

Meeting planning

Plan meetings with students
Plan meetings with my mentor

Figure 4.3.2-2 Grouped user requirements

The functional requirements

Then the user requirements are transferred into four functional requirements.

1. Clear visualization of the student's research progress
2. A database for managing student's research projects
3. A centralized library for managing all the documents.

4. Allow users to send the meeting request

4.3.3 The ideation

The reflection of student's research progress is the top user requirement, which is also consistent with the findings in Chapter 3. Therefore, finding a way to visualize student's research progress is the core feature of the new design.

With the inspiration of Research Storyline, we use *an instantly shared interactive timeline* to visualize student's research progress. The timeline indicates all the action points in the research progress. The related materials from each meeting or milestone are stored under the related action point. This new design is called Research Line.

More specifically, the Research line will have the following features:

1. Visualizes the student's research progress by an interactive timeline
2. Allows students to plan and record their research progress instantly
3. Allows mentors to get instant updates about the student's research progress
4. Allows mentors to get the overview of a group of students' research work
5. Allows mentors and students to share resources instantly and manage the resources systematically
6. Allows mentors and students to plan meetings with each other

The interactive timeline could be a possible solution for three reasons: First, the timeline visualizes (i) the big picture of the research progress, (ii) the action points in the research progress and (iii) the connections between those action points. Those are what mentors and students care about. Second, it supports the instant sharing and updating of the student's research progress. Third, the materials are stored under the related action points.

4.3.4 The design options exploration

We propose three design options: the linear Research Line, the circular Research Line, and the networking Research Line.

The linear Research Line: we first propose the linear timeline since it is the most natural form of a timeline. The linear Research Line presents the research progress in terms of time. As in Figure 4.3.4-1, different action points are distributed on the timeline. The time span between any two action points is indicated.

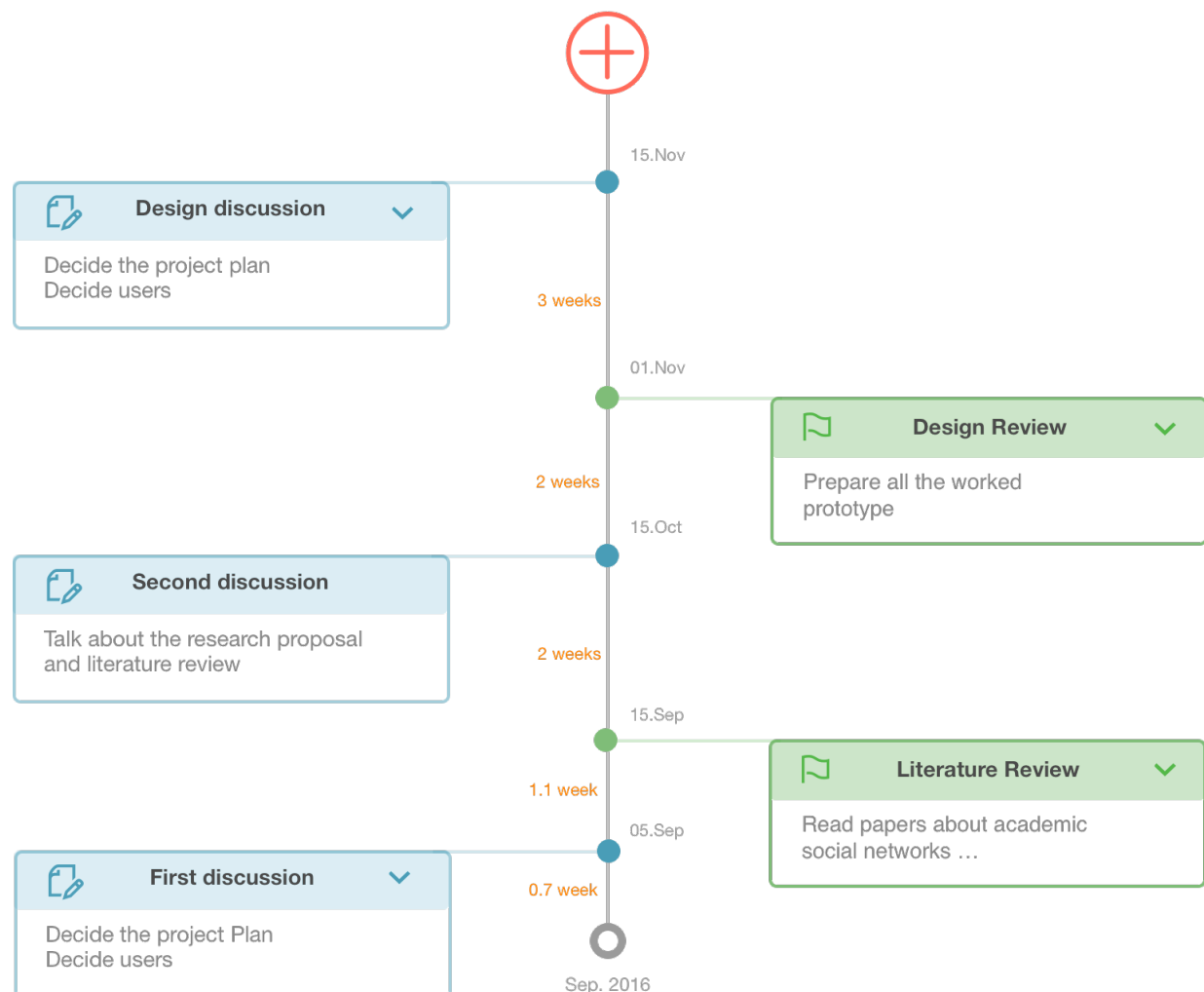


Figure 4.3.4-1 the linear Research Line

The circular Research Line: a circular Research Line is good at displaying multiple stages in the research process without taking too much space. A research cycle may contain four

phases. One color represents the one stage. Each stage can be expanded and present all the action points in that stage. A pointer in the center indicates the current stage of the research process. The whole circular Research Line also looks like a clock, which gives a good overview of the research progress.

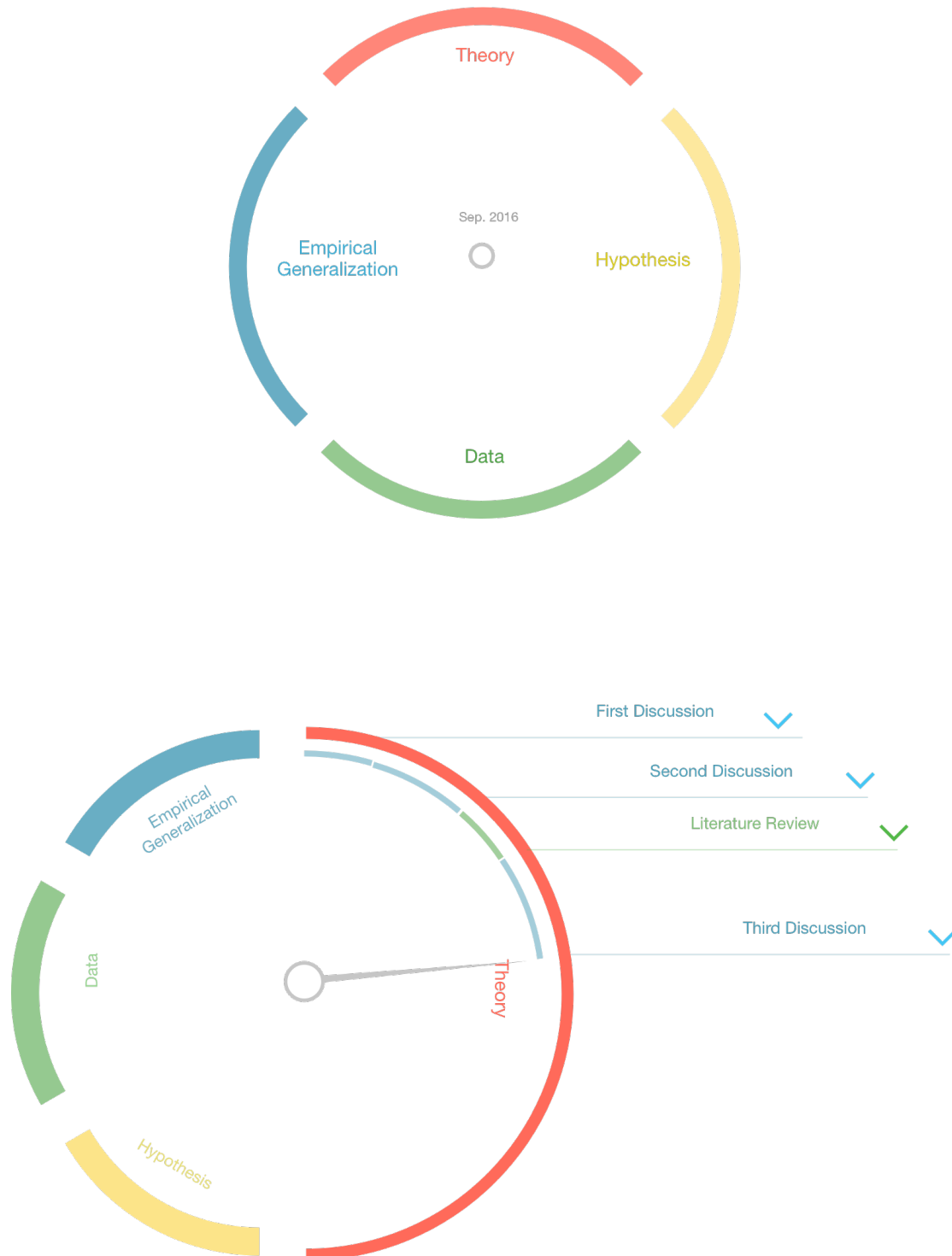


Figure 4.3.4-2 the circular Research Line

The networking Research Line: we propose the networking Research Line to give the users a flexible recording of their research progress. The four big circles represent the four stages of the research progress. Each big circle can be expanded. Those small circles that are around the big circle represent the action points. This structure encourages users to create a mind map for their research progress, which could be more flexible and inspiring.



Figure 4.3.4-3 the networking Research Line

To find out the best visualization among the three design options, evaluation is conducted and the data are collected in chapter 5.

4.3.5 The visual design

As a new feature on Mendeley website, the whole visual design of Research Line is consistent with the visual style of Mendeley website.

Colors

We choose the following three colors as the color theme of Research Line:

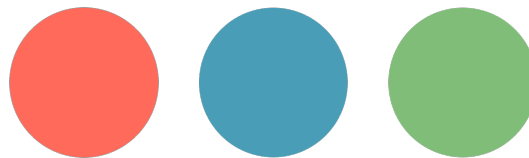


Figure 4.3.5-1 the colour theme

Icons

In the new design, icons are consistent with Mendeley website. The main icons include but are not limited to:



Figure 4.3.5-2 Main icons

Buttons

The main buttons are:



Figure 4.3.5-3 Main buttons

The first button is for adding meeting notes. The second button is for adding milestones. The third button is for adding action points. The last button is for planning a meeting.

4.3.6 The information architecture

The new design is a new feature of Mendeley Group. We define the information architecture of the new design here. The complex information architecture of the Mendeley website is omitted and only the related modules of the new design are presented here.

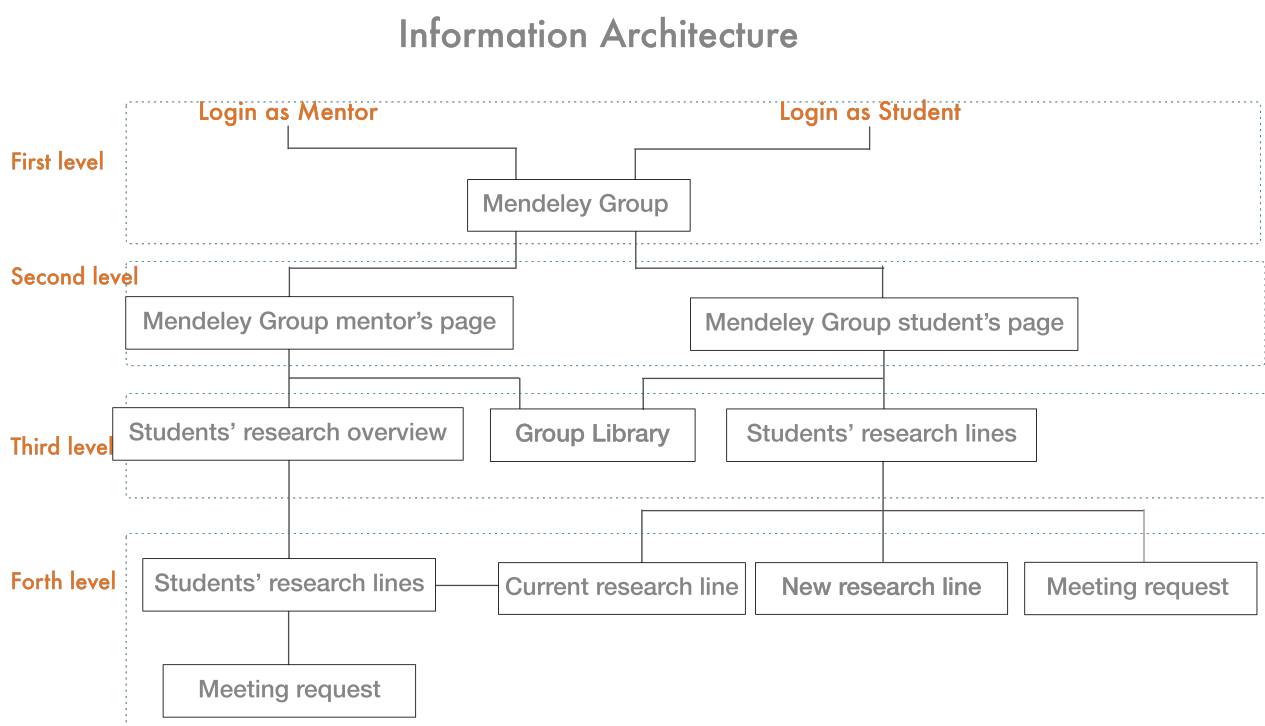


Figure 4.3.6-1 Information architecture

The information architecture of Research Line has four levels:

1. On the first level, users login to the Mendeley website and open their Mendeley Group.
2. On the second level, users navigate to their personal page of Mendeley Group. Users' identities decide the page they view.
3. On the third level, users have two choices. Mentors can either go to the Students' Research Status Overview page or go to the Group Library page. Students can choose to enter into Research Line page or go to the Group Library page.

4. On the fourth level, mentors can choose to open any student's research line from the Overview page. From any student's research line, mentors can send a meeting request. Students have three options: open an existing Research Line, create a new Research Line or send meeting request.

4.3.7 The Hi-fi prototypes

We develop the interactive Hi-fi prototypes in FramerJS (FramerJS is an interactive prototyping tool: <https://framer.com/>) based on the information architecture in 4.3.6. The prototypes for mentors and students are different.

The Hi-fi prototype for mentors

The prototype for mentors has the following features:

1. Check the recent activities of a group of students
2. Check one student's Research Line
3. Upload paper to the Group Library and share with students
4. Send meeting request to student

We put some screenshots here to help the readers understand how do the hi-fi prototypes work.

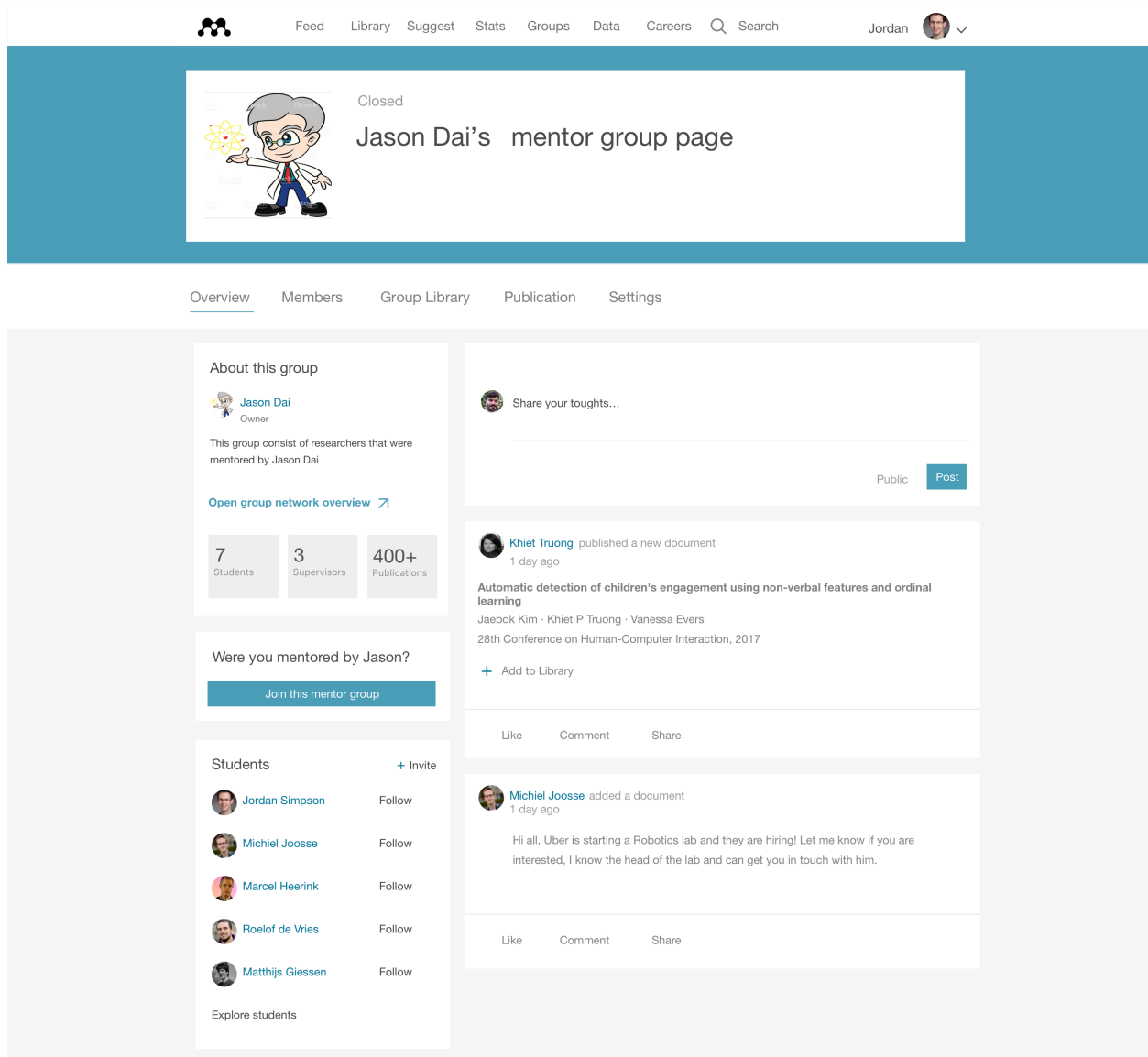


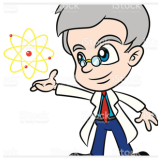


Figure 4.3.7-1 Mentor's personal page of Mendeley Group


This is mentor's personal page of his Mendeley Group. The information of the group and students are presented on this page.


[Feed](#)
[Library](#)
[Suggest](#)
[Stats](#)
[Groups](#)
[Data](#)
[Careers](#)
[Search](#)
Jordan 



Closed
Jason Dai's mentor group page

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Jordan Simpson
 University of Twente

User Testing
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Current stage: **User Testing**


Design discussion Nov. 15th 2017
 Discuss about design concepts
 Discussed on the clickable prototype


Deadlines
 User Testing
 User study report
 Thesis draft

Current stage: **Data Collection**

Design discussion Nov. 15th 2017
 Discuss about design concepts
 Discussed on the clickable prototype

Deadlines
 User Testing
 User study report
 Thesis draft


 personality and gender



Henriette S. M. Cramer
 Spotify

User Studies
 Groups in Conflict at the Airport: How People Think a Robot Should Act

Figure 4.3.7-2 Students' research status overview page

This is the students' research status overview page. On this page, mentors can check the recent activities of a group of students.

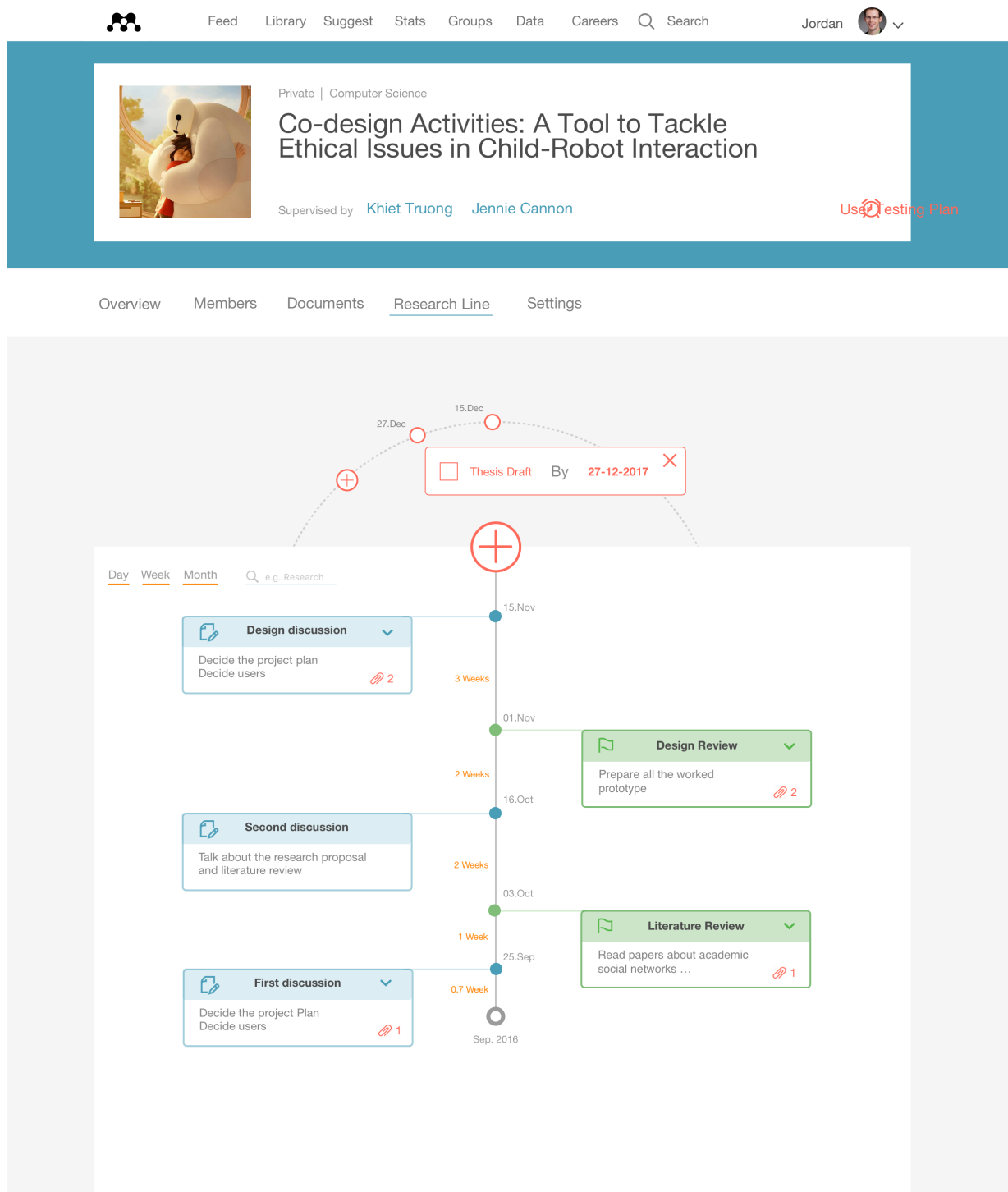


Figure 4.3.7-3 One student's Research Line

This is the page of one student's Research Line. Mentors can find the action points in research progress

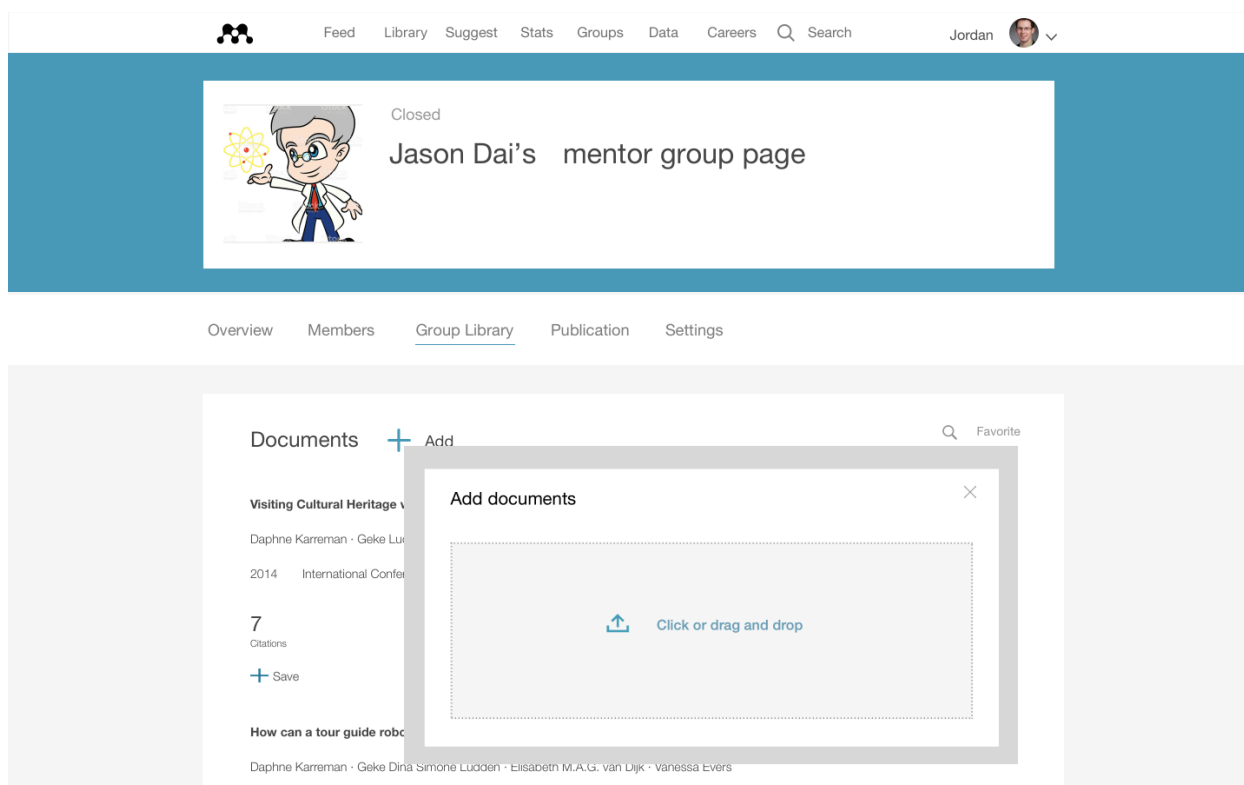


Figure 4.3.7-4 The group library uploading page

This is the group library page. On this page, mentors can upload documents to the group library.

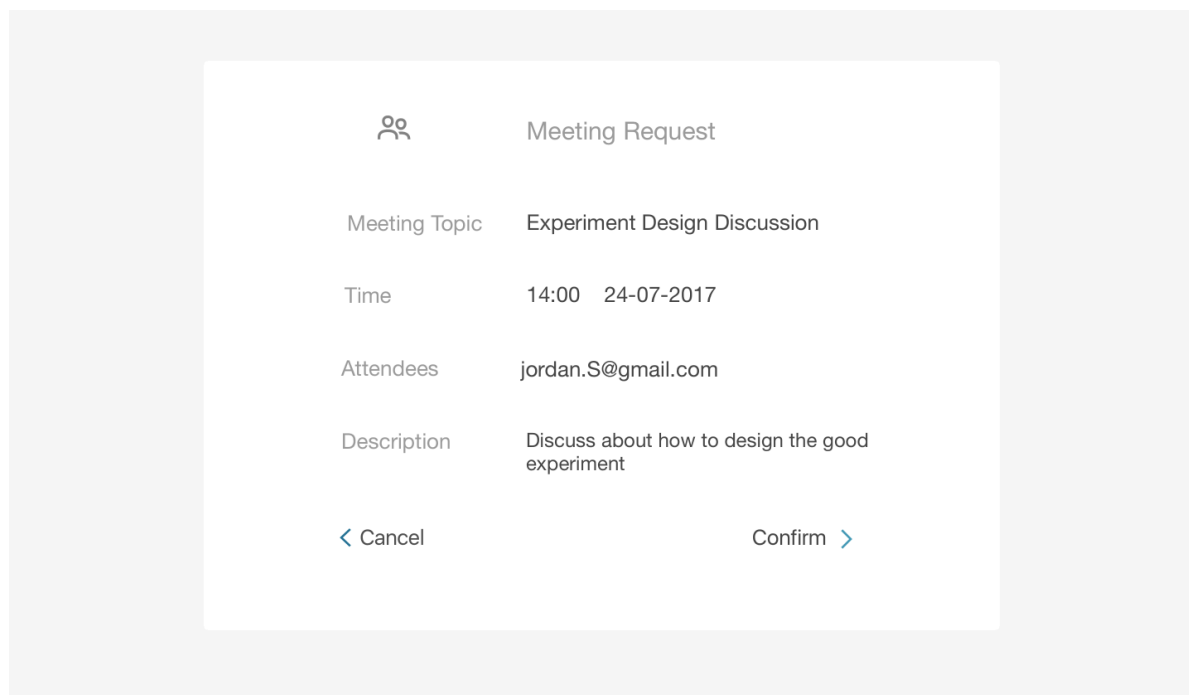


Figure 4.3.7-5 The meeting request page

This is the meeting request page. On this page, mentors can add the time, date and


description on the meeting plan.


The hi-fi prototype for students


The prototype for students has the following features:

1. Create a research line for a new research project
2. Add meeting notes or milestones to the new Research Line
3. Open an existing Research Line
4. Add meeting notes or milestones to the existing Research Line
5. Upload materials to the milestone or meeting note
6. Add deadlines for the research project
7. Mark the finished deadlines

Similarly, we select some screenshots to help the readers understand how the hi-fi prototypes work.


[Feed](#)
[Library](#)
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[Search](#)

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Jordan Simpson

PhD student
University of Twente

4

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[Overview](#)
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[Research Line](#)
[Settings](#)

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Author ID: 55416415900

Research interests

Human-Robot interaction


Current Research Project

Meeting the Expectations from Brain-Computer Interfaces
Feb 2017 Human Media Interaction

+ Add New Project


Mentors

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Figure 4.3.7-6 Student's personal page on Mendeley Group

This is student's personal page of his Mendeley Group.

Feed Library Suggest Stats Groups Data Careers Search Jordan



Jordan Simpson

PhD student

University of Twente

4

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27

Citations

Message

Following

Overview Members Group Library Research Line Settings

New Research Project

Title

Title

Research Field

Choose a field

Mentor

Email or name

From

DD-MM-YYYY

2016

May

To

DD-MM-YYYY

2019

> May

<

Cancel

Confirm

>

Figure 4.3.7-7 New research project information page

This is the page for filling in the basic information for creating a new research project.

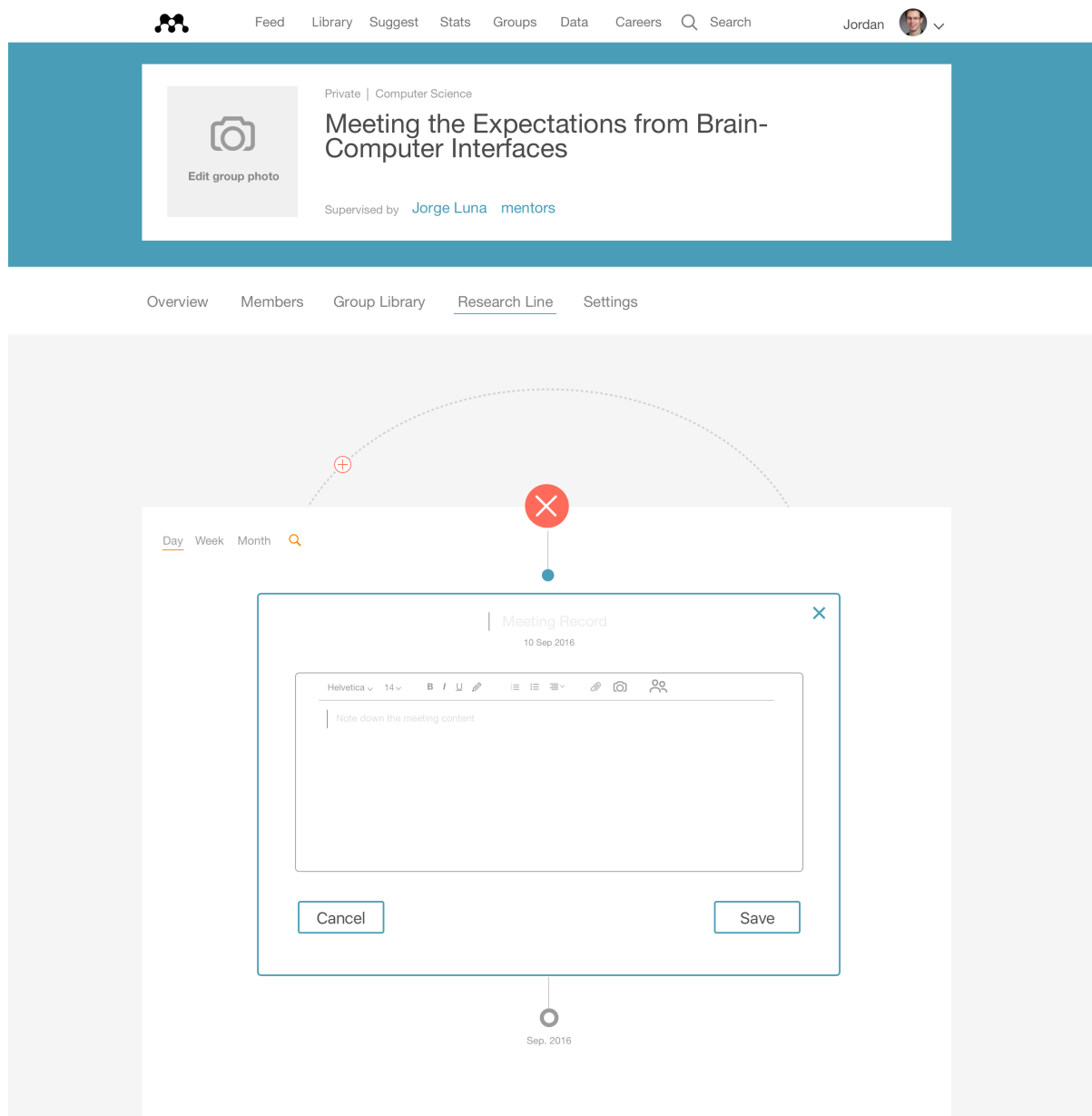


Figure 4.3.7-8 Adding meeting note page

This is the page for adding a meeting note.

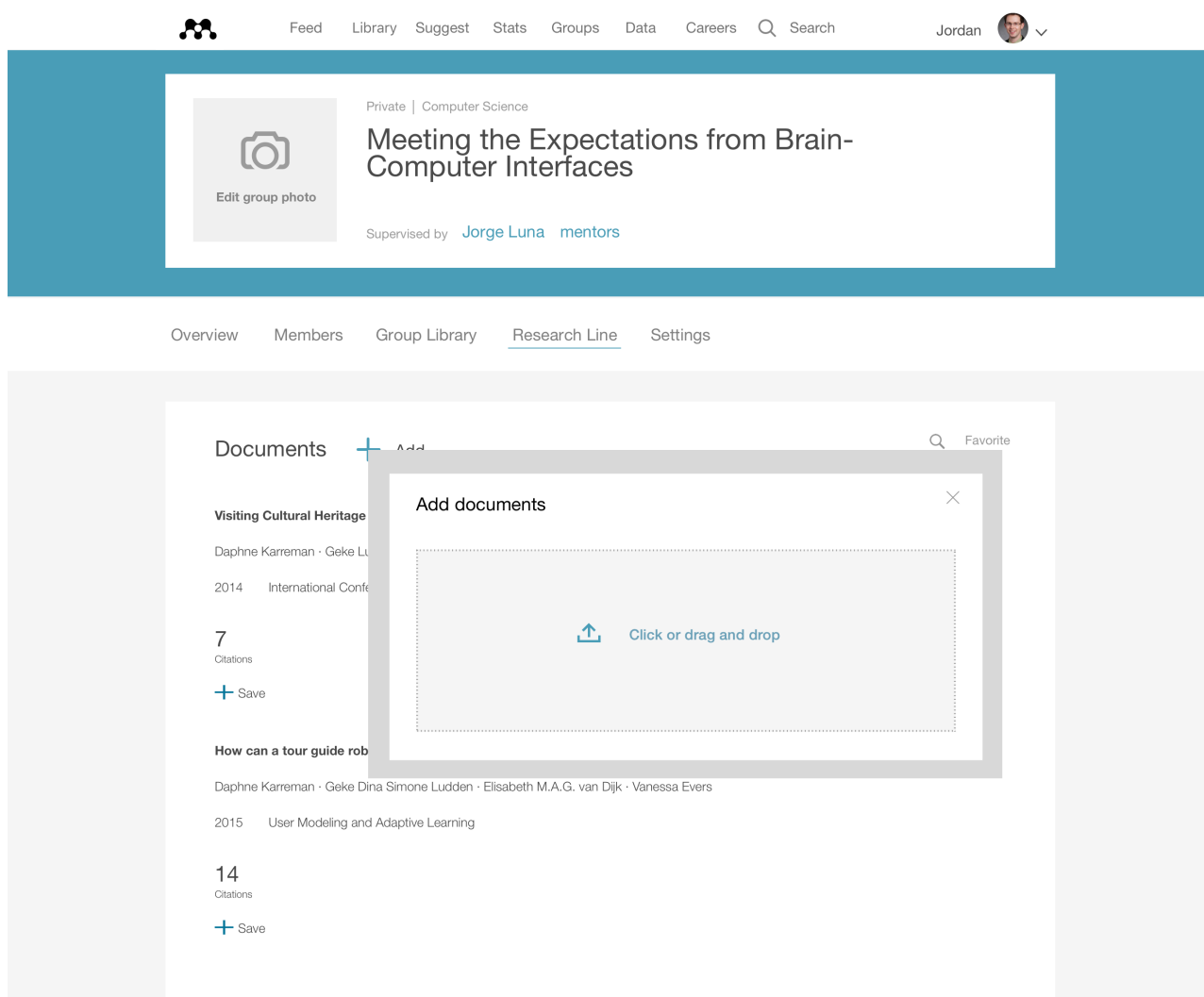


Figure 4.3.7-9 The group library uploading page

This is the group library page. On this page, students can upload documents to the group library.

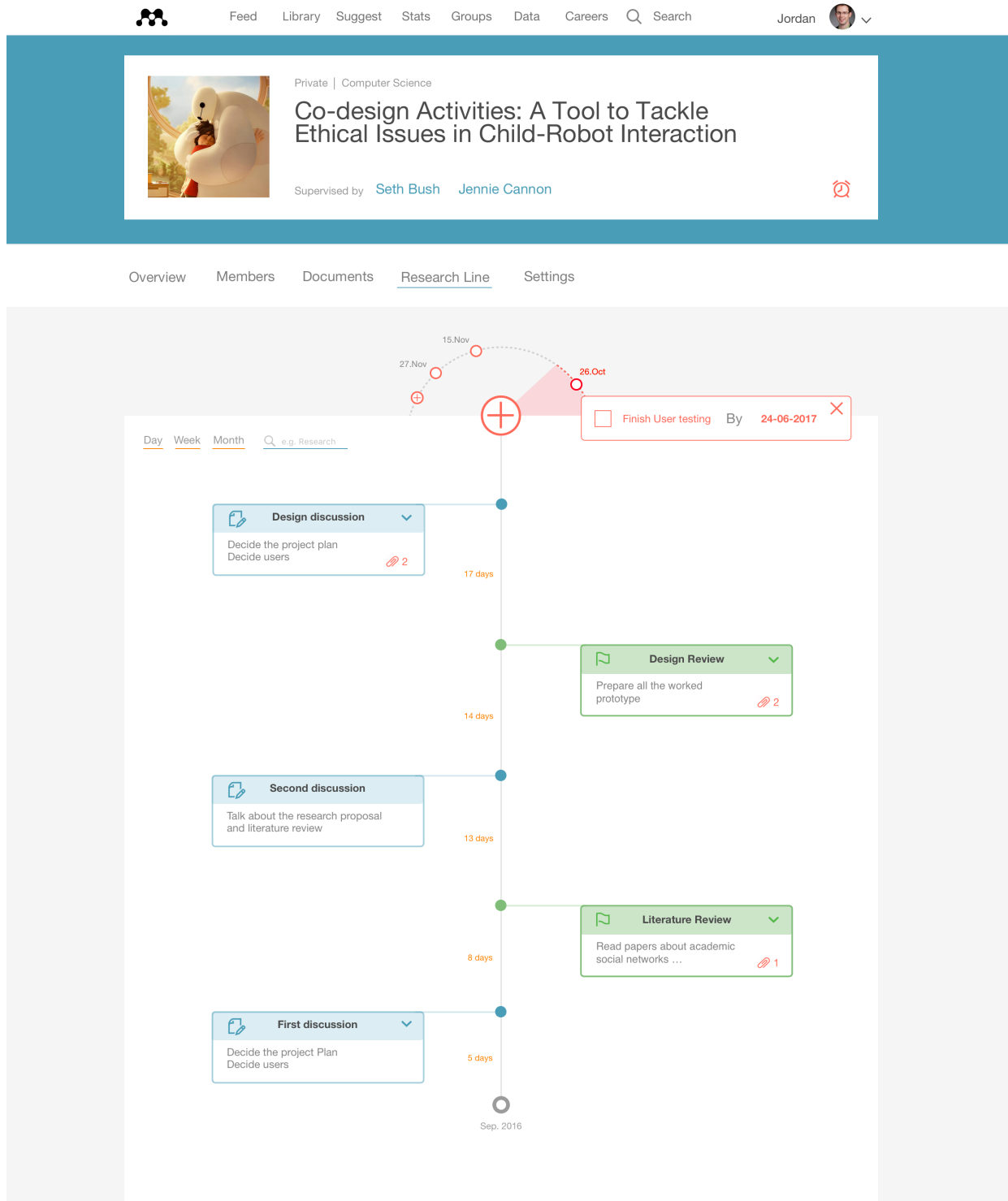


Figure 4.3.7-10 The existing Research Line page

This is the page of the existing Research Line.

A demo video of the prototypes can be found in <https://vimeo.com/237953052>

4.4 Design solution summary

In this chapter, we propose a design solution for better information sharing and storage in E-mentoring process. Starting from an inspiration, we follow the methodology in [20] and propose the design solution. We first identify the user requirements from the personas and the scenarios. Then we propose three design options. After that, we define the information architecture and develop the hi-fi prototypes. In the next chapter, we evaluate the design solution and answer the research question.

Chapter 5. Design solution evaluation

In Chapter 1, we propose a research question: *What could be a solution for better information sharing and storage between mentors and students in the E-mentoring process? Can it help improve the efficiency and effectiveness of current information sharing and storage process?*

The answer to the first question is proposed in chapter 4. Now to comprehensively answer the second question, we propose four sub-questions below:

1. *Can mentors and students understand the concept of Research Line?*
2. *Which design option could best represent the Research Line in users' minds?*
3. *Can the Research Line improve the efficiency of the information sharing and storage between mentors and students in E-mentoring process?*
4. *Can the Research Line improve the effectiveness of the information sharing and storage between mentors and students in E-mentoring process?*

The evaluations in this chapter are helpful to answer the four sub-questions.

This chapter is structured as follows: the evaluation objectives are firstly described in 5.1. Then the evaluation methodology is discussed in 5.2, including the detailed experiment design and the measurements. Results of the experiments are presented in 5.3. Finally, a short summary is given in 5.4.

5.1 Evaluation objectives

To answer the four sub-questions, we formulate four evaluation objectives:

1. **To find out if Research Line is understandable:** understanding is the basis of other evaluations. Given that Research Line is part of the Mendeley website, the understandability is mainly evaluated from its interface design. We evaluate the five aspects of the interface design: visualization of the concept; the meaning of the icons; the transitions between pages; the logic of the new design (the information architecture);

the purpose of the buttons. The detailed discussions can be found in 5.3.2.2.

2. **To find out if Research Line is efficient:** to find out if Research Line can improve the efficiency of the information sharing and storage in E-mentoring. More specifically, we want to test if the student's research progress and the related documents can be instantly shared and stored between mentors and students.
3. **To find out if Research Line is effective:** to find out if the Research Line could improve the effectiveness of the information sharing and storage in E-mentoring. More specifically, we want to test if the Research Line could share the information that mentors and students care about most.
4. **To find out users preferences on the visual options:** to find out users' preference on the three design options in 4.3.4.

5.2 Evaluation methodology

Based on the evaluation objectives, we define two evaluations: Visualization Preference Evaluation and Design Performance Evaluation. Visualization Preference Evaluation is to test users' preference on the three design options. Since preference is a relative simple and subjective concept, the user interviews were conducted. The Design Performance Evaluation is a relative complex process, therefore the usability testing was performed. Detailed discussions can be found below.

5.2.1 Participants

Similar to the user study, there are two types of participants in the evaluations:

1. Researchers with mentoring experience
2. Students with experience of research projects, include bachelor students, master students and PhD students

To follow the findings of the user study, participants who have attended the user study were invited to attend the evaluation. On account of the time arrangements, only 4 mentors from

the user study have attended the evaluations, new participants were therefore recruited.

Six Researchers and six students at the University of Twente have attended the evaluation. To reduce the influence of the research backgrounds, participants of different backgrounds were recruited. Their profiles can be found below.

Table 5.2.1-1 Mentors' profiles

Index	Gender	Title	Background
M01	F	Assistant Professor	Human Media Interaction
M02	F	Assistant Professor	Human Media Interaction
M03	M	Assistant Professor	Psychology
M04	M	Assistant Professor	Industrial Design
M05	M	Ph.D. student	Human Media Interaction
M06	M	Full Professor	Human Media Interaction

Table 5.2.1-2 Students' profiles

Index	Gender	Background	Research Project Period
S01	M	Data science	6 months
S02	M	Human-Computer Interaction	More than 12 months
S03	F	Biomedical Engineering	More than 12 months
S04	F	Human-Computer Interaction	More than 12 months
S05	F	Architecture	9 months
S06	F	Machine Learning	6 months

5.2.2 Experimental design

Visualization Preference Evaluation

Aiming at finding out users' preference, we conducted the Visualization Preference

Evaluation. Considering users' preference is subjective, the evaluation was conducted in the form of user interviews. Interviews are cheap, convenient and straightforward for collecting subjective data.

Participants were asked to choose from three colour printed design options that could best represent and visualize the design concept in their minds. The three design options are the linear Research Line, the circular Research Line and the networking Research Line. The sampled questions for mentors and students are:

Question for mentors: "You have several supervised students, each of them has their individual research project. You check their research progress regularly. If their research progress were visualized by a concept called Research Line for better planning and monitoring, which one below could best represent the Research Line? Why?"

Question for students: "Imagine that your research progress is visualized by a design concept – Research Line. It could help you better plan your research work and share information with your mentors, which one below could best represent the Research Line? Why?"

Usability Testing

To investigate the understandability, effectiveness, and efficiency of the Research Line in sharing and storing information in E-mentoring, we conducted the usability testing. Usability testing, as described in [21], involves representative users attempting representative tasks in representative environments, on early prototypes or working versions of computer interfaces. It is a widely used method in the Research of HCI field.

In the usability testing, we asked mentors and students to complete two tasks under two different scenarios. We used the hi-fi prototypes with linear Research Line in 4.3.7 to help the users to complete the tasks.

With the time limitation and prototype limitation, we designed the contexts under which mentors and students could most likely to use the Research Line. For mentors, Research Line mainly helps them to check student's research progress. Therefore, the two tasks for mentors are:

1. Check one student's Research Line;
2. Contact with the student who is behind the schedule.

Each task has a series of small tasks. A figure below summarizes the task list. The detailed description can be found in Appendix I.

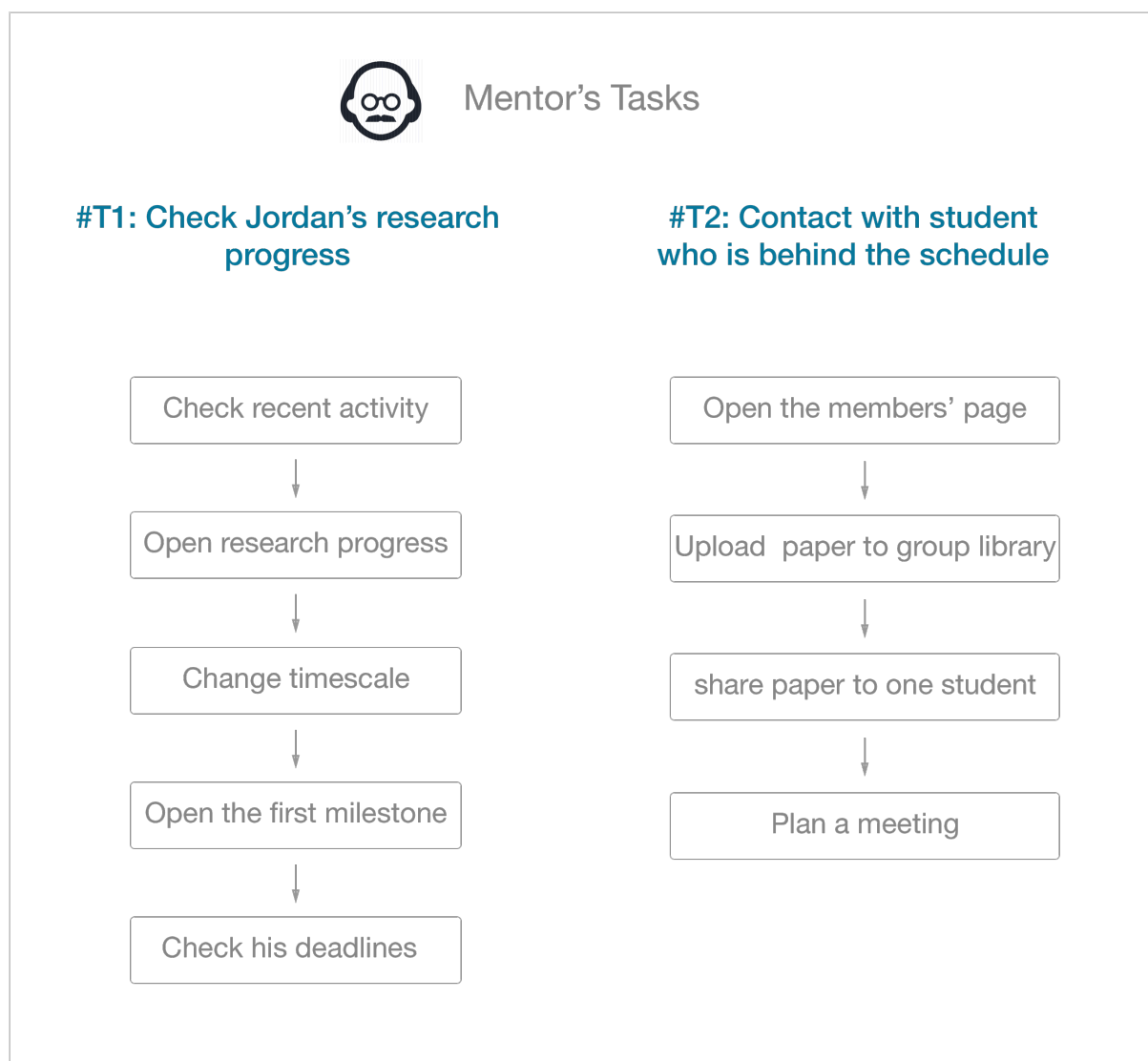


Figure 5.2.2.2-1 Mentor's Task Lists

Students mainly use Research Line for creating a new research project or recording the existing project. The two tasks for students are:

1. Create a new research project
2. Update the existing research project

Each task has a series of small tasks. A figure below summarizes the task list. The detailed scenario description can be found in Appendix II.

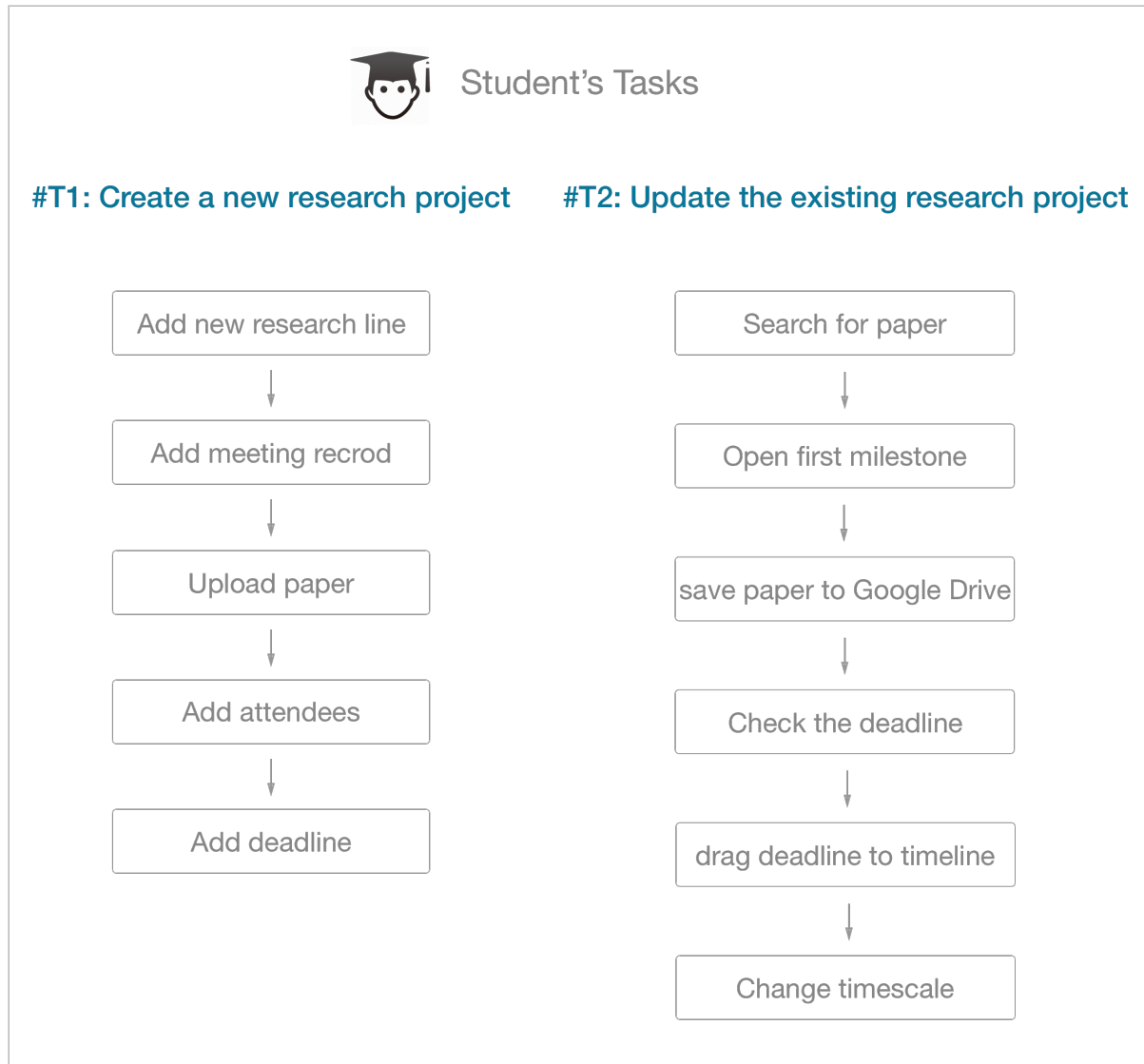


Figure 5.2.2.2-2 Student's Task Lists

5.2.3 Measurements

With the limited time and given that the E-mentoring is a complex process and objective measurements can't provide direct validations on the evaluation objectives, only the subjective measurements are collected in this study. We collected data from the questionnaires and the post-testing interviews.

To validate the improved efficiency and effectiveness in information sharing and storage of Research Line, the existing tools that mentors and students used in their daily lives should be regarded as the benchmark. However, A direct comparison can't be made in the usability testing for two reasons: first, the data of existing tools were not completely collected; second, E-mentoring is a complex process and various tools are used in different steps by different participants. There's no single tool that can be used as the explicit benchmark. But the user study and the post-testing interviews provide some information on the existing tools. General comparisons between those tools and Research Line are demonstrated.

Questionnaire

We use the questionnaire as the main measurement in the usability testing for two reasons: first, it's a common method in usability testing to evaluate users' satisfaction rates; second, it is a simple way to obtain users' subjective opinions. However, as discussed below, lacking the explicit benchmark may increase the subjectivity and variations of the data. The questionnaires were designed according to the research objectives. The statements in the Questionnaires were divided into three sections: efficiency, effectiveness, and understandability. Each section contains several specific statements. The full questionnaires are in the Appendix III and Appendix IV.

To quantify participants' answers, a 7-points Likert scale was used in the questionnaire. Compared with a 5-points Likert scale, the 7-points Likert scale can provide a wider range of answers, which gives more accurate demonstration to the research question. The 7-points Likert scale is as below:

Table 5.2.3-1 7-points Likert scale

1	2	3	4	5	6	7
Strongly Disagree	Disagree	Slightly Disagree	Neutral	Slightly Agree	Agree	Strongly Agree

Post-Testing interview

A post-testing interview was conducted after the usability testing to obtain participants' subjective opinions. The post-testing interview is helpful to providing the complementary information of users' opinions and finding the usability issues.

Thinking Aloud

The Thinking Aloud method was used during the usability testing process. Participants were asked to talk about their thoughts and the problems in the usability testing process. This is to help understand participants' behaviors and prevent system errors.

5.3 Data collection

We collected data of Visualization Preference Evaluation and Design Performance Evaluation respectively.

5.3.1 Visualization Preference Evaluation results

The goal of Visualization Preference Evaluation is to find out participants' preference on the design options. The evaluation was executed at the University of Twente and only 10 answers were collected.

Participants were asked to choose from three design options that could best represent the design concept in their minds. The choices, the percentages, and the reasons are summarized in Table 5.3.1.

Table 5.3.1 Visual preference evaluation results

Design Options	Number of participants	Percentage	Reasons for making the choice
Linear Research Line	5 in total	50%	<ul style="list-style-type: none"> • Presents the overview of the research process • Clear indication on time • Action points are very clear and intuitive
	3 mentors		
	2 students		
Circular Research Line	3 in total	30%	<ul style="list-style-type: none"> • Good presentation of the research process • Good reflection on the research phases • Attractive visual design
	1 mentor		
	2 students		
Networking Research Line	2 in total	20%	<ul style="list-style-type: none"> • Flexibility of adding iterations in research progress
	2 mentors		

This result gives an indication of participants' preferences on the visual design. In general, Linear Research Line is the most popular one that 50% participants chose it. Reasons include the clear indication of time, action points and overview of the research progress, reflecting users' expectations on the design. Participants that prefer the Circular Research Line and the Networking Research Line are 30% and 20%, indicating a small difference between the two options. The circular Research Line is preferred by its reflection on the research phases, presentation of the research process and attractive visual design. The Networking Research Line is voted for its flexibility of adding iterations in research progress.

One interesting phenomenon is that even though 50% participants finally chose the Linear Research Line, many of them mentioned that their favorite visual option is the Circular

Research Line.

The comparison between mentors and students demonstrates the difference. The results indicate that mentors prefer the linear design and they don't like the circular design. The flexibility of the Networking Research Line is not attractive to students since no student chose the networking design. However, the sample size is too small to make any assertive conclusion. Further evaluations should be conducted to find out the answers.

5.3.2 Usability Testing results

The Usability Testing evaluates the understandability, efficiency, and effectiveness of the Research Line. The testing was executed at the University of Twente with 6 mentors and 6 students. We collected 12 questionnaires.

5.3.2.1 Data processing methodology

To quantify the questionnaire results, four parameters were selected to process the data: Mean value; Standard deviation; Percentage Agree; Top Two Box Score.

Mean Value: calculate the average value of a group of data

Standard Deviation: is used to quantify the amount of variation or dispersion of a set of data values

Percentage Agree: calculate the percentage of all the agree respondents within total respondents. (The scale 5, 6, 7 are all counted as Agree Respondents)

Top Two Box Score: calculate the percentage of the two most favorable responses within the total responses. Since a 7-points Likert scale is used in the questionnaire, the point 6 and 7 are regarded as the top two box scores, the green areas in the diagram below are counted as Top Two Box Scores.

Table 5.3.2.1 Top Two Box Score

1	2	3	4	5	6	7
Strongly Disagree	Disagree	Slightly Disagree	Neutral	Slightly Agree	Agree	Strongly Agree

Mean value and Standard Deviation were selected because they are frequently used parameters in Statistics to reflect the statistical distribution of the data. The Percentage Agree and Top Two Box Score were selected to measure participants' attitudes. As recommended in [22], Percentage Agree and Top Two Box Score are reasonable and intuitive parameters to interpret participants' preferences when the benchmark is absent. Considering that the questionnaire data are ordinal data and the explicit benchmark is absent, the Percentage Agree and Top Two Box Score were selected.

The combination of Mean Value, Standard Deviation, Percentage Agree and Top Two Box Score gives a relatively complete presentation and interpretation on the results. The Top Two Box Score and the Percentage Agree provide the quickly assessing results for stand-alone studies when there's no meaningful benchmark. But the interpretations are not accurate since only two answers are counted. The Mean Value and Standard Deviation provide the complementary demonstration on the data.

5.3.2.2 Data collection

Existing tools summary

Even though there's no explicit benchmark, we still made general comparisons between the existing tools and Research Line. The tools that participants commonly used in the E-mentoring process are summarized in a table below. Some are collected from the user study, and some are from the Post-Testing Interviews. Those tools are grouped into: messaging tool, notes-taking tool, and project management tool.

Table 5.3.2.2-1 Existing tools summary

Categories	Tools
Messaging Tool	Email/ Whatsapp/ Slack
Notes-taking Tool	Notebook/ Notability/Drewboard/ Evernote/OneNote
Project Management Tool	Excel/Trello/Notebook

The following discussions reflect the comparisons between the Research Line and those tools.

Efficiency: data collection on mentors

Questions about efficiency evaluation can be found in the Appendix III and Appendix IV. The score for each question was collected and summarized in the table below. Participants are represented from M1 to M6.

Table 5.3.2.2-2 Mentor's respondents on efficiency evaluation

	Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8
M1-M6	6,5,6, 5,6,6	4,5,6, 6,7,6	6,4,4, 7,6,6	4,3,6, 6,7,5	5,6,6, 6,6,6	4,5,7, 2,3,5	3,3,6, 2,1,5	6,6,6, 6,5,6
Mean Value	5.66	5.66	5.83	5.16	5.83	4.33	3.33	5.83
Standard deviation	0.51	1.03	0.98	1.47	0.41	1.75	1.86	0.41
Percentage Agree	100%	83%	83%	67%	100%	50%	33%	100%
Top Two-Box Score	50%	67%	83%	50%	83%	17%	17%	83%

Table 5.3.2.2-1 presents mentor's respondents on the comparison of efficiency between the Research Line and the existing tools. According to the user study and Post-Testing Interviews,

most of the comparisons are made between email, Google drive and Research Line.

Q1, Q2 asked if Research Line is faster to understand student's research progress. Q3, Q4, Q5 asked if Research Line is faster to find the action points in student's research progress. Q6 asked if Research Line is faster to share documents with students. Q7 asked if Research Line is faster to plan a meeting with students. Q8, as the summary question, asked if Research Line generally provides more efficient reflection on student's research progress compared with the existing tools.

The mean, standard deviations, Percentage Agree and Top Two Box Scores were calculated respectively. First, we can find that most of the questions except for Q6 and Q7 (the red area), have a mean value that is larger than 4 (the neutral value) and a relatively small standard deviation. This indicates participants' positive evaluations on the efficiency improvements of Research Line. But the lower mean value of Q6 suggests that Research Line is not faster at sharing documents with students. The standard deviation demonstrates the variations on the opinions. This may be because email and Google drive have already met mentors' requirements on sharing documents. About planning a meeting with students, the lowest mean value and highest standard deviation of Q7 indicate the negative assessments from participants. Planning meetings through Research Line is not as efficient as other tools.

The Percentage Agree and Top Two-Box Score provide the similar results. For the Percentage Agree, Q6 and Q7 received a value that is equal to or lower than 50%. Most of the questions obtain a relative high Percentage Agree Score, and some even reached 100%, indicating that Research Line is more efficient in most aspects except for sharing documents or planning a meeting. And Q6 and Q7 got the same lower value with 17% on Top Two Box score.

Q8, as the summary question, presents the overall performance of the Research Line. Data of

Q8 suggests that even though the specific aspects present the negative result, the Research Line in general was perceived more efficient in information sharing and storage than email or Google Drive.

Efficiency: data collection on students

The questionnaires for students are slightly different from questionnaires for mentors. Based on the user requirements, students care about the efficiency of recording and checking their research progress. Planning a meeting is not included in students' questionnaires because students have the relatively freer schedule and it's easier for them to accept a meeting request than mentors who have the busier schedules.

Table 5.3.2.2-3 Students' respondents on efficiency evaluation

	Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8
S1-S6	7, 6, 5, 7, 2, 6	7, 6, 5, 5, 3, 5	3, 6, 4, 3, 3, 4	7, 6, 5, 6, 3, 5	7, 6, 6, 7, 5, 6	7, 6, 5, 5, 5, 7	6, 6, 5, 5, 5, 7	7, 7, 6, 6, 3, 6
Mean Value	5.5	5.16	3.83	5.33	6	5.83	5.66	5.83
Standard deviation	1.87	1.33	1.17	1.37	0.63	0.98	0.82	1.47
Percentage Agree	83%	83%	16%	83%	100%	100%	100%	83%
Top Two-Box Score	67%	33%	16%	50%	83%	50%	50%	83%

Considering students mainly use Research Line for recording and updating their research progress, the comparisons are made between Research Line and other project management tools. According to the findings of user study and Post-Testing Interviews, students mainly use Trello, Excel or Notebook to record their research progress.

Q1, Q2, Q3, Q4 asked if the Research Line is faster to add meeting notes, milestones, deadlines or documents of the research progress. Q5, Q6, Q7 asked if the Research Line is faster to find the meeting notes, milestones or deadlines from the research progress. Q8, as the summary question, asked if Research Line generally provides more efficient updating and reflection of their research progress.

The Mean, the Standard Deviations, Percentage Agree and Top Two Box Scores were calculated. For Mean value, it can be found that all the statements except for Q3, have reached a relatively high mean value, compared to the neutral value 4. It indicates that Research Line is generally perceived faster for students to add and find action points in the research progress. Only Q3 about adding and editing deadlines has the lowest mean value, which reveals Research Line's problem in the adding deadlines. Students' attitudes were also reflected in the Post-Testing Interviews. Most students stated that Research Line is faster to record and check their research progress. However, it's hard for them to figure out how to add the deadlines. The standard deviations of most statements are small, indicating the consistency of students' opinions. Only Q1 has the highest standard deviation. Participants have different opinions on adding meeting notes in Research Line, which may because that they use different project management tools.

The performance of Percentage Agree is consistent with the mean value. Only Q3 has the lowest value of 17%, which supports the analysis above. And for Top Two Box score, Q2 and Q3 are lower than 50%. That is to say, for adding milestones (Q2) and adding deadlines (Q3), Research Line is not as efficient as other operations.

For the general performance of Research Line, the results of Q8 provide the answer. The Percentage Agree and Top Two Box score are 83%. The Research Storyline is perceived more efficient for students to record and check their research progress.

Effectiveness: Data collection on mentors

There are fewer questions that relate to effectiveness, which can be found in the Appendix III and Appendix IV.

Table 5.3.2.2-4 Mentors' respondents on effectiveness evaluation

	Q1	Q2	Q3	Q4	Q5
M1 – M6	6, 7, 7, 6, 6, 6	6, 7, 7, 6, 5, 6	6, 6, 6, 5, 4, 4	1, 5, 5, 5, 2, 4	6, 6, 7, 6, 5, 6
Mean Value	6.33	6.17	5.17	3.67	6
Standard deviation	0.51	0.75	0.98	1.75	0.63
Percentage Agree	100%	100%	67%	50%	100%
Top Two-Box Score	100%	17%	50%	0%	83%

As discussed earlier, the effective sharing refers to that mentors could get the information that they care about most and the effective storage refers to the good management of documents. The comparisons are mainly made between Research Line and email, Trello and Google drive.

Q1 asked if Research Line is better at presenting the big picture of the research progress. Q2, Q3 asked if the Research Line is better at presenting and tracking the specific action points in the research progress. Q4 asked if the Research Line is better at storing documents systematically. Q5 is the summary question asked if Research Line generally provides more effective reflection on the student's research progress.

The Mean, the Standard Deviations, the Percentage Agree and the Top Two Box Scores were

calculated. As in table 5.3.2.2, except for Q4, other statements all received a relatively high mean value (more than 5). Combined the Percentage Agree with the Top Two-Box Score, the data of Q1, Q2, Q3, Q5 suggest that the Research Line is perceived more effective compared to the existing tools. Furthermore, Q1 has received 100% Percentage Agree and Top Two Box Score, indicating Research Line's good performance on presenting the big picture of the student's research progress. Q2 also received 100% Percentage Agree but with 17% Top Two Box Score. It suggests that Research Line's strength in presenting action points is not so strong. Similarly, data of Q3 also demonstrates that the little advantage of Research Line in tracking action points in the research progress. Q4 received the lowest values, which reflects participants' negative feedback on the performance of storing documents in Research Line. This may be because Google Drive and other software have already done well in storing documents.

The summary question Q5 presents a good performance with 100% Percentage Agree and 83% Top Two Box Score. We can infer that even though some aspects are not positive, the Research Line in general was perceived more effective than other existing tools.

Effectiveness: Data collection on students

Table 5.3.2.2-5 Students' respondents on effectiveness evaluation

	Q1	Q2	Q3	Q4	Q5
S1-S6	7, 3, 6, 3, 7, 5	7, 4, 6, 4, 7, 6	4, 6, 6, 5, 6, 5	4, 5, 6, 5, 6, 5	7, 6, 6, 5, 6, 6
Mean Value	5.17	5.66	5.33	5.17	6
Standard deviation	1.83	1.36	0.82	0.75	0.63
Percentage Agree	67%	67%	83%	83%	100%

Top Two-Box Score	33%	67%	50%	33%	83%
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Questions for students about the effectiveness are almost the same with mentors'. The comparisons are mainly made between the Research Line and Trello, Excel and other project management tools.

As can be seen from the table, students' answers present the similar trends with mentors' but vary on the individual question. Firstly, the mean values of all questions have exceeded the neutral score 4, but they are a bit lower than the values of mentors, which in general indicate students' positive assessments. For the standard deviation, Q1 and Q2 have a relatively higher standard deviation than the other questions.

Looking at the overall data in Percentage Agree and Top Two Box Score, the results are generally positive. All the Percentage Agree values have exceeded 50% and the summary question Q5 even reached 100%. The Top Two Box Score varies from question to question. Q1 and Q4 have received the relatively low Top Two Box Score with 33%. This suggests that students are not satisfied with the overview presentation and documents storage. Q2 and Q3 with higher Top Two Box Score indicate Research Line's effectiveness on presenting and tracking action points of the research progress. In the end, the summary question Q5 still presents a relatively good performance. Therefore, it can be found that even though some aspects are not good enough for students, the Research Line is generally perceived more effective than other project management tools.

What should be noticed is that the same questions got different answers from mentors and students. About the documents storage (Q4), mentors have negative attitudes while most students gave a positive answer. Given that the main interfaces are same for mentors and students, the difference may result from the different user requirements under different contexts. The detailed comparisons between mentors and students are discussed in 5.3.2.3.

Understandability: data collection on mentors and students

Research Line was developed based on the Mendeley website, so the understandability is mainly evaluated from its interface design. There's no difference in the questionnaire between mentors and students. The full questionnaire can be found in the Appendix III and Appendix IV.

Table 5.3.2.2-6 Data collection on understandability

	Q1 Visual of design	Q2 Meaning of icon	Q3 Transitions between pages	Q4 Logic of system	Q5 Purpose of button
M1-M6 S1-S6	5, 5, 4, 7, 5, 5, 7, 6, 2, 7, 6, 6	5, 5, 5, 5, 3, 3, 7, 4, 4, 4, 5, 4	5, 5, 2, 5, 3, 2, 7, 7, 5, 7, 6, 5	5, 5, 3, 5, 4, 2, 6, 4, 3, 7, 6, 6	5, 3, 3, 7, 3, 2, 6, 4, 4, 5, 5, 4
Mean Value	5.42	4.5	4.91	4.67	4.25
Standard deviation	1.44	1.087	1.78	1.49	1.42
Percentage Agree	83%	50%	75%	58%	42%
Top Two-Box Score	50%	8%	25%	33%	16%

From Q1 to Q5, five aspects of interface design have been selected to test participants' understandability:

1. **The visual design:** to test if the visualization of the Research Line is understandable for

participants.

2. **The meanings of icon:** icons are widely used in the interface. This is to test the reasonability of the icon design.
3. **The transitions between pages:** to test if the transitions between pages are understandable for users.
4. **The logic of the system:** to test if the information architecture of the Research Line is understandable for users.
5. **The purpose of buttons:** to test if the page transitions after clicking on the buttons are reasonable for users.

As can be seen in table 5.3.2.2-5, among all those items, the visual design has the highest mean value, Percentage Agree and Top Two-Box Score, suggesting that the visual design is the most understandable aspect of the interface design. This is also supported by the Post-Testing Interviews. Most participants mentioned that the visual representation of the Research Line was understandable when they saw it for the first time. Q5 that is about the purpose of buttons received the lowest mean value, Percentage Agree and lowest Top Two Box Score. The data reflects the problems of the design: purposes of buttons are not understandable and clear for users. Q2 has the similar results with Q5. Participants' scores are distributed around the neutral score, revealing the issues of the icon design. For Q3, the mean value is close to the neutral value and the standard deviation is quite big. Mentors and students have various opinions on the page transitions. Some participants thought the transitions are totally reasonable and gave the full score. Some participants argued that some transitions are repetitive so that it caused confusion in their operations. They also explained in the Post-Testing Interview that why the transition is unreasonable. Q4 received the similar results with Q3. The mean value is close to 4 and the standard deviation is quite big. It can be inferred that the information architecture of Research Line is not so clear for participants.

In general, the score of the understandability is not as high as the effectiveness and

efficiency.

5.3.2.3 Mentors and students data comparison

Since mentors and students have different user requirements, analyzing the difference between them is also helpful to further understand their answers. The data comparisons are summarized here to help find out the deeper user insights. The difference between mentors and students is reflected in both questionnaire and the Post-Testing Interview.

Efficiency comparison

In general, mentors and students hold similar views on the efficiency of the Research Line, which can be found from the summary question in the questionnaire:

Table 5.3.2.3-1 Efficiency comparison

	Mean	Standard deviation	Agree percentage	Top two box
Mentor	5.83	0.41	100%	83%
Student	5.83	1.47	83%	83%

We can infer that both mentors and students have a good impression on the efficiency of the Research Line, whereas students have the higher variation and the little bit lower Agree Percentage. For the particular operations, planning a meeting in the Research Line is not so efficient for mentors. Adding deadlines is not so efficient for students. The difference is also reflected in the Post-Testing Interviews. Five mentors mentioned, “I couldn’t find the planning meeting button”, reflecting the poor design of the planning meeting function. Mentors have the higher requirements on planning a meeting because mentors have a full schedule and it’s easier for them to send the meeting request than students.

Effectiveness comparison

Similarly, mentors and students generally have positive assessments of the effectiveness of the Research Line, which is reflected by their answers to the summary questions.

Table 5.3.2.3-2 Effectiveness comparison

	Mean	Standard deviation	Agree percentage	Top two box
Mentor	6	0.63	100%	83%
Student	6	0.63	100%	83%

However, for the storing documents, their opinions are quite different.

Table 5.3.2.3-3 Storing documents comparison

	Mean	Standard deviation	Agree percentage	Top two box
Mentor	3.67	1.75	50%	0%
Student	5.17	0.75	83%	33%

Mentors give negative answers to the question while students are in general positive. This phenomenon may result from their roles in the process. A mentor could supervise multiple students at the same time. Managing the documents of multiple students could always be a burden for a mentor, which could explain why they have higher requirements on the documents management. However, the situation for students is much easier since student usually only manage his own documents. Therefore, students have higher satisfaction rate on the document management than Mentors.

5.4 Evaluation summary

This chapter investigates Research Line's performance in information sharing and storage. To answer the Research Question and find out if Research Line could provide better information sharing and storage, the evaluations are conducted. Four research objectives: understandability, efficiency, effectiveness and visualization preference are proposed. Data from questionnaires and interviews are collected. The results of the two evaluations are presented and interpreted. In the end, the difference between mentors' answers and students' answers is analyzed. In the next chapter, I further analyze and interpret the results of the experiments and discuss the research question.

Chapter 6 Discussion

In the previous chapter, we present and interpret the data of the evaluations. We propose four sub-questions to answer the main research question:

1. *Can mentors and students understand the concept of Research Line?*
2. *Which design option can best represent the Research Line in users' minds?*
3. *Can the Research Line improve the efficiency of the information sharing and storage between mentors and students in E-mentoring process?*
4. *Can the Research Line improve the effectiveness of the information sharing and storage between mentors and students in E-mentoring process?*

This chapter further analyzes the results of the experiments and discusses about the research question. This chapter is organized in discussing the four sub-questions one by one.

6.1 Research question discussion

1. *Can mentors and students understand the concept of Research Line?*

The answer to this question is: mentors and students most likely to understand the concept of Research Line.

The results of the Usability Testing demonstrate that mentors and students could understand the design concept. Both questionnaire results and the Post-Testing Interviews suggest this. First, participants' answers suggest the positive feedback, even though the score is not as high as Efficiency and Effectiveness. Meanwhile, the understandability on the visual design received the highest score among all the related questions. Since the visual design is a direct reflection on the design concept, the high mean value and Agree Percentage could demonstrate users' understanding of the design concept. Second, in the Post-Testing Interviews, many participants mentioned that Research Line is a new but understandable concept for them. Mentors shared their experience on recording student's research work with

other tools. They mentioned that Research Line could be helpful to track student's research progress and communicate with students. Students talked about how they made their own schedule with other software on their research work. The similar experience suggests that Research Line is an understandable concept for them.

2. Which design option could best represent the Research Line in users' minds?

The answer for this question is: we can't conclude which design option could best represent the Research Line in users' minds.

The results of Visualization Preference Evaluation in Chapter 5 indicate that half of the participants prefer the linear Research Line. Their reasons include the clear indication of the time, overview and action points of the research progress. However, to draw conclusions from the experiment results, the factors that may affect the results must be carefully considered: only 10 samples were collected in the evaluation and design options were presented with color printed paper, which is not interactive. Taking those factors into consideration, the small-sample data can't be directly used to reflect users' preference on the design options. Therefore, there is no direct answer to this question.

3. Can the Research Line improve the efficiency of the information sharing and storage between mentors and students in E-mentoring process?

The answer to this question is: probably, a further evaluation with a larger sample size in the long term needs to be conducted.

As discussed in chapter 3, one important message that is shared between mentors and students is the student's research progress. The research progress includes what students have done in the past, what they are currently working on and what they will do in the future. Students want to update their research progresses efficiently. Mentors want an efficient sharing of student's research progress so that they can give the instructions in time.

The tasks and questionnaires in the usability testing are designed to reconstruct the situations where students and mentors share the student's research progress between each other, including finding out students' current stages, checking their milestones or meeting records in the past, and checking their deadlines for the future. That is to say, the positive questionnaire results under those contexts may suggest the improved efficiency of the information sharing between mentors and students.

As analyzed in chapter 5, the results from questionnaires exhibit a positive answer to this question. More specifically, for data collected on mentors, 100% Agree Percentage and 83% Top Two Box Score of the Summary Question reveal participants' highly agreements on the improved efficiency of Research Line. All the other statements, except for sharing documents with students and planning a meeting with students, have a relatively high mean value (>5), more than 67% Agree Percentage and more than 50% Top Two Box Score, suggesting Research Line's potential in the efficiency improvement. Students' answers are also generally positive. The summary question Q8 reached 83% Agree Percentage and 83% Top Two Box Score, reflecting students' positive feedback.

Qualitative data from the Post-Testing Interviews support the answer from the other side. Several mentors mentioned that the design is very helpful to quickly understand the student's research progress. M2 said, "I love this idea". M5 said, "I really hope it can be implemented then it would be much easier for me to find out if students behind their schedule." Most students are more satisfied with the idea of quickly writing down the meeting records. "This should be valuable if it allows me to quickly write down the important decisions at the meeting with my mentor". "I love that I can add meeting notes, milestones and deadlines together." But there are some objections. One student said that it's not efficient but time consuming to update his research progress on a totally new tool. Some students worried if they could update the progress as frequently as expected.

In summary, the combination of the quantitative data and the qualitative data generally demonstrate a positive answer to this question. Most mentors and students agreed on the improved efficiency of the Research Line in information sharing and storage. However, the limitations of the experiments also need to be considered: the small sample size reduced the reliability of the conclusion; the tasks are simple while the real situations are far more complex; objections in the user interviews can't be ignored; there is no explicit benchmark; only perceived efficiency was measured and no objective measurements were made. Therefore, we could only say that Research Line has the potential in improving the efficiency of information sharing and storage, but future studies need to be conducted to provide stronger validations.

4. Can the Research Line improve the effectiveness of the information sharing and storage between mentors and students in E-mentoring process?

The answer to this question is: probably, a further evaluation on a larger sample size in long run needs to be conducted.

The findings of the user study suggest that the effective information sharing for mentors should indicate the “big picture”, the “next step” and the materials of the research progress. The effective information sharing for students should stress the deadlines.

Both the qualitative data and the quantitative data exhibit the positive answer. For data collected on mentors, the summary question Q5 has received 100% Agree Percentage and 83% Top Two Box Score, suggesting perceived improved effectiveness of the Research Line. Except for storing documents, all the other statements have a relatively high mean value (>5), more than 67% Agree Percentage and more than 50% Top Two Box Score. Students' attitudes towards this question are even more positive. Looking at the Table 5.3.2.2-3, we can find that all the columns have a mean value of >5 and more than 67% Agree Percentage.

The post-testing interviews provide more detailed explanations. Five out of six mentors mentioned that they love the design of the timeline because it “reflects the big picture”, “can check each action point” and “present the time and the process”. Two mentors wanted a shared Research Line with all the students under their supervision. Some even wanted a super Research Line for themselves. Most students thought Research Line was a useful tool to present their research progress. More than four students mentioned that the design of timeline makes the process look clear and succinct. However, Negative feedback were also collected. The objections are mainly focused on the misleading icons and confusing buttons. “I don’t understand the milestone button”. “I can’t find the planning meeting button”.

In summary, even though there are some design problems, the results of the experiment generally demonstrate a positive answer to this question. However, consider the limitations that are discussed in the third question, we have no certain answer to this question. Future studies need to be conducted.

After answering the four sub-questions, the research question can be reviewed and answered consequently. The Research Line, once used for visualizing student’s research progress in the E-mentoring process, has the potential in improving the effectiveness and efficiency of the information sharing and storage between mentors and students in E-mentoring process.

6.2 Discussion summary

In this chapter, the results of experiments have been further analyzed and interpreted. Four sub-questions are discussed and answered, based on which the research question is analyzed and answered. In the next chapter, the conclusion, limitations and the future work are presented.

Chapter 7 Conclusion, limitations and the recommendations

Mentors and students share information and store resources in the E-mentoring process. To achieve better information sharing and storage, we propose one research question at the beginning of the study: *What could be a solution for better information sharing and storage in E-mentoring process? Can it help improve the efficiency and effectiveness of current information sharing and storage process?*

To answer the research question, we conducted this study in three steps. The user study revealed that existing tools have limitations in sharing and storing the student's research progress efficiently and effectively. The new design solution—Research Line was proposed through a step-by-step design process. We construct the personas and scenarios and extract the user requirements. We propose the linear, circular and networking Research Lines and develop the interactive hi-fi prototypes.

To evaluate the performance of Research Line, we propose four evaluation objectives and define two evaluations. We conducted the Visualization Preference Evaluation to test participants' preference on the three design options (the linear, the circular and the networking). Results suggest that 50% participants prefer the linear design option, but the best design option can't be decided with the small sample size.

We conducted the usability testing to test the understandability, efficiency, and effectiveness of the Research Line. The feedback on the understandability is in general positive. The high score of visual design indicates participants' understanding of the design concept. The data collected from questionnaires and Post-Testing Interviews suggest that Research Line has potential in improving the efficiency and effectiveness of information sharing and storage in

the E-mentoring process. However, negative feedback was collected on the planning meeting buttons and adding deadline buttons. The confusing position of planning meeting button and the repetitive transitions between pages were exposed in the experiments.

The combination of the quantitative data and the qualitative data exhibit the potential of the Research Line in improving the efficiency and effectiveness of information sharing and storage between mentors and students in the E-mentoring process. However, the limitations of the empirical studies should be necessarily discussed, those limitations include but are not restricted to:

1. **Small sample size:** the experiments were conducted with a rather small sample size.
2. **Limited participants:** participants were only recruited from the University of Twente.
3. **Only short-term evaluation:** with limited time, the evaluation was executed only by one-time operation on the hi-fi prototypes. However, the real E-mentoring process could last for a long period of time and the real mentor-student interaction is far more complex and flexible.
4. **Lack of the explicit benchmark:** the explicit benchmark is not indicated in the evaluations, which increases the subjectivity and the variations of the experiment results to some extent.
5. **Lack of objective measurements:** on account of limited time and the complex prototypes, the objective measurements are not collected in the experiment. The lack of objective measurements reduces the reliability of the experiment result.

Recommendations for the future studies are given from the following aspects:

1. **A refined evaluation:** The real mentor-student interaction in E-mentoring is complex, flexible and could last for a long period of time. To improve the convincing of the effect of Research Line, a refined evaluation should be conducted in the future. The refined evaluation should consider the bigger sample size, diversified participants, a clear indication on the explicit benchmark and objective measurements.

2. **Full website implementation:** the fully implemented Research Line could provide users with the working database and real-time feedback, which could reduce the errors and misunderstandings that are caused by the hi-fi prototypes and increase the accuracy of the experiment results.
3. **Research Line Redesign:** considering that the usability issues in current hi-fi prototypes could affect users' feedback on the functional performance. The Research Line should be redesigned to reduce its usability issues as much as possible. Research Line can be redesigned from the following aspects: the icons could be clearer; the buttons can be more explicit; the transitions between pages could be simpler and more explicit.
4. **Expansion of Research Line:** the concept Research Line can be expanded to other communications. The essence of Research Line is to enhance the collaborations between any two groups online. Therefore, not only for mentors and students but also for the information sharing between any researchers. A shared research line or a super research line can be further developed for other researchers.

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Appendix I: Mentor's Tasks

Task 1

You just came back from a Conference and didn't contact with your students for two weeks, now you are sitting at the airport and want to check how are they doing in the past two weeks. You open one student's research and try to find out how was he doing in the past. This student is called Jordan Simpson.

#Check the research progress of one student

1. Open recent activity page and check how was everyone doing in the past two weeks
2. Find out Jordan's research progress and open Jordan's current research storyline
3. Change timescale to see his research progress
4. Under the month scale, open his first milestone and see what he did
5. Look at his deadlines

Task 2

You have a remote supervised student who is doing his internship in the company, and you didn't talk to each other very often. Last time checking makes you realized that he is behind the schedule. Today you found a very good paper and want to share with him. Plus, you want to have an f2f meeting with this student.

#Contact with the student that is behind the schedule

1. Open the member page and check students
2. Upload a new paper to the group library
3. Share the paper to Jordan
4. Plan a meeting with Jordan for the next discussion

Appendix II: Student's Tasks

Task 1

You are having your first meeting with your mentor on the new research project. Your mentor asked you to read a paper and ask you to write the literature review for the next two weeks. To track your research process, now you want to create a new research storyline for this project,

#Create a new research storyline

1. Add a new research storyline
2. Fill in basic information for the research project
3. Add a meeting record
4. Upload a paper to the meeting record
5. Add one attendee to the meeting record
6. Add a new deadline for the literature review

Task 2

Several months later after the first meeting, you've made much progress. You just finished the user testing before the deadline, now you want to update your research storyline with the new progress. Besides, you also want to find a good history paper to help you write the thesis.

#Update existing research storyline

1. Search for the paper of the first milestone
2. Open the first milestone
3. Save the paper of the first milestone into Google Drive
4. Check the user testing deadline
5. Drag the finished deadline to timeline
6. Change timescale to see the difference of research line

Appendix III: Mentor's Questionnaire

Please rate the following questions with scale (1-7)

1	2	3	4	5	6	7
Strongly Disagree	Moderately Disagree	Slightly Disagree	Neutral	Slightly Agree	Moderately Agree	Strongly Agree

Efficiency

Comparing the tools that I currently used, I found the new system

1.is quicker to help find out what the student is currently working on

1	2	3	4	5	6	7
---	---	---	---	---	---	---

2.is quicker to help understand what the student has done in the past

1	2	3	4	5	6	7
---	---	---	---	---	---	---

3.is quicker to help understand the milestones students have made in the research

1	2	3	4	5	6	7
---	---	---	---	---	---	---

4.is quicker to help find out the meeting records in the research progress

1	2	3	4	5	6	7
---	---	---	---	---	---	---

5.is quicker to help understand deadlines that student needs to complete

1	2	3	4	5	6	7
---	---	---	---	---	---	---

6.is quicker to help share documents with students

1	2	3	4	5	6	7
---	---	---	---	---	---	---

7.is quicker to help plan a meeting with students

1	2	3	4	5	6	7
---	---	---	---	---	---	---

8. make it more efficient to track student's research progress

1	2	3	4	5	6	7
---	---	---	---	---	---	---

Effectiveness

Comparing the tools that I currently used, I found the new system

1. is better at reflecting the structure of student's research progress

1	2	3	4	5	6	7
---	---	---	---	---	---	---

2. is better at reflecting the action points of student's research progress

1	2	3	4	5	6	7
---	---	---	---	---	---	---

3.is easier to help track the action points in the research progress

1	2	3	4	5	6	7
---	---	---	---	---	---	---

4.is better at sharing and storing the documents systematically

1	2	3	4	5	6	7
---	---	---	---	---	---	---

5.make it more effective to track student's research progress

1	2	3	4	5	6	7
---	---	---	---	---	---	---

Understandability:

1.The visualization of the research storyline is understandable

1	2	3	4	5	6	7
---	---	---	---	---	---	---

2.The meanings of Icon are clear

1	2	3	4	5	6	7
---	---	---	---	---	---	---

3.The transitions between pages are understandable

1	2	3	4	5	6	7
---	---	---	---	---	---	---

4.The logic is easy to understand

1	2	3	4	5	6	7
---	---	---	---	---	---	---

5.The purpose of the buttons is clear

1	2	3	4	5	6	7
---	---	---	---	---	---	---

Appendix IV: Student's Questionnaire

Please rate the following questions with scale (1-7)

1	2	3	4	5	6	7
Strongly Disagree	Moderately Disagree	Slightly Disagree	Neutral	Slightly Agree	Moderately Agree	Strongly Agree

Efficiency

Comparing the tools that I currently used, I found the new system

1. is quicker to help add and edit the meeting notes

1	2	3	4	5	6	7
---	---	---	---	---	---	---

2. is quicker to help add and edit the milestones of the research process

1	2	3	4	5	6	7
---	---	---	---	---	---	---

3. is quicker to help add and check the deadlines for my research progress

1	2	3	4	5	6	7
---	---	---	---	---	---	---

4. is quicker to help add related documents

1	2	3	4	5	6	7
---	---	---	---	---	---	---

5. is quicker to help find out action points in the research progress

1	2	3	4	5	6	7
---	---	---	---	---	---	---

6. is quicker to help find out meeting records in the research progress

1	2	3	4	5	6	7
---	---	---	---	---	---	---

7. is quicker to help find out related documents

1	2	3	4	5	6	7
---	---	---	---	---	---	---

8. make it more efficient to update my research progress

1	2	3	4	5	6	7
---	---	---	---	---	---	---

Effectiveness

Comparing the tools that I currently used, I found the new system

1. is better at reflecting the structure of my research progress

1	2	3	4	5	6	7
---	---	---	---	---	---	---

2. is better at reflecting the action points of my research progress

1	2	3	4	5	6	7
---	---	---	---	---	---	---

3.is easier to help track the action points in the research progress

1	2	3	4	5	6	7
---	---	---	---	---	---	---

4.is better at sharing and storing the documents systematically

1	2	3	4	5	6	7
---	---	---	---	---	---	---

5.make it more effective to track my research progress

1	2	3	4	5	6	7
---	---	---	---	---	---	---

Understandability:

1.The visualization of the research storyline is understandable

1	2	3	4	5	6	7
---	---	---	---	---	---	---

2.The meanings of Icon are clear

1	2	3	4	5	6	7
---	---	---	---	---	---	---

3.The transitions between pages are understandable

1	2	3	4	5	6	7
---	---	---	---	---	---	---

4.The logic is easy to understand

1	2	3	4	5	6	7
---	---	---	---	---	---	---

5.The purpose of the buttons is clear

1	2	3	4	5	6	7
---	---	---	---	---	---	---



Thanks for reading

