UNIVERSITY OF GOTHENBURG

DEPARTMENT OF EDUCATION, COMMUNICATION & LEARNING

DIGITAL HIGHLIGHTING AND NOTE TAKING IN ACADEMIA

Empirical research to inform design for digital reading technologies

Dayane Proaño

Thesis:	30 higher education credits
Program and/or course:	International Master's Programme in IT & Learning
Level:	Second Cycle
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Supervisor:	Johan Lundin
Examiner:	Sylvi Vigmo
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Abstract

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Keywords:	Digital highlighting, digital note taking, reader software, digital texts.

Purpose: The purpose of the study is to explore the digital highlighting and digital note taking practices in university students. The findings of this empirical ethnographic research provide information on highlighting and note taking practices in academic digital reading. The findings in this research also contribute to informed design to develop digital tools and technologies for digital reading. Also, the research provides guidelines for digital note taking and highlighting.

Theory: The study is built upon Bloom's Taxonomy as a theoretical framework. The research also adopted Study Social Practices to explore study practices among university students. Thoughtful Interaction Design was chosen to create the beginning drafts of prototypes for reader software and reader technologies.

Method: The study included a combination of methods. Research Approach of the Study of Documents, Online Semi-structured interviews, and Probing in digital prototype allowed to explore the digital note taking and highlighting practices in academic digital reading.

Results: The main contribution of the study is the identification of digital highlighting and note taking practices that can support academic digital reading. Another contribution is informed design to develop reader software or technological devices for academic reading.

Foreword

Firstly, my strong gratitude to the Swedish Institute. In 2019, I was chosen as a scholarship holder to study in Sweden. All the knowledge and experiences learned are priceless, and I will take them with me for the rest of my life. I want to thank my supervisor Johan Lundin at the University of Gothenburg for his support, guidance, and feedback. His advice allowed me to develop further ideas and provide design ideas. I also want to thank all professors at the University of Gothenburg. Looking back to 2019, I have learned a lot, and I can say I have improved my academic skills.

I want to thank my friends Zuleica and Hilda. We have gone through this journey helping each other what a treasure to find friends that help you to be better. I would wholeheartedly like to thank my family and friends for making it possible to finish my studies through long-distance support. I want to thank all the students who participated in this research; without you, I would have started the reader software considering my own needs. Now I have new perspectives on digital reading and reader technologies.

Dayane.

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Abbreviations	Explanation
PDF	Portable Document Format
EPUB	Electronic Publication
DOC	Document file format

1 Introduction

Note taking and highlighting are common techniques used for academic work and are associated with good academic performance (Heyne et al., 2020; Oefinger & Peverly, 2020; Schepman et al., 2012). For many years, research work on highlighting and note taking techniques have focused on how these techniques are used for reading comprehension (Leonard et al., 2021; Oefinger & Peverly, 2020), active engagement in the intention of learning and recalling information (Mizrachi, 2015; Oefinger & Peverly, 2020; University of North Caroline at Chapel Hill, n.d), and to identify important information in texts (Gier et al., 2010). However, there is a lack of research on how highlighting and note taking skills are practiced when students read academic texts in digital documents using reader software. Identifying the practices of highlighting and note taking techniques in digital documents and understanding students' needs in both techniques when using reader software, the easier to support academic digital reading. Moreover, the more research on digital highlighting and note taking techniques in digital documents, the better design of reader software interfaces and functionalities.

Digital highlighting and note taking can provide alternatives and solutions for the limitations of traditional highlighting and annotation on papers. For instance, online collaboration for note taking and highlighting on reader software such as Adobe Acrobat Reader DC and Mendeley Desktop Reference Management on Portable Document Format (PDF) (Adobe, 2021; Mendeley, 2020). Also, the organization of notes and highlights by tags and keywords. The visualization of notes by timeline on the Paperly app (Paperly, 2019). In addition, documents with the digital format in contrast with print format offer more alternatives for highlighting and note taking practices such as reduce weight in portability, lower cost (Ji et al., 2014; Leonard et al., 2021; Mizrachi, 2015), possibility to mark and unmark on them and keep a personal archive of notes and highlights of academic documents. Coyle (2008) mentioned some characteristics of reader technologies such as web launching searches, integration of dictionaries, and modification of fonts and size. Reader technologies such as Kobo Libra and Kindle Paperwhite provide exporting notes, timeline progress, translation of words, and night mode reading (Amazon, 2021; Kobo, 2021). With the exponential growth of digital publication every year, it is necessary to explore how students read and interact with academic digital texts and reader software. Thus, highlighting and note taking functionalities on reader software technologies might meet students' needs or generate challenges in academic digital reading.

This research explores the highlighting and note taking practices and challenges in digital format to provide solutions to support students' digital reading in academia. Identifying challenges could generate recommendations for interface and functionality design. Leonardo et al. (2021) pointed out that one of the challenges of digital reading on mobile technologies is determining whether or not it has an academic benefit to the students. The authors also stated that digital reading should be more interactive, taking into account the advantage of technologies. However, Mizrachi's (2015) comparison research worked on print vs. digital texts found no relevant difference in reading comprehension with the use and non-use of highlights and notes. Digital highlighting and note taking technologies also have limitations. In two studies of preference of print versus digital text, undergraduate students reported a higher preference for print texts due to digital reading caused eyestrain (Dilevko & Gottlieb, 2002; Mizrachi, 2015). Other challenges were distraction (Foasberg, 2014; Leonard et al., 2021; Mizrachi, 2015; Rosenwald, 2014), nonlinear reading (Mangen et al., 2013; Rosenwald, 2014), inability to mark the text and to see the entire text at one time (Leonard et al., 2021). However, research work also showed that students could read more digital texts if they had

technologies to make highlighting and note taking on digital texts (Mizrachi, 2015; Rockinson-Szapkiw et al., 2013). Previous studies have investigated students' preferences on digital texts, and physical texts. The preference for reading electronic texts can vary depending on the level of studies of the readers and the field of study (Ji et al., 2014; Mizrachi, 2015). For instance, Mizrachi (2015) found that post-doctoral researchers indicated a higher preference for digital texts, followed by graduate students. On the other hand, undergraduate students reported a higher preference for print texts. The reason for digital or print text preference might lie in the reader's preference or the accessibility of the reading resources.

While some research has investigated highlighting and note taking benefits in education, very little is known about the practices and challenges of digital highlighting and note taking using technologies such as reader software and word processor. In addition, this research identifies the most common format for digital reading: (1) Portable Document Format (PDF) and (2) Electronic Publication (EPUB). And a third format for digital writing (3) Document file format (DOC). The benefits and limitations of highlighting and note taking tools for supporting reading and academic writing will also be analyzed.

Students use highlighting and note taking for multiple academic purposes mentioned before (Mizrachi, 2015; Oefinger & Peverly, 2020, the University of North Caroline at Chapel Hill, n.d), and students use multiple digital tools for studies. Therefore, the importance of this theoretical and empirical ethnographic research work is that it aims at identifying students' practices and challenges in highlighting and note taking on digital texts and the motivations to perform these techniques in academia. The research also proposes design recommendations for academic reading in reader software technologies. This research study is conducted in higher education with international students studying the undergraduate and master degree level in three universities in Europe. The students were enrolled in social science and computer science careers. Consequently, this research will attempt to answer the following research questions:

RQ1: *How and why do university students use highlighting and note taking techniques in academic digital reading?*

RQ2: *How can highlighting and note taking practices inform design for academic digital reading technologies?*

The findings of this empirical ethnographic research work will provide information on highlighting and note taking practices in digital documents that have not been explored before. Moreover, the findings can be used as recommendations for the design of functionalities and interface of the reader software and a new file format for digital reading.

This thesis is composed of six themed chapters. The first section of this paper presented the introduction. The second chapter deals with previous relevant literature and is followed by a third chapter on the theoretical background to explore how previous research might support the research aim and questions. The fourth chapter is concerned with the methodology used for this study. This section intends to investigate and analyze digital highlighting and note taking practices by observing digital documents and interviews. Finally, findings and reflections are discussed in the discussion and conclusion section. Suggestions for future research based on the limitations of this study are also provided.

2 Related Literature review

This chapter presents a relevant literature review in highlighting and note taking techniques. The literature review aims to support digital highlighting and note taking practices in academia and how current reader software allows students to practice these study techniques digitally. Highlighting and note taking are two different techniques. However, literature review research found that both techniques are used in parallel. This section intends to integrate both techniques evenly but also presents both techniques separately to understand their unique characteristics.

Also, the literature review includes principles of how humans read on digital screens, how technologies support digital reading, and thoughtful design for reading tools in education.

2.1 Highlighting and Note taking

Highlighting and note taking techniques in education are used to support students' learning (Mizrachi, 2015; Oefinger & Peverly, 2020; the University of North Caroline at Chapel Hill, n.d). These techniques are commonly used by college students when reading texts to keep track of information. Students also use both techniques for exams and assignments. The practice of both techniques can promote active reading, learning, and recalling information (Mizrachi, 2015; Oefinger & Peverly, 2020; the University of North Caroline at Chapel Hill, n.d). Also, Leonard et al. (2021) pointed out that these techniques can support reading comprehension. There is evidence that highlighting is not an effective skill as note taking skills. However, the practice of both skills can promote active reading and learning (University of North Caroline at Chapel Hill, n.d).

Leonard et al. (2021) explored the differences in comprehension and behavior between highlights and notes on computer-based and paper-based texts. The research worked showed that reading comprehension with the use and without the use of highlights and note taking did not find any relevant difference in reading comprehension. Interestingly, highlighting behavior had differences; students highlighted fewer texts but more words on digital texts. On the other hand, students highlighted more text but fewer words on paper-based text. The same research found that students took more time reading when they had the opportunity to highlight and take notes on both types of texts. Note taking is not limited to academic reading but to the organization of studies. In 2012, Schepman et al. carried out an observational study adopting electronic notes on the Evernote app in undergraduate students. Students reported positive evaluations and manifested that notes were beneficial for organizing their activities and felt that notes facilitated the completion of tasks.

2.1.1 Highlighting

Cambridge Dictionary (n.d.) and Merriam-Webster Dictionary (n.d.) define Highlighting as an action to mark a text with a bright or lighter-colored area on the surface of something. On electronic screens such as a computer or smartphone, highlighting is used to stand out and emphasize something important. The purpose of highlighting is to draw attention to important information in a text, and highlighting can be effective when the reader picks out the important parts, and this might lead to an effective way to review that information later (Dunwoody College, n.d.; Seli & Dembo, 2019). Highlighting is an individualized practice; accordingly, students should develop their personal system of highlighting and consistently using it (Dunwoody College, n.d.)

Research work on highlighting as study strategy has shown mixed or limited benefits for learning purposes (Dunwoody College, n.d.; Fowler, R., & Barker, 1974; Lindner,1996; Seli & Dembo, 2019; the University of North Caroline at Chapel Hill, n.d). Fowler & Barker (1974) research found that highlighting on paper improved retention of selected information and that students might likely mark information that they agreed or statements suitable for objective examination such as test. In the same research, another traditional technique, underlining, also was found effective as an emphasis technique. Also, Lindner's (1996) research work explored if using different colored highlighters leads to greater use of schema building, thus increasing recall of information. A total of 171 university students enrolled in an educational course at the university level participated in the research. Students were required to read and highlight a nine-page chapter from a book focused on several topics relevant to the audience participating in the study and perform a first immediate and a second delay multiple-choice test. The author found that students who used one or two colored highlighters did not significantly differ in the test score. However, the use of colored highlighter helped students to recall information and obtained a higher score in the second multiple-choice test (Lindner, 1996).

On the other hand, highlighting words and phrases in textbooks and rereading is a passive and ineffective strategy for learning. Instead, involving other active strategies such as outlining, making questions, and summarizing the content might help students recall information (Cortina et al., 1995 as cited in Seli & Dembo, 2019). Another reason why highlighting should not be considered one study strategy is that students spend a considerable amount of time finding and sorting the content students consider important instead of thinking critically about the text highlighted. Highlighting limits learning because there is no indication that students understand the text and can apply, analyze, and evaluate the material (the University of North Caroline at Chapel Hill, n.d.). Leonard et al. (2021) found no significant difference in reading comprehension between highlights and notes on the computer-based text and paper-based text. Gier et al. (2010) emphasized that highlighting can help identify relevant information. However, it is the students' responsibility to make highlights to relevant information. Otherwise, poor highlighted text might contribute to poor reading comprehension.

According to Seli & Dembo (2019), one of the components for successful learning is highlighting the key points and important ideas summarized at the end of each chapter. In addition, research worked has also provided strategies to make highlighting more effective for learning. For instance, identify and highlight the main ideas and supporting ideas after finishing a paragraph or section. Also, limit the number of highlights on texts, highlight only keywords relevant to the topic and use color-coding to differentiate between concepts, statements, examples, others. (the University of North Caroline at Chapel Hill, n.d.).

For highlighting digital papers, research work suggested software such as Microsoft Word and Adobe Acrobat and formats such as PDF (Dunwoody College, n.d.; the University of North Caroline at Chapel Hill, n.d). Research work on digital highlighting practices is very little known. Therefore, this research aims to provide information on how and why university students are using digital highlighting practices for studies.

2.1.1.1 Effective highlighting

Guidelines for effective highlighting in academia are presented as tools to support students learning processes (Dunwoody College, n.d.; the University of North Caroline at Chapel Hill, n.d). For instance,

- Before highlighting, identify main concepts. Highlighting can help to identify relevant information.
- Highlight after a paragraph or section is finished.
- Highlight short sentences or phrases per paragraph and reduce the number of highlights.
- Highlight keywords that are relevant or connected to the texts.
- After highlighting the section, read the highlighted words alone and make sure highlighted words make sense.
- Use different colors to identify different ideas, concepts, others.
- Review regularly highlighted content to recall the information read before.

2.1.2 Note taking

Note taking is the action of writing notes about relevant information read or listened (Lund University, n.d.). Literature review showed that there is not a specific way of taking notes, this means that notes are written in a personalized way. Therefore the structure changes from one individual to another individual (Castelló & Monereo, 2005; Mizrachi, 2015; Oefinger & Peverly, 2020; Seli & Dembo, 2019; the University of North Caroline at Chapel Hill, n.d). Espino (2012) pointed out that students take notes in different situations, different forms, and motives. For instance, note taking can facilitate learning when the context is complex. Whether learners are studying online or in person, the physical act of writing notes can be more effective than typing on the computer. It can help remember better than just listening or reading (Cornell University, n.d.; May, 2014).

Note taking can facilitate learning when the context is complex (Espino, 2012). According to Oefinger and Peverly (2020), notes are used to recall and retrieve information and language comprehension. Also, students reported that note taking helps them to reread and review texts. Mizrachi (2015) found that note taking produced more active engagement in the intention of learning and recalling information. Note taking can be a useful tool to write information, but it is the students' responsibility to makes notes on relevant information; paying attention to poor notes could contribute to reading comprehension (Gier et al. 2010). According to Castelló & Monereo (2005), "note taking is the hegemonic study activity at university," this means that note taking is a strong and powerful practice that exerts influence in learning. These findings are relevant for the purpose of learning in higher education. It would be interesting to explore the social practices note taking to understand students' practices in today's digital learning.

Comparisons between hand and digital notes have been widely investigated. Paper notes seemed more effective for remembering than typing on the computer (Cornell University, n.d.; May, C. 2014). On the other hand, Bui et at. (2013) and Leonard et al. (2021) showed that reading comprehension and recall did not have a relevant difference in paper and digital notes. Also, a case study from Stanford University (2011) on the use of Mendeley Reference Management for academic reading found that reader software helped researchers and graduates to share their notes and articles easily. Literature review in preferences of notes showed that students preferred writing notes on paper because students experience tactile aspects such as holding and flipping (Leonard et al., 2021; Mizrachi, 2015). With the digitalization of texts, Keim (2014) pointed out that comparisons should not be strong points of investigation but rather how digital tools in education should be complementary tools for learning.

Note taking is not limited to academic reading. For instance, Schepman et al. (2012) carried out an observational study using digital notes using the Evernote app in higher education. The study found out that students reported positive outcomes toward digital notes. Digital notes helped them to organize their activities and completion of tasks in their studies and personal activities. The authors pointed out that note taking app preferences among students are a personal choice. However, they can be useful for different purposes in education, such as references and citation and reference (Schepman et al., 2012).

2.1.2.1 Effective note taking

Several university websites present guidelines for effective note taking in academia to support students learning processes. For instance, the Cornell method is suggested to take direct notes, make questions and comments about the notes, and summarize the notes. The method focuses on paper note taking, and suggests writing the notes in three sections (see Figure 1) (Cornell University, n.d.; the University of Gothenburg, n.d.). The Cornell method can be useful to structure notes effectively. It can help recall information from lectures or texts, considering that short-term memory is limited (the University of Gothenburg, n.d.). With the digitalization of texts, the Cornell system can be also used in digital tools (GoodNotes, 2017)

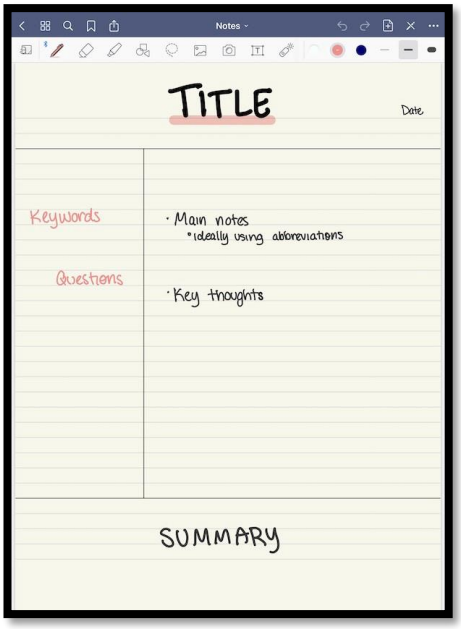


Figure 1 The Cornell Note Taking System. GoodNotes on Medium Copyright.

Some universities provide other guidelines for effective note taking and encourage university students to make use of this technique as part of students´ practices in education (Cornell University, n.d.; Lund University, n.d.; Massachusetts Institute of Technology; University of Gothenburg, n.d.; University of North Caroline at Chapel Hill, n.d). This is a summary of the guideline for effective note taking:

- Write down main ideas of the introduction, conclusion, abstract and other sections in the text.
- Identify different format styles: bold, italic, underline, bullets, different sizes, color, spaces and make notes accordingly with the text.
- Write notes on graphics, tables, concepts, formulas, facts, and processes mentioned in the text.
- Date your notes and provide headings, it can also include numbering of pages.
- Paraphrase the notes, with exception of for formulas, definitions, and specific facts (i.e. involving dates), which should be recorded exactly as in the text.
- Use quotations, make sure they are well quoted. In case of paraphrasing quotes, give credit to the author.
- Use symbols, shapes, colors, graphs to organize note
- Organize the notes after a lecture or session has concluded. This might be helpful for studying.

There is strong evidence of the use notes and its impact on learning, but more research on students´ social practices in digital note taking might provide insights on how university students are using certain tools to take notes and how it affects their educational practices.

2.2 Academic Reading

Fox & Alexander (2011) defined "Reading as the complex communicative behavior of deriving meaning from presented text". The authors described academic reading as goal oriented (Fox & Alexander, 2011). Sengupta (2002) agreed academic reading is goal oriented, but also discipline-specific assigned as part of academic coursework. According to Lockhart & Soliday (2016) academic reading engages students in studies, and improves students' writing. Students read literature review to support arguments, contrast information and produce new work. This research focuses on how students do highlighting and note taking in academic reading. Thus, to explore students' social practices in preference of texts for its content and digital format. At the end, the type of content students choose to read in academic reading will depend on the field of study (Fox & Alexander, 2011; Sengupta, 2002).

For the digital format in academic reading, Mizrachi (2015) research work students commented that depending on type of text, they would choose print or digital. For instance, larger books were preferably printed, but shorter text such as articles were read digitally. In addition, digital texts could also be printed for student's reading preference. The same research concluded that students did not have a predominant preference for digital texts or print texts. The comparison between print-based text and digital texts also included advantages and disadvantages of both text versions. As advantages, digital texts were considered cheaper, more accessible and portability of higher number of texts but caused eye fatigue, dislike in vertical scrolling and more distraction. On the other hand, paper-based text advantages included tactile sensations, linear progression, less eye fatigue, less distraction,

annotation on papers and the perception of learning more, but the disadvantages included higher cost and weight. Digital texts bring opportunities for highlighting and note taking, for instance PDF and EPUB documents have low cost and easier accessibility (Ji et al., 2014; Leonard et al., 2021; Mizrachi, 2015).

There are digital tools and technological devices for academic reading such as Adobe Reader, Mendeley Reference Management, and Paperly. Research work in social practices with these tools is little and focused mainly on how these tools can support learning. This research aims at identifying what tools university students are using for academic reading, and interestingly in writing and challenges they encounter with technologies.

2.3 Academic Writing

Academic writing at the university level is complex, writing strategies could include combinations of activities such as outlining, drafting, or free writing (Lavelle, 2007). Lavelle (2007) mentioned graduate writers usually synthesise perspectives and extend theories, this academic writing activities require higher-level construction skills and attention to accuracy, voice, and audience. Strunk (2011) suggested academic writing should use principles of composition in such as construction of paragraphs, punctuation and other principles to create quality academic writing in the English language.

University students usually receive support in academic writing. One of the main focused is to help students to organize ideas, paraphrase and avoid plagiarism and self-plagiarism (Cornell University, n.d.; Lund University, n.d.; Massachusetts Institute of Technology; University of Gothenburg, n.d.; University of North Caroline at Chapel Hill, n.d). Academic writing integrates norms that aim at providing credits to the sources and authors. For instance, writing references and proper quotation avoid plagiarism. Plagiarism represents academic dishonesty and can lead to serious consequences for students (Lund University, n.d.; University of Gothenburg, n.d.). Universities' academic writing support provide to students sessions in writing skills and how to avoid plagiarism which can lead to improvement of academic writing (Cornell University, n.d.; Lund University, n.d.; Massachusetts Institute of Technology; University of Gothenburg, n.d.; University of North Caroline at Chapel Hill, n.d).

2.4 Designing tools for academic reading and writing

According to Selwyn (2011) technologies in education require personalization and user participation, this means that technologies should be created and designed paying strong attention to users' needs and interest. Lundin & Svensson (2016) pointed out that technologies in higher education should be user-centered design, mainly because students are active agents in study practices and choose what digital technologies to use for educational purposes. Technological devices such as computers have a significant role in how students learn (Lundin et al., 2010). In Mizrachi's (2015) research, desktop computers and laptops are the main devices for digital reading, followed by phones and tablets.

For Lievrouw and Livingstone's (2002) three interconnected descriptions describe technologies: (1) what technology is itself; design and material, (2) what people do with technologies and (3) the context of use. If we look at technological reader devices such as Kindle or Kobo, the designers have identified their target and needs. Both devices allow digital reading adapting screens similar to print

paper (Amazon, 2021; Kobo, 2021). Reader software such as Adobe Acrobat Reader DC and Mendeley Desktop Reference Management allow highlighting and note taking in digital reading, and include other demands such as portability and sharing of documents (Adobe, 2021; Mendeley, 2020). Schepman et al., (2012) found that software preferences among students is a personal choice but it is clear that they are useful for different purposes in education.

Löwgren & Stolterman (2004) stated "We shape technology, and technology shapes us" (Löwgren & Stolterman, 2004, p142). The authors presented Thoughtful Interaction Design as a design perspective on information technology. The perspective merges knowledge creation and knowledge production to design technologies that aim at providing problem solving solutions for specific users' needs. Thoughtful Interaction Design will be further explain in the theoretical section as design perspective to develop a prototype for academic reading.

Weinschenk (2011) highlighted some characteristics that facilitate digital reading. The author stated that digital reading technologies should start understanding how people read digital texts. For instance, linear reading is more common and reading long lines is faster, but people prefer shorter with pictures. Readers preferred texts divided into chunks, short paragraphs and presence of bullets and pictures. Also, Tahoma and Verdana, larger x-heights are easier fonts to read. White background using black texts is more readable (Weinschenk, 2011). Showing progress in digital reading motivates people to achieve their goal, because readers focus on what is left (Amazon, 2021; Weinschenk, 2011). Readers are used to linear reading and prefer print texts (Keim, 2014; Mizrachi, 2015). But paying attention to the readers preferences, reading technologies could adapt to current demands and provide advantages where the paper is limited.

Some characteristics of reader technologies could include web launching searches, integration of dictionary and modification of fonts and size for reading disability (Coyle, 2008). Reader technologies such as Kobo Libra and Kindle Paperwhite provide additional features such as night mode, translations of words and the timeline progress recommended by Weinschenk (Amazon, 2021; Kobo, 2021). Digital reading can also present challenges, for instance students reported that reading on screen caused eye strain (Mizrachi, 2015). It might be necessary that digital texts provide solutions for eye strain, however not only digital reading causes eye strain, but also looking at screens for longer periods of time for non-academic purposes.

3 Theoretical background and analytical frameworks

This section presents Bloom's Taxonomy and Social Practices theoretical frameworks as supporting theories for this research work. The Social Practices framework will be focused on the use of technologies in higher education by students. Bloom's taxonomy framework was chosen because it relates with the Cognitivism theory, and it presents the cognitive processes with action verbs by which thinkers encounter and work with knowledge (Armstrong, 2010). A considerable amount of literature has been published on note taking and highlighting. These studies focus on how highlighting and note taking intervene in cognitive processes such as understanding concepts, metacognition, construction of knowledge, intrinsic motivations, and discovery (Greeno et al., 1996).

Identifying students' social practices in higher education can help to design technologies to provide support for students (Lundin & Svensson, 2016). Highlighting and note taking are social practices in higher education (Mizrachi, 2015; Oefinger & Peverly, 2020, the University of North Caroline at Chapel Hill, n.d). With the digitalization of books, the traditional highlighting and note taking practices on print text have adapted to digital texts. Much of the current literature on highlighting and note taking pays particular attention to learning. However, there is the necessity of identifying study social practices in digital highlighting and note taking to understand uses in digital tools and design technological tools that facilitate social practices in higher education.

3.1 Theoretical background

3.1.1 Bloom's Taxonomy

This research chose the revised Bloom's taxonomy framework because it relates with Cognitivism Theory and presents the cognitive processes in focusing on how the knowledge is identified and worked by thinkers (Armstrong, 2010; Krathwohl, 2002). These action verbs are: remember, understand, apply, evaluate and create. Highlighting and note taking are techniques that require cognitive processes. The information highlighted and annotated seems to be developed in all levels of Bloom's taxonomy. According to the literature review, university and college students use notes and highlights:

- To recall and recognize (remember level).
- To classify, summarize, compare (understand level)
- To execute work (apply level)
- To differentiate and organize (analyze level).
- To critique (evaluate level).
- To generate, plan, and produce (create level).

This research considered using Bloom's taxonomy because using specific methods might be possible to identify the cognitive process mentioned before. Cognitivism Theory is also a relevant theory for this research. However, this theory focuses on how information is received, organized, stored, and retrieved by the mind (Greeno et al., 1996). The Cognitivism Theory will be mentioned as part of the cognitive processes because of its relation with Bloom's Taxonomy. The main focused will be Bloom's Taxonomy. Hoadley & Van Haneghan (2011) pointed out that the cognitive process in Bloom's Taxonomy emphasized factual recall, development of complex pattern recognition, build knowledge structures that focus on "big ideas," and support metacognitive processes are more likely to generate more durable learning.

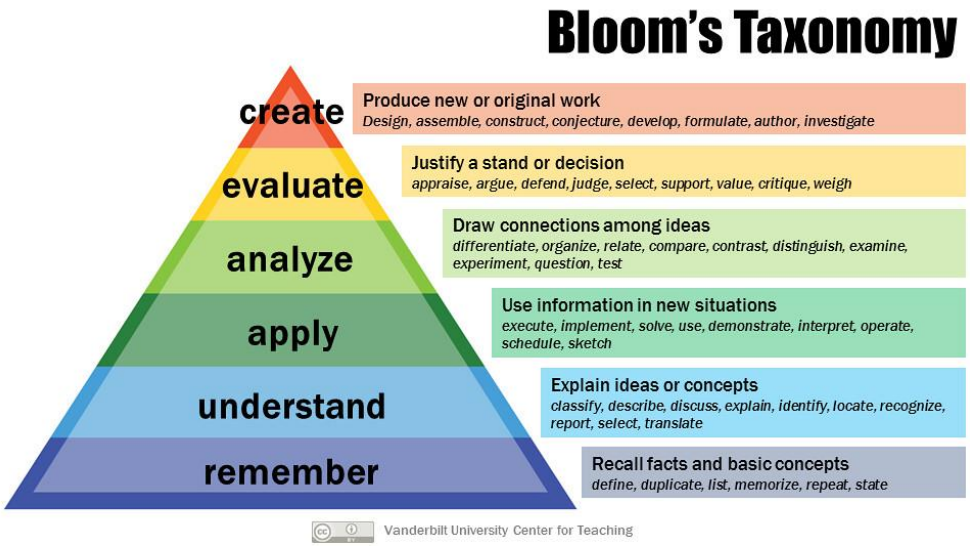


Figure 2 Bloom's taxonomy. Vanderbilt University Center for Teaching.

3.2 Analytical frameworks

3.2.1 Social practices in higher education

Exploring students' social practices in higher education in digital tools could provide insights on educational activities, and even more interestingly/relevant, how they can support learning (Lundin & Svensson, 2016). Also, Heath & Luff (2000) were more interested in using technology in social practices than learning. This implication worked as an understanding of people's social interaction and technologies (Heath & Luff, 2000). As students are active agents in their educational practices and decide what and when to use technologies for educational purposes (Lundin & Svensson, 2016), it could be necessary to explore what software and digital text format students are using to support learning with the use of highlighting and note taking technological tools. Digital highlighting and note taking practices have little investigation in literature and by identifying these practices, the better design of technology for study practices.

Even though highlighting and note taking are individual students' social practices performed for academic motivations (Castelló & Monereo, 2005; Mizrachi, 2015; Oefinger & Peverly, 2020; Seli & Dembo, 2019; the University of North Caroline at Chapel Hill, n.d). Identifying these study practices among students could support the design of technologies for academic reading and writing. Lundin & Svensson (2016) emphasized that technologies should refer to the teacher's perspective and, importantly, students' perspective. In their research, two of these two perspectives are developed in the use of technological tools in higher education. The approach in engaging students in the design of tools could facilitate learning and study practices. Also, technological devices such as laptops have a role in educational practices and social interaction in students (Lindroth & Bergquist, 2010). Lindroth & Bergquist (2010) pointed out that technologies are facilitators of educational practices and should be analyzed as actual practice and digital competence.

3.2.2 Thoughtful Interaction Design

Thoughtful Interaction Design is a design perspective on information technology focused on a user-center approach (Löwgren & Stolterman, 2004; Sharp et al., 2019). Löwgren & Stolterman (2004) stated that digital devices directly impact people's lives, and digital devices can also shape people's lives. For technologies to become useful for students, designers should understand the context of use and how the users, in this case, students, will use the devices. The authors present three abstraction levels of the design process to design technologies: Vision, operative image, and specification (See figure 3). The vision level aims at organizing ideas and principles. The operative image is the externalization of the ideas. It is the bridge between imagination and reality, and one strategy is sketching. The specification level convergences specific solutions and make use of prototypes.

Designers should identify design situations to identify needs and problems. Design situations can be approached in different use-oriented qualities: structural, functional, ethical, and aesthetic. Structural qualities require knowledge of technology and material. Functional qualities require expertise in the use of technologies, ethical qualities require knowledge of values and ideals, and aesthetic qualities demand the ability to compose, putting things together. Norman (2013) mentioned that successful design is assessed when people use and enjoy technologies.

The perspective merges knowledge creation and knowledge production to create technologies prioritizing users' needs. Also, participatory design pointed out legitimate participation in classroom environments to formulate goals for students, communicate the design process and reflections of design (Barendregt et al., 2016). Norman (2013) mentioned that incremental innovation in technologies makes current technologies better. This incremental innovation in reader technologies and reader software for highlighting and note taking could support academic reading and writing more effectively. The designer's role in Thoughtful Interaction Design is to use different methods, have critical thinking, ability to judge, receive feedback, and be active listeners to understand users' needs.

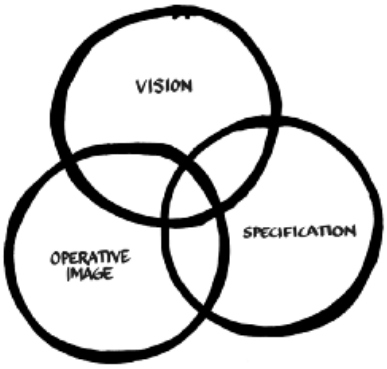


Figure 3 The three abstraction levels of the design process by Löwgren & Stolterman, 2004.

4 Methods

4.1 Data collection

4.1.1 Participants

In total, 23 university students were recruited for this study, 21 students were master students, and 2 were undergraduate students. The students were recruited through my network, employing convenience sampling and snowball sampling (Cohen et al., 2018; Salkind, 2010). In this study, fourteen female and eight male university students participated, 21 out of the total were international students working on their master thesis for their graduation. The students were enrolled in social science and computer science careers in universities in Europe.

The students signed the consent form using Google Forms. The consent form described two inclusion criteria to participate (See appendix). The primary inclusion criterion for the students was to provide a minimum of 5 academic digital documents with highlights and notes and upload those digital texts to individual Google Drive folders shared with my university institutional Gmail account. The secondary inclusion criterion for the participation was a recorded semi-structured interview conducted with all students. The interview included questions about note taking and highlighting and the visualization of a prototype. Both methods could provide further knowledge of the students' relation to using software for academic reading.

4.1.2 Digital documents and visual images of digital documents

This empirical ethnographic research collected highlights and notes made on 149 academic digital papers read by the students. The collection of academic digital texts started by asking students how highlighting and note taking were made on digital documents. Three options were provided in the consent form to collect the academic digital documents with highlights and notes: (1) to upload digital texts, and (2) to upload photographs or screenshots of notes and highlights made by hand on individual shared folders on Google Drive; (3) to share academic digital documents through the preferred reader software, and (4) open option to allow students to describe how to share the digital documents. As the second option could collect information through photographs and screenshots, this option is described in the section called visual images.

4.1.2.1 Digital documents

According to Coffey (2014), documents can help interpret social groups, times, and lives. The collection of digital documents might provide authentic, credible, and valid data as background material to produce and verify oral accounts (Silverman, 2016) and tools that can help understand digital documents and their content and their use and function (Prior, 2008). Thus, the digital documents could generate questions for the interview and correspond with students' responses (Crabtree et al., 2012; Silverman 2016). The description of the type of the digital documents uploaded by the students was the following: 45 PDF documents, 28 Word documents (in the Word documents, information from multiple literature reviews was copied and pasted), one spreadsheet, and one slide presentation. The main reason to ask for five digital documents was to identify if students repeated the same pattern in highlighting and note-taking in all the documents read.

4.1.2.2 Visual images of digital documents

Cohen et al. (2018) pointed out that images provided by participants and brought to an interview can help participants to focus, clarify, illustrate and explain an issue. Also, to judge the importance given to the issue or the personal meaning and significance attached to it (Cohen et al., 2018). Photographs and screenshots of highlighted and annotated academic printed texts were used as background material to generate questions for the interview and as tools to understand the content, the use, and function of the academic digital texts (Prior, 2008). In total, 24 photographs and a screenshot of highlighted and notes from academic texts were collected during the research.

Crabtree et al., 2012 stated images can also be a "vivid exhibition" to promote the researcher's understanding of students' social practices (Crabtree et al., 2012, pg 112). The collection of photographs and screenshots of notes and highlights on printed texts invited the students to remain active during the research and comment on visual images during the interview (Silverman, 2016).

4.1.3 Online Semi-structured Interviews

The online semi-structured interview was held online using Zoom, a video conferencing tool that allowed to record the interviews and screen sharing for the visualization of the digital documents, visual media, and the digital design probe. Synchronous online interviews have the advantage of connecting the interviewer and interviewees that are not necessarily present at the same place and can stimulate the parties' engagement (Cohen et al., 2018; Silverman, 2016). The online interviews recalled the research's aim, introduced the nine semi-structured interview questions, and considered a digital prototype for reader software. The interview was split into two sections. The first section involved questions regarding digital documents, visual media, and semi-structured planned questions. The second section involved the opinions and feedback on a digital prototype for academic software reading.

This research adopted ethnographic semi-structured interviews to identify highlighting and note taking practices on academic digital texts. The initial nine questions were developed using the ethnographic research method, which aims at understanding the practical action and practical reasoning of people's interactions with tools (Crabtree et al., 2012). In addition, initial questions could lead to probing until no further relevant information is provided by students (Sharp et al., 2019). The questions were formulated in the following order: (1) How students do their highlighting and note-taking on academic digital texts, (2) What do they do with the highlights and annotations made on academic digital texts? (3) What time during the day they read academic digital texts? (4) Where do they read academic digital texts? (5) What technological devices do they use to read digital texts? (6) What software do they use to highlight and make annotations? (7) Do they share their notes and highlights? (8) Why do they engage in highlighting and note taking, and (9) do they see any current challenges using software for academic reading. In addition, emerging probes (Beatty & Willis, 2007) and expansive probes (Priede et al., 2014) were used to see and gather further information on highlighting and note taking practices and for producing informed design (Crabtree, 2012).

To organize the online interviews with the 23 students, I created a weekly calendar with Doodle, a digital web tool that allowed students to choose preferred multiple times for the interviews. Before the online interviews, I examined each student's digital documents or visual media to generate questions. The interview could integrate the oral account data with the social practices of highlighting and note-

taking on the digital documents and visual media provided by the students (Crabtree et al., 2012; Coffey, 2014; Silverman 2016). The interviews ran after the month's collection of digital documents. Before the interview, students had a few reminders to upload the documents before the online meetings. The semi-structured interview involved informal communication using respectful language, active listening, and understanding how students perform highlighting and note-taking on academic digital texts (Crabtree., 2012).

4.1.4 Digital prototype

To create the digital prototype, I used the three abstraction levels for the design process by Löwgren & Stolterman (2004). The tree abstraction levels correspond to the vision, operative image, and specification stages that aim at organizing preliminary ideas about solutions, the externalization of the idea through sketches, and the convergence of highlighting and note taking opportunities and solutions for academic digital texts. The three abstraction levels contributed to the creation of one digital picture prototype using Figma Prototyping Software. A picture prototype is a low fidelity design that can be useful in the first stages of designing a product (Sharp et al., 2019).

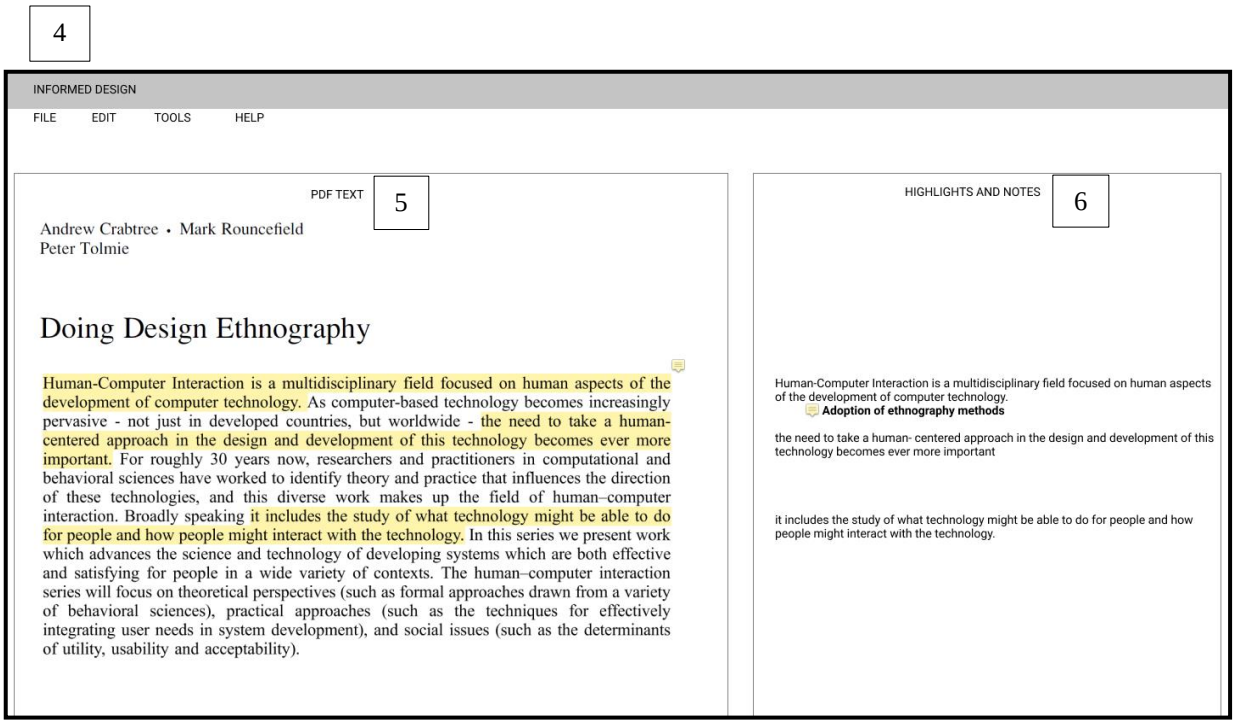


Figure 4 Reading interface for PDF visualization and collection of automatic highlights and notes.
Figure 5 PDF Extract from the book Doing Design Ethnographic by Crabtree et al., 2012.
Figure 6 Automatic copy and paste of highlights and notes made on the PDF.

The digital prototype was showed to all students during the second section of the interview and aimed at probing and collecting students' opinions and feedback (Crabtree, 2012). The prototype was designed during the month of collecting the digital documents. As documents were uploaded regularly, three patterns on student's highlighting and note taking practices on academic digital texts

were identified. The first and second pattern included highlighted texts with digital notes on PDF documents and a third a copy and paste action on Word Processors. The digital prototype was a low-fidelity prototype (Sharp et al., 2019) and enabled the creation and modification of it after feedback received by students (Crabtree, 2012; Razzouk & Shute, 2012). Also, the digital prototype aimed at informing designers what functionalities an academic reader software should offer to the academic field as technological tools.

4.2 Data analysis methods

Firstly, for the analysis of the quantitative data collected from the digital documents and visual images of digital documents were used Research Approach of the Study of Documents by Prior (2008) and Thick Descriptions by Geertz (Cohen et al., 2019; Crabtree, 2012; Geertz, 1973) with Praxeological accounts (Crabtree, 2012).

The Research Approach of the Study of Documents (Prior, 2008) focuses on analyzing documents by the content, use, and function. This approach also aims at recognizing documents as active agents in social life and how the interaction with the documents can provide information of social interaction and the purpose of the content. (Prior, 2008; Silverman, 2011). Therefore, the analysis of the digital documents and visual images of the digital documents can provide information to answer both research questions. The questions propose understanding students' motivations to take notes and highlighting in academic digital texts and how the practices of highlighting and note-taking can produce an informed design. In addition, Thick Descriptions (Cohen et al., 2018; Crabtree, 2012) and Praxeological accounts are included to provide details "instructable observable" for designers (Crabtree, 2012)

Focus on Research Approach	Documents as Resource	Document as topic
Content	Focus on what is “in” the document	Focus on how document content comes into being
Use and Function	Focus on how documents are used by humans and the purpose	How documents function and impact on social interaction and social organization

Table 1 Approaches to the study of documents by Prior (2008).

Secondly, the online semi-structured interview and feedback from the prototype were analyzed using Thematic Analysis by Clarke & Braun (2014). Thematic analysis is an analytical technique that aims to identify, analyze and report patterns in data "theme" in qualitative data (Clarke & Braun, 2014; Cohen et al., 2018; Gareth et al., 2017; Sharp et al., 2019). The key processes for Thematic Analysis included: (1) familiarizing with the dataset, (2) generation of initial codes, (3) Searching of themes, (4) Reviewing themes, (5) Refining Themes (Silverman, 2016). Thus, Thematic Analysis can provide information to answer both research questions, motivations to highlight and make notes in academic digital reading, and social study practices to identify themes for informed design in technological tools for academia.

4.3 Ethical considerations

The study follows the Swedish research council's ethical guidelines (Swedish research council Vetenskapsrådet, 2017) and the collected data was handled and processed according to The General Data Protection Regulation "GDPR" (EU regulation 2016/679). This research adhered to the norms of voluntary participation, anonymity and confidentiality to collect the students' data (Vetenskapsrådet, 2017). Voluntary norm involves willingly given participation. Anonymity involves removing the connection between samples or questionnaire answers to a certain individual. And confidentiality involves the obligation not to convey information given in confidence, it also means the protection against unauthorized persons partaking of the information (Vetenskapsrådet, 2017).

Initially, the consent form stated the data collection methods such as digital documentation and online interviews and the privacy regulations (see Appendix). Crabtree (2012) mentioned, "Informed consent is not only about addressing legal and ethical requirements of data gathering but also, and importantly, of data storage and use" (Crabtree, 2012 p. 94). The consent form informed students: a description and explanation of the purpose of the research, who is conducting the research. A description of the research methods to be used, a description of the types of data to be gathered, and the option to agree or refuse to data types being gathered. A description of the intended uses of the data, a description of the procedures for storage and disposal of the data, including an option to agree or disagree with these procedures. Finally, a statement describing to what extent records will be kept confidential, including a description of who may have access to research records and an option to agree or disagree with these procedures (Crabtree, 2012 p. 94). Documents and video interviews concern interpersonal interaction and produce information about the human condition (Cohen, 2018; Silverman, 2016). Therefore, data will be treated with anonymity and confidentiality.

5 Results and Analysis

This chapter presents the findings of the study obtained via the collection of digital documents, visual images, online semi-structured interviews, and feedback on prototyping. This section also includes informed design as recommendations for reader software focused on digital highlighting and note taking. Also, guidelines for digital highlighting and note taking in academic reading. The findings will be analyzed under Bloom's taxonomy and social practices in education. Also, the findings will be presented using Thematic Analysis.

5.1 Students' social practices in digital highlighting and note taking

5.1.1 Sharing digital texts

Before the collection of digital documents, in the consent form, 65% of students chose to upload highlights and notes from academic digital documents on individual google drives, and 35% of students share digital notes and highlights from academic texts through reader software. However, after analyzing digital documentation uploaded and shared by students, 96% preferred to use google drive to share the highlights and notes in digital documents. On the other hand, only 4% shared through Adobe reader software. One student reported that notes on PDF documents disappeared when required to share the documents with notes with the thesis supervisor on Mendeley Desktop Reference:

> *"It is very confusing and annoying. I do not know why my highlights disappeared when I share the document with groups on Mendeley Desktop Reference. I recently found that if I make highlights in shared groups, they do not disappear" Student 1.*

> *"I use Paperly because it allows me to organize my ideas. Unfortunately, there is no option to share my notes and highlights in the software" Student 2.*

Crabtree (2012) mentioned one of the social practices in the use of technologies is to include the sharing with others functionality. The author suggests asking students with whom they share or using technologies to get insights on motivations in using technologies. In this research, students were asked if they shared their notes and highlights. The findings showed that 50% of students do not share highlights or notes with others. 32% of students mentioned that they would be willing to share highlights and notes if they were asked. Nevertheless, they would warn classmates that personal notes would not make much sense to them. 18% of students mentioned they were more organized in notes and highlights if the assignments required to share notes, ideas, and highlights for group assignments.

> *"I am not sure if my notes would make sense to someone else. They make sense in my brain" Student 3.*

> *"I would be distracted if I get a document with highlights. My attention will be direct to the highlights, and this can disturb my reading. I find share notes to be more helpful if they are on the side of the screen, like comments on Word Docs" Student 4.*

"Only when there are group assignments, I would care more about the organization of notes. Thus, the rest of the group can understand my point of view. I consider using different colors can facilitate the understanding of different points of views" Student 5. (See figure 7)

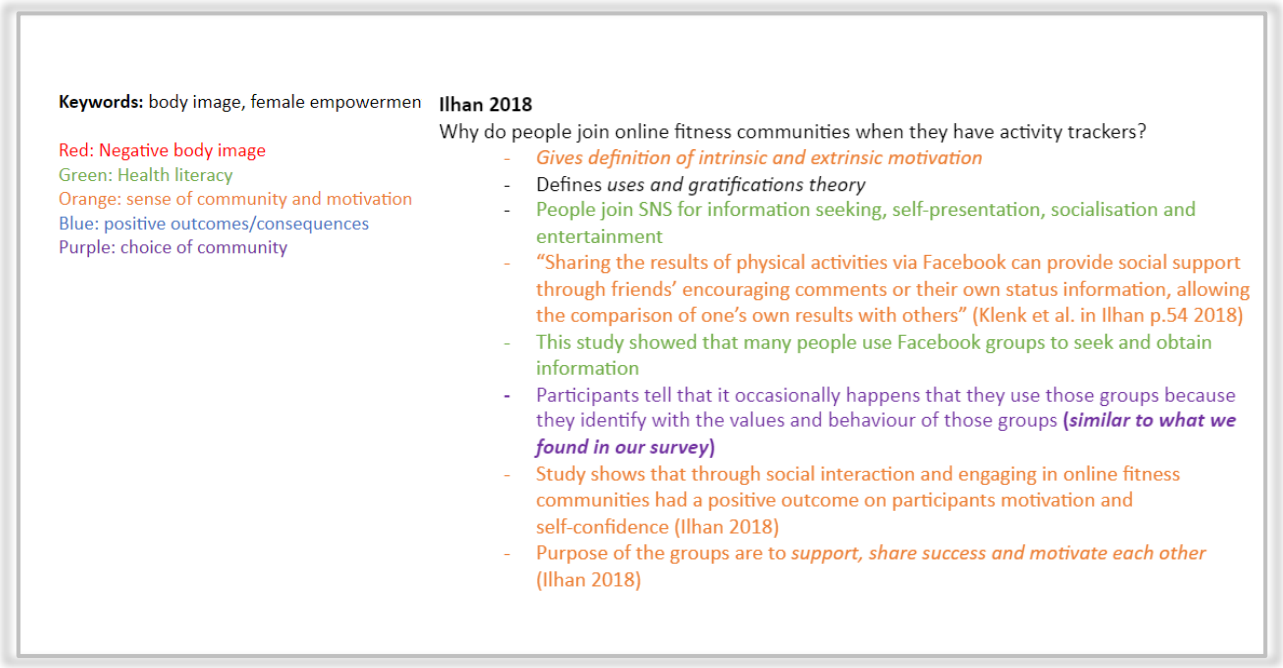


Figure 7 Extract from Motivations to Join Fitness Communities on Facebook,. Ilhan (2018).

Students reported that digital documents were easy to share, but sharing personal notes and highlights is a study practice rarely seen in activities related to higher education. Previous research has found that highlighting and note taking are individual practices (Castelló & Monereo, 2005; Mizrachi, 2015; Oefinger & Peverly, 2020; Seli & Dembo, 2019; the University of North Caroline at Chapel Hill, n.d). Castelló & Monereo (2005) also found that students could share notes with teachers and classmates depending on the assignment. This research shows that notes and highlights can be shared if students are required to do group assignments or students are requested.

5.1.2 Digital highlighting and note taking

This empirical ethnographic research aimed at identifying digital highlighting and note taking practices in university students. The findings might provide insights on how to design and develop applications for academic digital reading. Students said they did not change their study practice in highlighting and note taking techniques to participate in this research during the interview. Students were asked how they perform highlighting and note taking (see graphic): 35% of students mentioned highlighting text on digital documents. 31% of students mentioned using copy and paste as note taking strategy when reading PDF documents. 16% mentioned writing notes on digital documents, and 18% mentioned performing hand note taking. (see Figure 8)

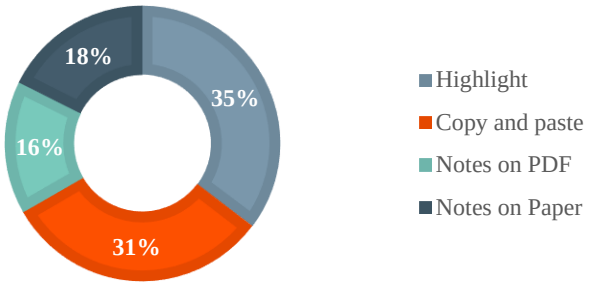
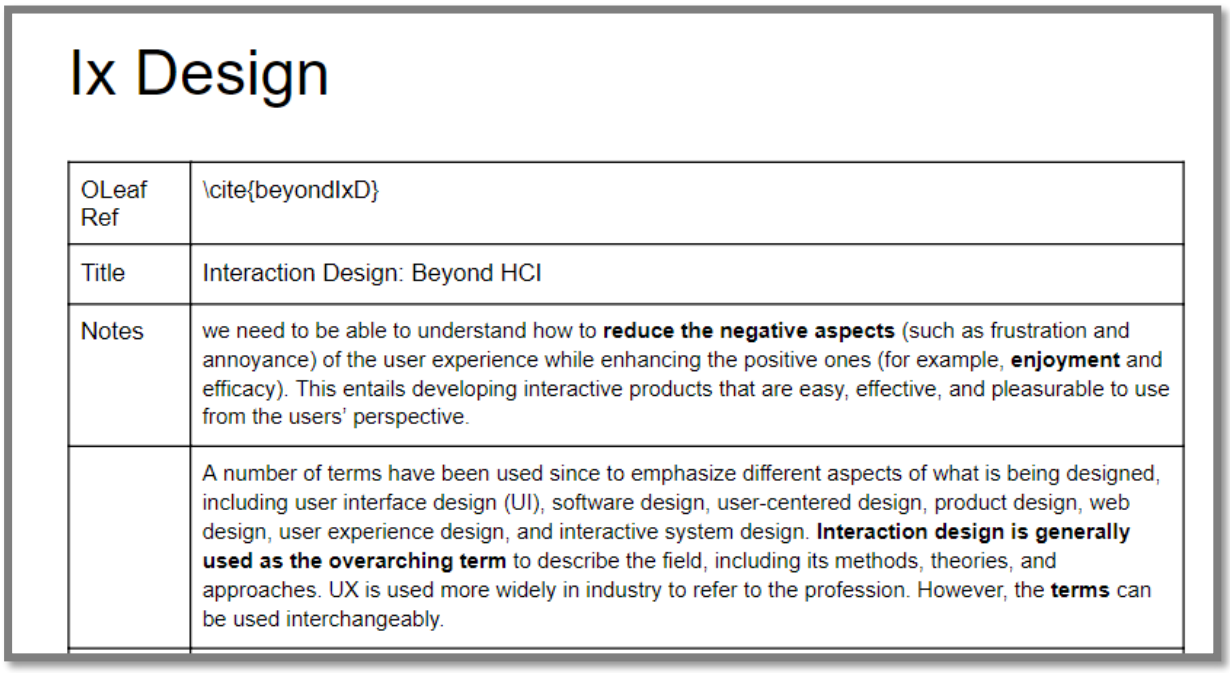


Figure 8 How do university student highlight and take notes on academic digital texts?

> *"The easiest way to make notes is to copy and paste the information from the papers. I use LaTeX and tables to organize the information and share it with my thesis partner. I use bold faces, quotations as reminders on what specific information I should focus in my paper and to citate properly. This can be double work but helps me to organize all the data I gather in literature review" Student 6 (See figure 9)*



lx Design

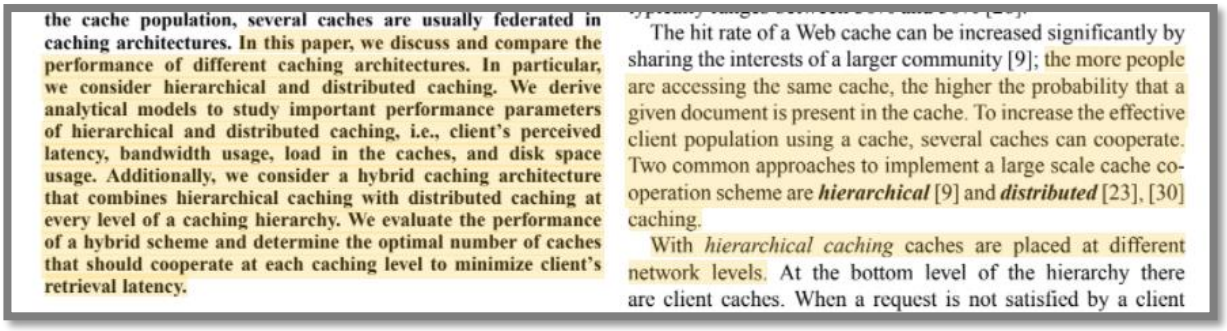
OLeaf Ref	\cite{beyondIxD}
Title	Interaction Design: Beyond HCI
Notes	we need to be able to understand how to **reduce the negative aspects** (such as frustration and annoyance) of the user experience while enhancing the positive ones (for example, **enjoyment** and efficacy). This entails developing interactive products that are easy, effective, and pleasurable to use from the users' perspective.
	A number of terms have been used since to emphasize different aspects of what is being designed, including user interface design (UI), software design, user-centered design, product design, web design, user experience design, and interactive system design. **Interaction design is generally used as the overarching term** to describe the field, including its methods, theories, and approaches. UX is used more widely in industry to refer to the profession. However, the **terms** can be used interchangeably.

Figure 9 LaTeX document, table with notes using boldfaced format.

This research did not find difference between the analysis of shared documents and the information provided by the students in highlighting and note taking practices. Students were conscious of their practices in highlighting and note taking, and the interview helped clarify questions that emerged in digital documentation analysis. For instance, the students copied and pasted text and used boldface format to point out relevant information.

Interestingly, in the analysis, most of the digital highlights are longer and can cover entire paragraphs. Leonard et al. (2021) found the same pattern in a comparison of highlighting between print text and digital texts.

"Highlighting concepts help me to return to the text and focus on what I need to study" Student 3. (see figure 10)



the cache population, several caches are usually federated in caching architectures. In this paper, we discuss and compare the performance of different caching architectures. In particular, we consider hierarchical and distributed caching. We derive analytical models to study important performance parameters of hierarchical and distributed caching, i.e., client's perceived latency, bandwidth usage, load in the caches, and disk space usage. Additionally, we consider a hybrid caching architecture that combines hierarchical caching with distributed caching at every level of a caching hierarchy. We evaluate the performance of a hybrid scheme and determine the optimal number of caches that should cooperate at each caching level to minimize client's retrieval latency.

The hit rate of a Web cache can be increased significantly by sharing the interests of a larger community [9]; the more people are accessing the same cache, the higher the probability that a given document is present in the cache. To increase the effective client population using a cache, several caches can cooperate. Two common approaches to implement a large scale cache co-operation scheme are ***hierarchical*** [9] and ***distributed*** [23], [30] caching.

With *hierarchical caching* caches are placed at different network levels. At the bottom level of the hierarchy there are client caches. When a request is not satisfied by a client

Figure 10 Highlighted text from the document: Analysis of Web Caching Architectures. Pablo et al., 2001.

Then, students were asked what they do with the highlights and notes made from academic digital texts (See graphic). 41% of students said that before writing or studying, they would categorize the notes and highlights. 30% said they use notes and highlights to write directly on word processors. Finally, 29% said they would paraphrase the notes and highlights made from academic papers.

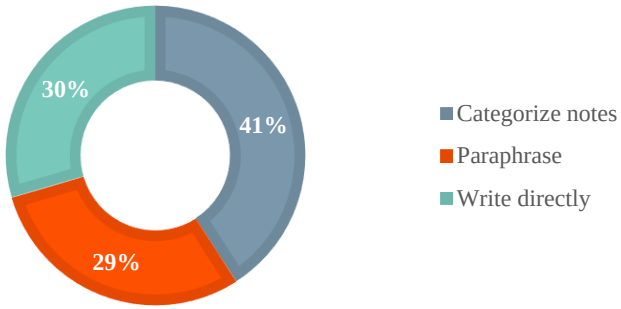


Figure 11 What do students do with the highlights and notes made on academic digital texts?

Word documents allowed the categorization of notes. The categorization of notes included different types of fonts and colors. When students were asked why there were different types of fonts in one document, they reported that the font format came from a PDF document and did not waste time editing it. Different font formats also helped them to remember that the information came from different sources. For instance, the following image shows how the student used references and different styles of fonts to categorize and differentiate the sources.

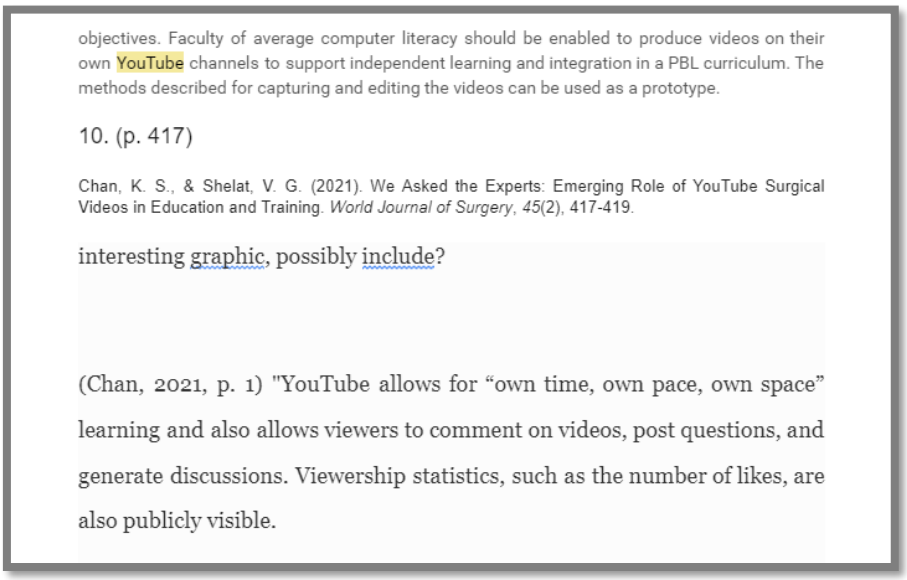


Figure 12 Notes from different literature reviews on Youtube videos and learning.

5.1.3 Technological devices and reader software

5.1.3.1 Technological devices

Students reported that the laptop was the primary technological device for reading academic papers. Larger screens helped to highlight and make annotations. Surprisingly, smartphones were also used for reading academic papers. Nevertheless, its use was for specific situations, such as rereading notes or highlights previously made on computers or laptops. Students reported that technological devices with smaller screens such as smartphones, Ipads/tablets, or e-readers were mostly used for commuting or convenience in portability.

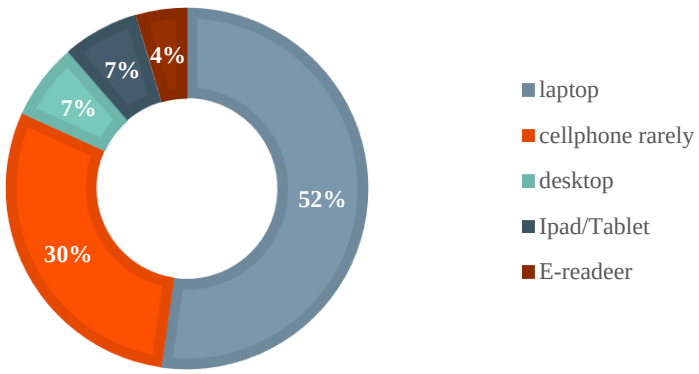


Figure 13 Technological devices for reading digital texts

5.1.3.2 Reader software and document format

35% percent of students used Adobe Acrobat Reader for digital reading. 22% mentioned that they used the default web browser PDF reader. Other digital tools for reading such as Word Docs, Paperly, Mendeley, LaTeX, Zotero, Nvivo, and Kobo e-reader range from 8% to 4%. Students reported using Adobe Acrobat Reader and Web browsers as a default PDF reader. However, both reader software presented several limitations for students, such as locked PDFs. Students mentioned they would prefer to have more colors for highlighting and that selecting texts with the mouse should be specific.

> *"Sometimes PDF documents are locked and do not facilitate copy and paste. I do not understand why PDF documents are blocked if, at the end, I will paraphrase the information" Student 8.*

> *"I would like to have more colors for highlighting. I use a yellow color to highlight text because it is the first color in the reader software. I would prefer to have another first color to highlight texts" Student 9.*

5.1.4 Academic digital reading routines

Ethnographic research focuses on environments and times where technological devices are used (Crabtree, 2012). This research aimed to identify academic reading routines to understand how students set time and environments for academic digital reading. Students reported that home and libraries were the preferred places to read. With 23% of answers, both places were usually quiet and facilitated concentration. Two students were parents and reported that home was not a suitable place for studies. They would prefer to go to libraries to be able to concentrate. 17% of students mentioned that the place to read was not relevant, but it had to be quiet. Other results showed that students would prefer to listen to music while reading 6%, read in a cafeteria 6%, be outside 4%. Also, another 4% said that reading on the bed was not helpful for concentration. Students also reported that the Covid pandemic affected their reading routines.

Students were about the preference of time for reading academic texts. 56% of students reported that daytime was better for reading academic texts, other 31% mentioned nighttime was preferred. 13% of students stated that they did not have a specific time for reading. The results found that the reading schedule depends on individual preferences. However, two parents mentioned that they would use the time where children are in schools to work without distractions.

5.2 Analysis of digital documents and interviews

The Research Approach of the Study of Documents by Prior (2008) supported the analysis of quantitative data of 149 academic texts shared by the students. The digital documents included PDFs, DOCs, pictures, screenshots, spreadsheets, and slide presentations. The following table (See table 2) describes what content students extract to make notes and what content they highlight from the academic documents. The table also reports what type of academic sources the students read.

Moreover, the table presents the interaction students have with the academic digital documents and the digital documents' functions in students' social practices.

In the documents' digital documents and visual images, the highlighted content was identified in the introduction, result, discussion, and conclusion sections. The abstract and method section was the least highlighted. The documents students chose to read for university assignments were reports, journals, books, articles, magazine articles. The findings in the analysis of digital documents will be analyzed with the findings of the interview.

In the analysis of digital documentations, students had more alternatives to manage the information from the digital text than print text. For instance, students organized copied and pasted text from different sources in multiple sections. Students created introduction, method, conclusion sections and then pasted the relevant information in each section. Students reported that copying and pasting text meant extra work. However, the copied and pasted text organization helped them review different points of view in the literature review and paraphrase the text. Copied and pasted text allowed students to use different formats, such as boldfaces, italics. Also, copying and pasting tables, graphs or photographs facilitated the analysis of data.

Copy and Paste could be a path to Plagiarism, a dishonesty act in academia, and can lead to serious consequences for students (Lund University, n.d.; the University of Gothenburg, n.d.). None of the students reported having had a plagiarism notice during their studies. The students who mentioned using copy and paste said that this action facilitated using quotes and statements by other authors in their own individual written assignments. Also, copying and pasting references and citations reduced the amount of time in academic writing.

> *"I build tables to create different sections of the text to include different sources. My thesis partner did not like the idea, but he found it helpful to look at the tables and find the original text of the different literature reviews" Student 6.*

On the other hand, 30% of the students who reported writing the highlighted text directly to word processors said that different open tabs used different colors or not in texts to organize their thoughts in their minds and then write their arguments on word processors.

> *"I do not use copy and paste. It takes more time. But I can use it for reference and citation." Student 9.*

The following table show the practices of digital highlighting and note taking.

Content " In the document"	Digital notes	Digital highlights	Use " Interaction of users"	Digital notes	Digital highlights	Function " Purpose"	Digital and handwritten notes & highlights
	• Agreement and disagreement notes written in comments Copy and paste text from digital text to word processors: • Concepts of topics • Theories • Statements by the author (s) • Quotes by authors • Findings of previous research work • Methods used in the research paper read and previous research • Findings produced from the research paper • Citation	• Concepts of topics • Theories • Statements by the author (s) • Quotes by authors • Findings of previous research work • Methods used in the research paper read and previous research • Findings produced from the research paper • Citation		• Note taking on PDF files. • Copy of texts from digital documents to Word Processors. • Use of different fonts, formats (bold face, italics) and colors on word documents • Creation of sections to copy and paste the notes • References are written at the beginning or end of copied text • Screenshots of tables and graphs and pasted on word documents.	• Use of different colors, generally yellow. • Long and short highlighted paragraphs • Keywords highlighted only on PDF files.		• To identify information • To Summarize • To Track of references • For Agreement and disagreement • For Organization
	Handwritten notes	**Handwritten highlights**		**Handwritten notes**	**Handwritten highlights**		
	• Rephrase and paraphrase of information of literature review. • Concepts of topics • Agreement and disagreement notes • Citation	*Same as digital highlights		• Creation of Mind maps • Use of shapes and lines such as circles, arrows, etc.	• Use of different colors, but also pens, pencils, markers. • Short highlighted paragraphs • Keywords highlighted • Underline was also observed as highlighting technique.		

Table 2 Analysis of digital documentation with highlights and notes.

5.3 Cognitive processes in highlighting and note taking practices

The analysis of cognitive processes of digital and handwritten notes and highlights will be analyzed under the Blooms' taxonomy and its action verbs in cognitive processes (Armstrong, 2010). The analysis will start from the pyramid base until the top of the pyramid (see figure 14). Thematic analysis will also support the qualitative data from the interviews and digital documentation.

The following figure describes how highlighting and note taking are presented in the six cognitive processes in Blooms' taxonomy.

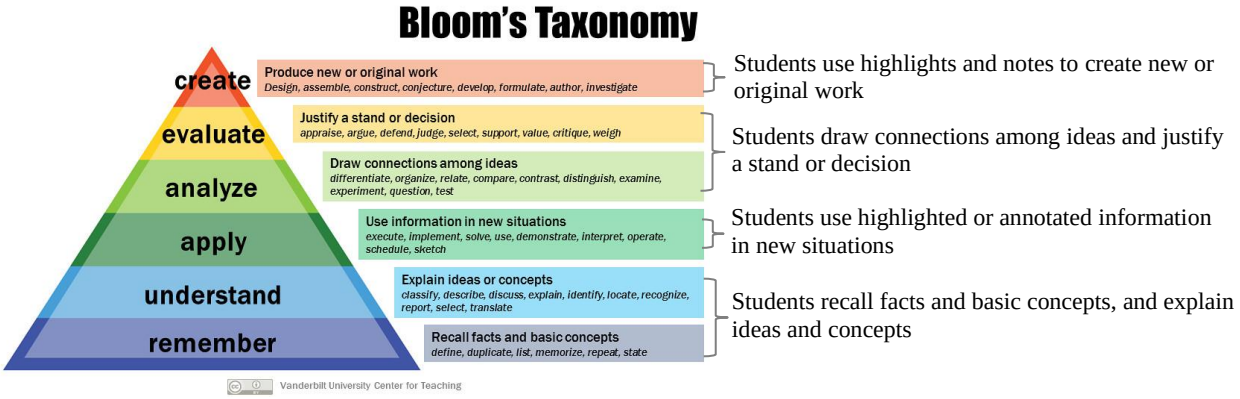


Figure 14 Bloom´s Taxonomy and digital highlighting and digital note taking.

5.3.1 Students recall facts and basic concepts, and explain ideas and concepts

Armstrong (2010) stated that "knowledge is at the basis of these six cognitive processes". Learners can use factual knowledge, which means knowledge and understanding of terminologies, classifications, categories, principles, theories, and others. This research found that students use highlights and notes to remember information: recognize, recall. Also, students were able to understand the information and are able to classify, summarize and explain. During the interview, students reported using highlighting and note taking to find information, identify statements, concepts, ideas, theories, quotes by authors, findings, methods. Some students mentioned that highlighting and notes helped to recall information previously read or heard. Interestingly, the highlighting and annotations on the digital documents showed that students look for specific information such as definitions and concepts to support their literature review in their academic writing assignments.

> *"I highlight concepts, facts, definitions and methodological strategies. I use different colors to connect the highlights and then to write. I do not use notes, I paraphrase" Student 1. (see Figure 15)*


Form of Medical Fake News?' Packer, 2017). What fake news stands for, however, is something larger than the term itself: a fundamental shift in political and public attitudes to what journalism and news represent and how facts and information may be obtained in a digitalized world.

The purpose of this paper is to restructure the existing literature and future research efforts dealing with the phenomenon of 'fake news' at large. We posit that fake news is, in essence, a two-dimensional phenomenon of public communication: there is the *(1) fake news genre*, describing the deliberate creation of pseudojournalistic disinformation, and there is the *(2) fake news label*, describing the political instrumentalization of the term to delegitimize news media. While research

Figure 15 Extract from Fake news as a two-dimensional phenomenon. Jana & Lecheler (2019).

"I prefer notes on paper and I work with graphic organizers. I use graphic organizers to organize the information. This helps me to categorize subjects, topics. I have not explored any tool for note taking, but I would prefer to use rows, shapers and use a digital pen" Student 2. (see Figure 16)

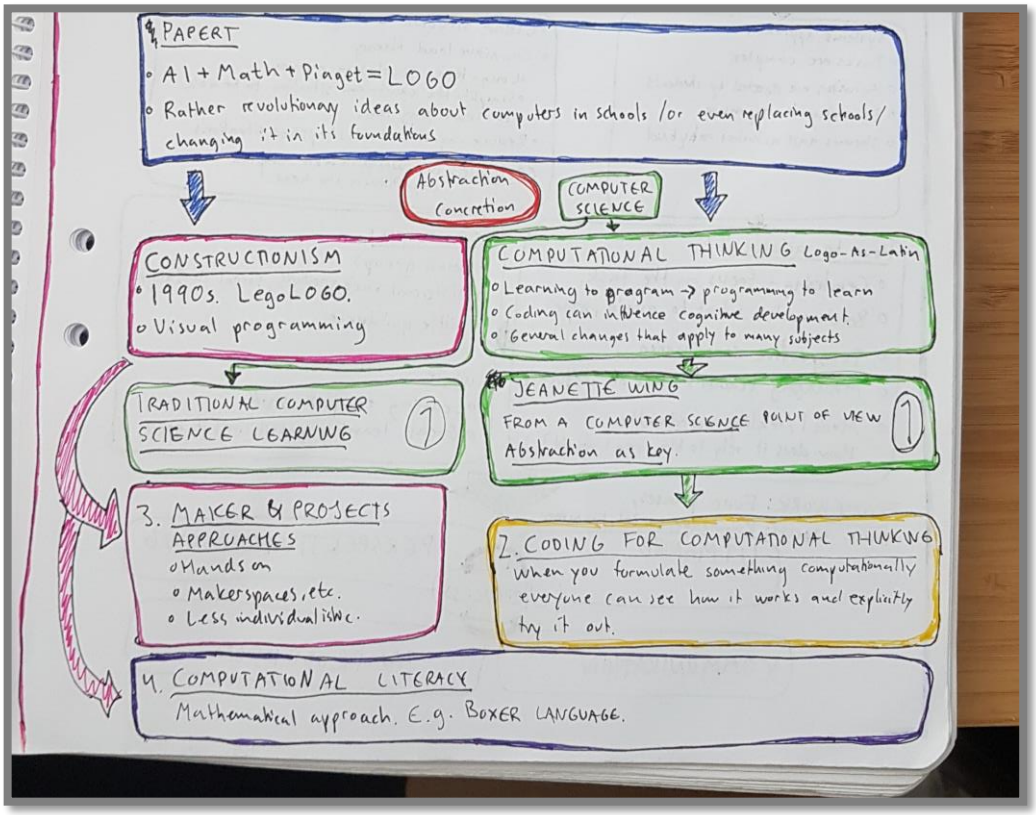


Figure 16 Mind map of Constructionism Learning Theory by Papert (1993).

Students mentioned that taking notes and highlighting texts helped them to recall information for later use. Previous research has found that these techniques help learners to recall information (Mizrachi, 2015; Oefinger & Peverly, 2020; University of North Caroline at Chapel Hill, n.d). In the analysis of documentation, it was possible to observe that students used notes and highlights to summarize ideas and keep track of references.

5.3.2 Students use highlighted or annotated information in new situations

According to Greeno et al. (1996) metacognition is a cognitive process which learners work with strategic knowledge, knowledge about task and self-knowledge. Students mentioned that highlighting or note taking helped them to discuss individual ideas with group members. Also, the selected information either with notes or highlights allowed students to participate in discussions in seminars and lectures. Students mentioned that notes help them to address questions about the content.

"I take notes before the class, so I can make questions… the notes that I take during the lecture can help me to work in new assignments" Student 11.

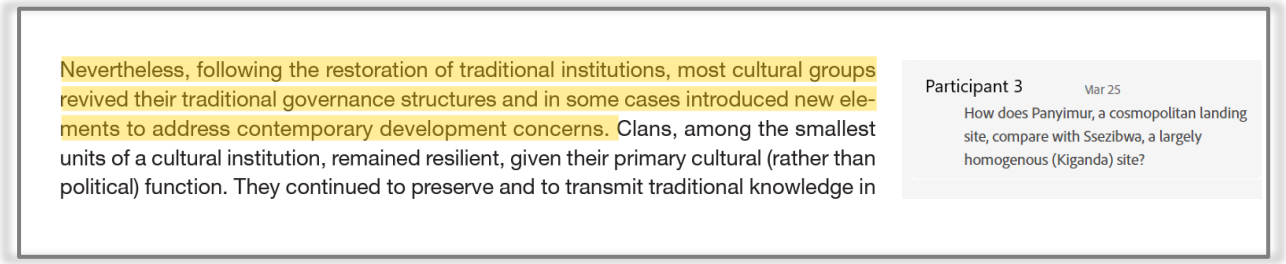
"Highlighting quotes or statements in PDFs, can be helpful to identify information I want to discuss in groups" Student 12.

This research suggests that after students highlight and take notes on information, this can help them to participate in new situations and be active agents of their own learning.

5.3.3 Students draw connections among ideas and justify a stand or decision

Students mentioned that notes and highlights helped them to agree or disagree on statements by authors and question the findings. Also, students used the information highlighted and annotated to build their own arguments. Students that used copy and paste found it easier to organize the ideas. Some students mentioned that dividing the document into sections such as introduction, methods, etc., supported the expansion and contrasts of concepts. The use of different colors and text format supported the organization of concepts and ideas.

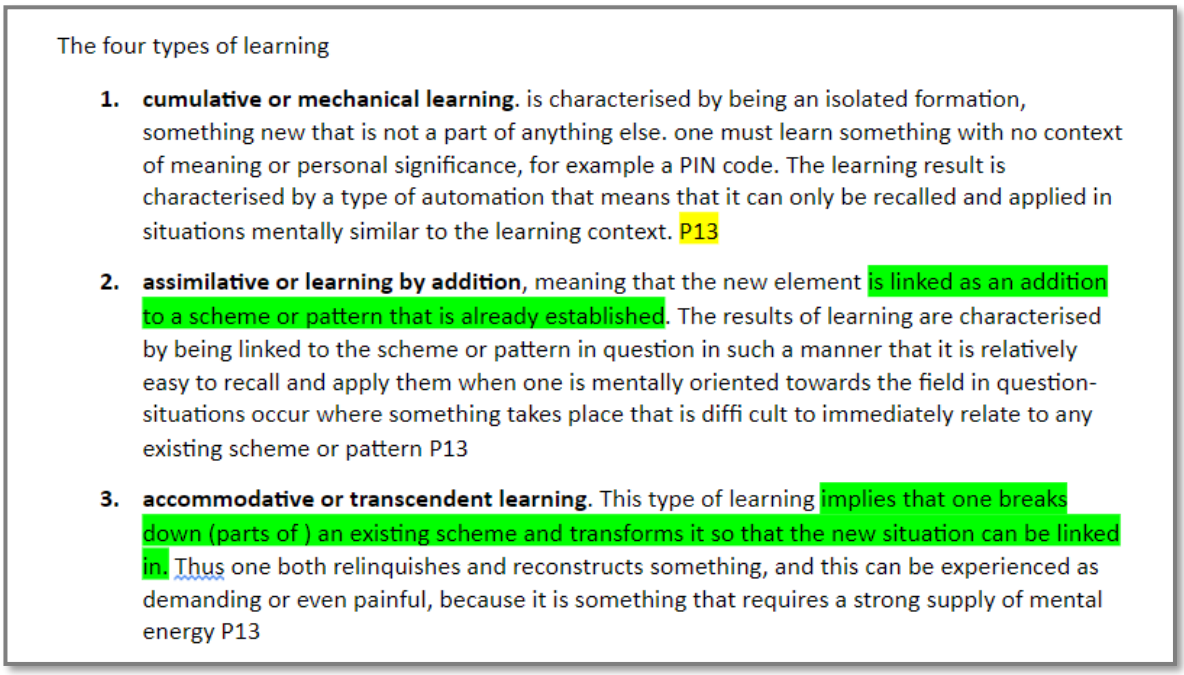
I use Adobe Reader to read PDF, I highlight texts and write notes. My notes can be about questions, but also about agreement and disagreement. I use this tool because I can collaborate with others and share comments" Student 3.


Nevertheless, following the restoration of traditional institutions, most cultural groups revived their traditional governance structures and in some cases introduced new elements to address contemporary development concerns. Clans, among the smallest units of a cultural institution, remained resilient, given their primary cultural (rather than political) function. They continued to preserve and to transmit traditional knowledge in

Participant 3 Mar 25
How does Panyimur, a cosmopolitan landing site, compare with Ssezibwa, a largely homogenous (Kiganda) site?

Figure 17 Extract from Culture and Conservation (Bakels et al., 2016). Students 3

"I copy and paste notes from PDF and use colors to categorize topics. Choosing information helps to build my own arguments. I use the notes to paraphrase" Student 4.


The four types of learning

1. **cumulative or mechanical learning**. is characterised by being an isolated formation, something new that is not a part of anything else. one must learn something with no context of meaning or personal significance, for example a PIN code. The learning result is characterised by a type of automation that means that it can only be recalled and applied in situations mentally similar to the learning context. P13
2. **assimilative or learning by addition**, meaning that the new element is linked as an addition to a scheme or pattern that is already established. The results of learning are characterised by being linked to the scheme or pattern in question in such a manner that it is relatively easy to recall and apply them when one is mentally oriented towards the field in question-situations occur where something takes place that is diffi cult to immediately relate to any existing scheme or pattern P13
3. **accommodative or transcendent learning**. This type of learning implies that one breaks down (parts of) an existing scheme and transforms it so that the new situation can be linked in. Thus one both relinquishes and reconstructs something, and this can be experienced as demanding or even painful, because it is something that requires a strong supply of mental energy P13

Figure 18 Extract texts from literature review. No name or source. Students 10.

5.3.4 Students use highlights and notes to create new or original work

This research found that students use more digital highlighting and note taking than handwritten format. Students mentioned that either highlighting or note taking supported the development of university assignments. Students reported that the main works they needed to write (create) were essays, course papers, thesis work, seminars, reports. Interestingly, students rarely mentioned that notes and highlights helped to learn new information. As this paper focuses in other perspectives of highlighting and note taking, further research work needs to be undertaking to investigate how digital highlights and notes support learning in higher education.

> *"Now that I am writing the thesis, it's overwhelming the amount of data I need to manage. Creating tables has helped me to build the systematic review about online exhibitions and accessibility" Student 12.*

> *"I am planning to write on how politicians influence fake news on Twitter for my thesis work. I have found Paperly organize the highlights and notes. But I need to transition from Mendeley and Paperly to keep track of the content I want to write… this is time consuming" Student 1.*

5.4 Informed Design and Prototype

5.4.1 Informed design for reader software and reader devices

This section aims at providing praxeological accounts to inform design. Praxeological accounts are descriptions to inform designers what functionalities digital tools should include and how the design should be built (Crabtree, 2012). This section will also include digital prototypes to facilitate the observation of the praxeological accounts. In order to build the informed design section, the interview asked students challenges they had in academic digital reading, and also digital highlighting and note taking practices. Most of the students mentioned that current reader software do not keep track of notes and highlights made on PDFs. Also, students mentioned that after using information highlighted or annotated in digital documents, they forget where they saved the documents.

The following list addresses the challenges and suggestions students mentioned regarding digital reading and digital highlighting and note taking. Then, praxeological accounts with prototypes will be developed to provide possible solutions for the challenges in reader software and e-reader devices.

- Use of more digital notes if they had digital pens.
- Make notes with digital pens and be easily transformed to digital format.
- Similar experience of writing notes on paper when making digital notes.
- Creation of shapes, arrows is difficult with the mouse or touchpad on laptops and phones (smartphones).
- The colors for highlighting are too limited.
- Keep track of read and unread documents.
- Copy and paste information is double work.
- Manual references are time wasting.
- PDFs documents sometimes are locked and do not facilitate digital note taking.

- PDFs are not user friendly for highlighting and note taking.
- Manual saving action of notes and highlights in PDF readers.

5.4.1.1 Digital highlighting and note taking experience = handwritten experience

> *"I would like to be able to do the same notes I do on note books on screens, but I also want these notes too in digital format to be able to use them later" Student 12.*

> *"I do notes using a digital pen, but my digital pen is low cost and sometimes I need to repeat the note because the pen does not work in my Lenovo tablet" Student 13.*

Adapting digital highlighting and note taking similar to handwritten experience could be less challenging for students. Nowadays, technologies for digital note taking are expensive and students usually do not have budgets for different gadgets. It seems counterproductive to mentioned that reader software is not the only solution, but a complement of a technological device. This research suggests the following ideas to address the challenges to provide digital note taking and highlighting experience similar to handwritten experience:

- A new type of document file that facilitate copy and paste of highlights and notes. The document should help students to copy and paste the text and be able to change text format. It has been around 25 years that PDF files allowed digital reading. A new type of file could provide solutions to current needs in digital highlighting and note taking.
- A technological device that allows handwritten notes and that include a software to make the transition from notes made by hand to digital format.
- Affordable technologies for students.
- Use of shapes, figures such as arrows to connect the notes with the texts.

5.4.1.2 Keep track of digital notes and highlights

> *"I do not know where are my notes from the first semester, I guess they are in one forgotten folder" Student 10.*

> *"I like how Mendeley keeps track of the read and unread documents. For example, I believe that if the small circle next to the name of document is big, it means that the documents is unopened. Keeping track of read and unread documents would be helpful for me" Student 15.*

> *"Mendeley is helpful to find keywords, but it does not keep track of notes. I also use Paperly to keep track of notes, but the software also has limitations" Student 2.*

This research aims at identifying possible solutions to keep track of digital notes and highlights. This research suggests to build libraries of notes and highlights made on digital documents. The notes and highlights could be automatically saved by categories using keywords or folders. During the research of current tools for highlighting and note taking on Windows computer, Paperly app allowed the organization of notes by keywords and time line. But when the user required to find information using keywords the result only showed the annotated text that included the keyword. Therefore, the reader

software should allow readers to find keywords in the whole library and also only in notes and highlights.

5.4.1.3 Features in reader software

> *"I feel that highlighting in a PDF needs to have other support features that can allow for example one to comment like in Word´s. Another innovation would be to have a feature that provides for few colors such as red to indicate against, green for agreement and yellow for neutral. Student 16.*

> *"The strength of being against, agreement or neutrality should lie in differentiating the three colours in intensity i.e. from light to dark depending on the strength of the issue being highlighted" Student 4.*

Additional features in the reader software should include diversity of colors. The default color should be chosen by the user. Some students reported that used yellow because it was the first color to highlight, but they would use other colors. Current highlighting features are rectangle boxes that cover texts, other type of softer textures could also support new ways of highlighting.

The highlighting and annotation on readers software should allow to follow conversations in group assignments. New technologies in reader software could also allow readers to be able to active and disactivate highlights made by other members in group assignments.

Another feature to support digital highlighting is that once relevant text is highlighted, this should be automatically copied and pasted for further paraphrase in word processors.

5.4.2 Prototype: technologies for digital notes and highlights

5.4.2.1 Gadgets

This research work suggests to design a pen that carries a thin plastic sheet inside of it. Both gadgets are digital tools that complement each other. The reason to choose a pen as suggestions is that pen is a common tool that people are used to carry to write. The plastic sheet will be a thin layer of plastic that can be used in any surface to write and read (see figure 19).

Figure 19 Digital pen with digital sheet screen inside.

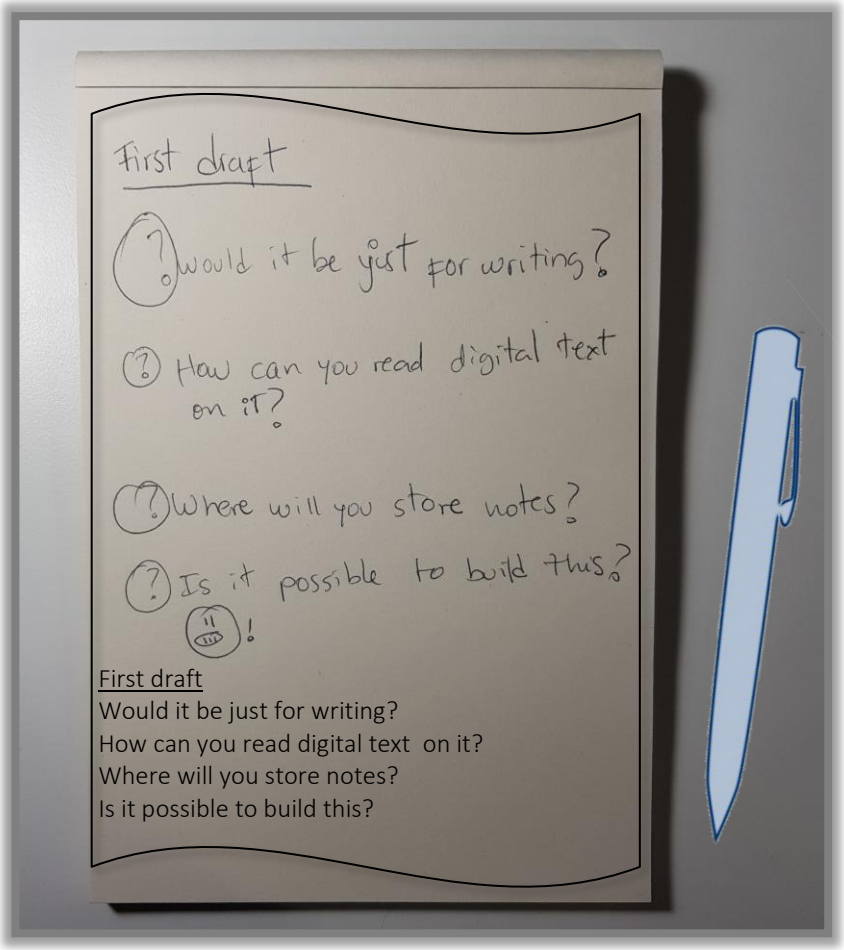


Figure 20 Digital sheet screen on a traditional notebook. Digital pen on the right.

To illustrate, the handwritten notes are automatically transcribed to digital format in the same sheet. The sheet might be a thin screen similar to iPad or Tablet screens. The sheet screen aimed at writing notes and reading digital papers. The portability of the pen will provide comfort to users because the weight will be light and will not use much space. The notes or highlights could be automatically saved in the reader software (see next figure 21). This is the first draft to the gadget. New innovation in screen have been developed during the years. It might be possible to develop this gadget and facilitate digital highlighting and note taking.

5.4.2.2 Reader software

Most of the students mentioned that the prototype of reader software would be really useful for their study practices. Students suggested recommendations to improve the prototype. For example: the use of multiple tabs with different digital documents. The possibility to do the notes and highlights in one document on the right. To be able to hide the screen of notes and highlights. To be able to choose the type of reference they required for writing assignments. Students reported that the features of comments on Word Docs could work well for selecting highlights and have a better interaction with the text. The prototype evolved after the recommendations of the students. Interestingly, two students questioned the default highlighted text and said that they would not find the information relevant. Features such as search box, multiple tabs, coloring should be implemented.

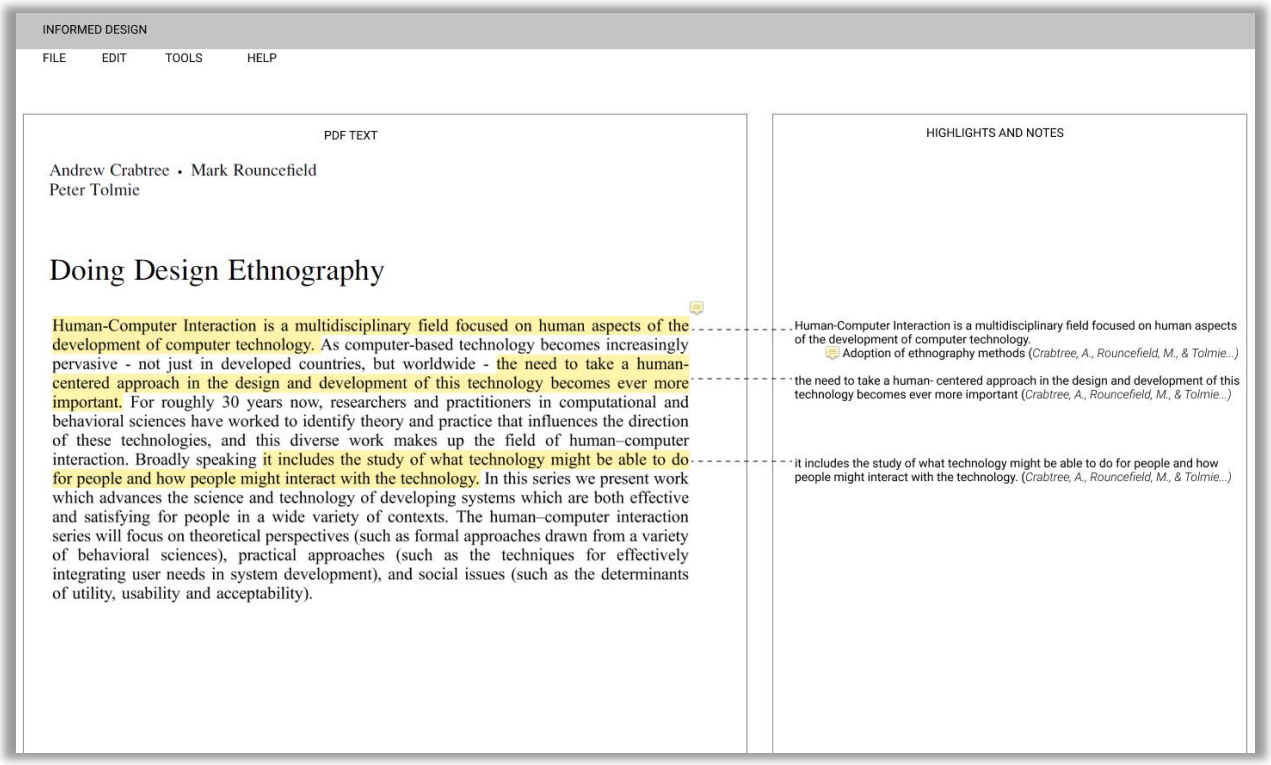


Figure 21 Prototype of reader software

5.5 Guidelines for digital highlighting and note taking

This research work found that digital highlighting and note taking had important uses in academic writing and reading in higher education. Therefore, the following list aims at providing guidelines to college and university assignments in digital highlighting and note taking for current reader software and technologies:

5.5.1 Digital notes:

- Create a DOC file and copy and paste the desired text.
- Copy and paste relevant information: concepts of topics, theories, statements by the author (s), quotes by authors, findings of previous research work, methods used in the research paper read and previous research, findings produced from the research paper, citation or reference.
- Add sections such as introduction, literature review or topics to organize the digital notes
- Use bullets or numbers to organize the information.
- Copy and paste the reference to keep track of the authors.
- Use different formats in the text to point out relevant information. For instance: boldface, italics, and different types of font.
- Add comments on PDF files to point out relevant information
- Importantly, paraphrase the literature review copied and pasted.

5.5.2 Digital highlighting:

- Use multiple colors to differentiate ideas in the text.
- Highlight keywords or relevant information. For instance: concepts of topics, theories, statements by the author (s), quotes by authors, findings of previous research work, methods used in the research paper read and previous research, findings produced from the research paper, citation or reference.
- Keep the highlights short.
- Copy and paste the highlights if desired.
- Use underline options (if available) to differentiate ideas.
- Write comments next to the highlights.

This short guideline might help students to summarize, keep track of references, to organize ideas and build libraries of notes and highlights. The usability of this guideline might be limited to written assignments. Further research needs to be done to identify if digital note taking and highlighting help students to learn new information in the long term.

6 Discussion

This empirical ethnographic research used different methods of data collection and data analysis to provide information based on actual practices of digital highlighting and note taking in higher education. The findings demonstrate that the observation of digital documents using the Research Approach of the Study of Documents, Online Semi-structured interviews, and Probing in digital prototype allowed to explore the digital note taking and highlighting practices in academic digital reading. The theoretical frameworks chose Blooms' taxonomy framework (Armstrong, 2010) aimed at understanding how digital highlighting and note taking intervene in cognitive processes.

6.1 Students' social practices in digital highlighting and note taking

6.1.1 Digital highlighting and note taking

Most of the guidelines and tips from the literature review focused on highlighting and note taking on paper (Cornell University, n.d.; Lund University, n.d.; Massachusetts Institute of Technology; University of Gothenburg, n.d.; University of North Caroline at Chapel Hill, n.d). Universities website pages provide little support for digital highlighting and note taking. Previous research in highlighting and note taking is mainly focused on how to use the techniques to support learning which is important. However, providing guidelines for effective highlighting and note taking using digital texts might help students in study practices. 96% of students in this research read digital texts such as PDFs, DOCs, EPUBs, and content from blogs, websites, etc., to do their university assignments. This means that digital documents were more prominent than print paper, still students did not know how to manage the digital highlighting and note taking in most of the cases.

Interestingly, digital highlighting and note taking are individualized practices both in paper and digitally. This research found three patterns in digital note taking: copy and paste, highlighting on the digital text and use of the highlights to paraphrase the text. Previously, Leonard et al., (2021) observed that highlighting on digital text were longer than highlighting on paper. This paper also found that students highlighted longer paragraphs in digital texts, rather than short paragraphs or keywords. This research found that highlighting is more common on PDF files, and it is rarely seen on DOC files, where copy and paste is more common.

This research did not find any connection between copy and paste of literature review and plagiarism. Students reported to use paraphrase or rephrase techniques to build arguments or new information for written assignments. Students also mentioned that copying and pasting text required more time to work on assignments, but facilitated the selection of relevant information to build paragraphs. The selection of texts included information such as concepts of topics, theories, statements by the author (s), quotes by authors, findings of previous research work, methods used in the research paper read and previous research, findings produced from the research paper, citation or reference. Students created sections and tables to organize the information copied and pasted. As this research did not find any connection between copying and pasting more research work needs to be undertaken to identify reasons that lead to plagiarism in higher education.

The findings in this research in digital highlighting and note taking allowed to provide guidelines for digital highlighting and note taking for current technologies. Also, an image with the guidelines are provided to facilitate the observation of the guidelines. The current digital highlighting and note taking practices seem to be effective for the students in this research work. But many students reported that

they would prefer to have technologies to facilitate not only digital reading but also note taking in digital texts. For instance, students mentioned that they would like to take notes with similar experience as handwritten notes. There are technological devices such as iPads, tablets, e-readers that allow to use digital pens to offer handwriting experiences on screens (Apple; 2021; Lenovo, 2021; Kobo; 2021; Amazon, 2021). Unfortunately, the costs of these screens are high and students usually have limited budgets.

This research work in digital highlighting and note taking can contribute with informed design for digital reading technologies and software. This can lead to incremental innovation, an emphasis put by Norman (2013) in which current technologies can improve the services for digital reading, and to radical innovation where new technologies are implemented. This paper considered that pen and sheet screen gadget are both, incremental and radical innovation. The incremental innovation meant that the pen can facilitate handwritten notes on a sheet screen, and that the notes can be transformed to digital format. The radical innovation suggest that a thin sheet screen is not yet developed for academic reading. Current e-reader technologies are devices that require portability care, require space and are expensive. This research is limited in terms of providing information of the cost of the digital pen and reader software. More research work in how screens are developed to suggest that the reader software or digital pen could be more affordable than current digital technologies. Also, more research in User Experience (UX) Design needs to be developed to apply usability testing and observe how readers might use the digital note taking and highlighting in reader software.

6.1.2 Students' social practices

Students prefer to study in quiet places or used music to concentrate when reading academic texts. Before the pandemic libraries, university campus or home were the preferred places to study. This research found that students read academic text at home, cafeterias and if possible, in open libraries. Also, students adapted spaces to read academic texts at home. Students mentioned they would try to create a space where they could be focused on academic reading. Most of the students said that creating a space for concentration was not complicated, but sometimes they did not have the motivation to read. On the other hand, students who were parents mentioned that they use day time to read because children would be at school, and this meant that the environment to study was quiet.

Social practices in the use of technologies integrate sharing features (Crabtree, 2012). This research found that students did not share highlights or notes with other classmates, unless they were asked to do it. Another motivation to share digital and handwritten highlights and notes were in group assignments. Students who needed to do group assignments and share notes used collaborative tools such as Adobe Acrobat Reader DC, students made sure that their notes were clear for the members of the group. Students also presented challenges in sharing notes, for instance, sharing notes and highlights with the researcher was complicated. In the first place, students who used Mendeley Desktop Reference Management and wanted to share the notes found that moving one document to a group work on the software deleted all the highlights and notes made on the digital document. The student who reported this issue found that creating notes and highlights on digital documents in shared groups kept the highlights and notes to be observed or worked by others. This is interesting because the issue happened in the same platform.

Students who would be willing to share the digital notes and highlights for no group assignments, would recommend the reader to be aware that the notes might not be clear to read or follow. Most of the students copied and pasted information from different sources and organize the structure of the

digital highlights and notes as they consider the notes makes sense for them. The prototype reader software in the results section could help students to be more organized with the copy and paste text and also with the digital highlights. The most common reader software was Adobe Acrobat Reader DC and default PDF readers on web browsers. Most of the students reported challenges with the use of current reader software such as creation of shapes, arrows are difficult with the mouse or touchpad on laptops and phones (smartphones), and the colors for highlighting are too limited. Students also said that keeping track of references and what documents were already read or not was time consuming. Regarding PDF documents, students mentioned that some PDF files were locked and that they needed to transcribe the information on the text to a Word Doc. Also, students said that current digital papers are not user friendly for highlighting and note taking. Automatic saving in highlighting and note taking could also facilitate study techniques in digital texts.

6.2 Digital highlighting & notes and knowledge

The findings in this research pointed out to that students do digital highlight and digital notes of information they understand, agree or disagree. Also, previous research work identified that students highlighted text they understood and agreed or disagreed with (Fowler & Barker; 1974; Gier et al., 2010). In order to observe how students encounter and work with knowledge, this research chose Bloom´s Taxonomy. This theoretical framework presented the cognitive processes in focusing on how the knowledge is identified and worked by thinkers (Armstrong, 2010; Krathwohl, 2002).

This research found that *students recall facts and basic concepts, and explain ideas and concepts*. According to Armstrong (2010) the first and second categories of cognitive process are to remember and understand information. The analysis of documentation using the Research Approach of the Study of Documents by Prior (2008) supported the observation of what information students use and interact with. The analysis of documentations and interviews under Thematic Analysis identifies what information and knowledge students select to do university assignments: concepts of topics, theories, statements by the author (s), quotes by authors, findings of previous research work, methods used in the research paper read and previous research, findings produced from the research paper, citation or reference.

The third category in Bloom´s taxonomy, learners apply knowledge in new situations (Armstrong, 2010). This paper suggests that *students use highlighted or annotated information in new situations*. Most of students mentioned that taking notes (copy and paste), and highlighting on digital academic text helped them to present ideas, opinions and arguments in group assignments. The information selected in notes and highlights seem to engage students with activities they need to do for university assignments. Also, students use digital notes and highlights actively to create new work. Digital highlights and notes seem to engage students with their studies and remain active when working on assignments. Beyond participation of ideas and opinions, digital highlighting and note taking helped students to create new work. *Creation of new and original work* is in the top category of Bloom´s taxonomy and emphasizes on how learners are able to construct knowledge and create new information (Armstrong, 2010). Students in this research reported that during their studies they completed essays, course papers, thesis work, seminars, reports. There is a strong connection between highlighting and note taking for applying knowledge in new situations and creation original or new work.

Digital notes and highlights helped *Students draw connections among ideas and justify a stand or decision.* The fourth and fifth category in Blooms´s Taxonomy focused on how learners use knowledge to make connections and justify a stand or decision (Armstrong; 2010). Students in this research mentioned that digital notes and highlights helped to recall information to agree or disagree on statements by authors and question the findings. The digital annotations also helped to draw connections of topics and were able to build paragraphs that included different points of views. Interestingly, students used the information highlighted and annotated to build their own arguments.

This research has provided new knowledge on digital highlights and digital notes in academic texts. Also, how digital notes and highlight support cognitive process and potentially learning. Identifying the motivations and reasons why students perform digital highlighting and note taking, the easier to develop technologies that can provide solutions to current needs in digital reading tools and technologies.

6.3 Informed Design and Prototype

This paper provided informed design with praxeological accounts and low fidelity prototypes to design technological devices and tools for digital reading. The prototypes also aimed at providing solutions for digital highlighting and note taking practices. In the first place, this research recommends the creation of a new file format in which readers have more possibilities to interact with the text. For instance, to change the font size, type of font and accessibility to use graphs and photographs (with copyright). It was found that highlighting using multiple colors in digital text using one particular software, highlights changed to yellow color in other reader software. The creation of a library of highlights and notes is strongly recommended to keep track of the information in the academic field.

Most of the students mentioned that the reader software would be useful and good for their studies. Students also mentioned that highlighting a text and the text be automatically pasted in word processors would save time. Other features, students provided during the interviews is to attach references to digital highlights and notes. Interestingly, the interview provided more feedback to design the application. Students mentioned that adding an option to hide and unhide the notes would facilitate reading PDF files. Other features to include could be: add bullet points, add more colors with levels of intensity, be able to write by hand, use of shapes and arrows. Syncing digital notes and highlights in multiple devices and automatic saving of highlights and notes were also recommended. The size screen is an additional point to take into account the division of the screen between the PDF view and digital highlights and notes.

The design of the reader software or reader technological device should use participatory design. Participatory design pointed to include the students to design and create the technologies (Barendregt et al., 2016). Also, Design Thinking method could be suitable to find further challenges in digital note taking and highlighting and digital academic reading. This research used Thoughtful interaction design as starting point of the designs of reader software and reader technologies. The role of the designer for creating or improving digital tools in education should be: to be good listeners and readers, to be open to give and receive feedback. Also, the role of the designer is to challenge assumptions and beliefs in academic digital reading and highlighting and note taking.

6.4 Limitations and further research

The strength of the present work is primarily related to ethnographic empirical research (Crabtree, 2012) and The Research Approach of the Study of Documents (Prior, 2008). The findings provided information on digital highlighting and note taking practices. Also, this research provided guidelines for digital note taking and highlighting using current technologies for academic reading. The participation of university students provided information of social practices in digital highlighting and note taking. The first limitation of this research work included the students from medicine field were not recruit to participate. The population was university students in Europe. Digital note taking and highlighting could vary depending on the regions or countries. this research only included undergraduate and graduate students and not included Ph. D students and university professors. Ph. D students and professors also read a big amount of academic text (digital and print text). This paper recommends to include teachers in the design process of reader software or reader technologies.

A second limitation of this research it was not possible to identify how digital highlighting and note taking could support students learning. Bloom´s taxonomy was chosen to identify how students work with knowledge (Armstrong, 2010). In order to assess learning, more research work using Cognitivism theory and other relevant theories should be applied to identify the scope of digital highlighting and note taking and learning.

There is a big concern in plagiarism in higher education (Cornell University, n.d.; Lund University, n.d.; Massachusetts Institute of Technology; University of Gothenburg, n.d.; University of North Caroline at Chapel Hill, n.d). This research did not find any connection between copy and paste as digital note taking finding in this research with plagiarism. This research suggests to university departments in charge of Language Writing support to provide sessions where students can practice paragraph writing with the use of connectors, conjunctions, transitions, punctuation and others.

One example of further research could include that groups read multiple digital documents and then analyse what content students highlight and take notes. What part of the text is more highlighting and annotated and how students use the information highlighted and annotated to create new information.

7 Conclusion

This research was conducted to understand the social practices of digital highlighting and note taking among university students. The research also aims at providing informed design to help designers to innovate in digital reading and reader software. Two research questions were posed to address this purpose.

RQ1: *How and why do university students use highlighting and note taking techniques in academic digital reading?*

For this research question the findings demonstrate that the observation of digital documents using the Research Approach of the Study of Documents, Online Semi-structured interviews, and Probing in digital prototype allowed to explore the digital note taking and highlighting practices in academic digital reading. The theoretical frameworks chose Blooms' taxonomy framework (Armstrong, 2010). The theory aimed at understanding how digital highlighting and note taking intervene in cognitive processes.

The online semi-structured interviews and feedback on the digital prototype were analyzed under Thematic Analysis by Clarke & Braun (2014). Both methods provided data on motivations to do highlighting and note taking in academic digital text reading among the students. Also, the Research Approach of the Study of Documents by Prior (2008) allowed further probing on motivations and challenges during academic digital reading. This approach intended to understand what might motivate students to use academic texts for their content, use and function. The analysis of the digital documents provided limited information of motivations and practices in digital highlighting and note taking. Therefore, the interview aimed at obtaining more information on digital highlighting and note taking practices.

The results showed that Research Approach of the Study of Documents may be a suitable approach for analysing the highlighting and note taking practices in the academic digital documents and visual images of digital documents (see table 2). The approach might develop the researcher's understanding of the study practices when analysing the documents, but required the intervention of the online semi-structured interview to get specific answers for highlighting and note taking practices observed on the digital documents and images. To describe the informed design, the Praxeological Accounts included descriptions of the documents combined with the feedback from the prototype and challenges on highlighting and note taking on reader software.

The theoretical frameworks aimed at understanding how digital highlighting and note taking intervene in cognitive processes. Blooms' taxonomy framework (Armstrong, 2010) supported the observation of cognitive process using highlighting and note taking study practices. These cognitive processes included the understanding of concepts, metacognition, interaction, discovery and problem solving. Previous research pointed out how highlighting and note taking are techniques that help students to recall information, to support reading comprehension and learning (Heyne et al., 2020; Leonard et al., 2021; Mizrachi, 2015; Oefinger & Peverly, 2020; Schepman et al., 2012; University of North Caroline at Chapel Hill, n.d). The analysis of study social practices in higher education found that highlighting and note taking come from intrinsic motivation. Highlighting and note taking are individual practices that students perform for particular reasons and with the use of the techniques students are more

engaged with digital and non-digital academic texts. Also, students used digital highlighting and note taking to produce new work. Hoadley & Van Haneghan (2011), mentioned that learners develop learning through receiving, storing, and retrieving information. Also, new information is most easily acquired when people can associate it with knowledge they have already learned.

RQ2: *How can highlighting and note taking practices inform design for academic digital reading technologies?*

The findings of this empirical ethnographic research work provided information on highlighting and note taking practices in digital documents that have not been explored before. Moreover, the findings were used as recommendations for the design of functionalities and interface of the reader software and a new file format for digital reading. Two prototypes were suggested to improve digital reading experience. Reader software functionalities could be adapted in the short term. For the digital pen and sheet screen the future is uncertain. This research aimed at providing a simple idea that could facilitate portability and convenience. After the identification of digital highlighting and note taking practices, this research provided guidelines for digital notes and highlights. These tips can be used in the short term with the current technologies for reading academic digital text.

Interestingly, the practices of digital highlighting and note taking were repeated by most of the participants. This means that there are social practices in digital highlighting and annotation. Through the interview, students mentioned challenges with current technologies. Also, students suggested more ideas to include in the prototype for reader software. The idea of the pen was developed in the latest stages of the thesis work. The digital pen might provide students the handwritten experiences in note taking and highlighting. Also, this thesis work challenged the research to think out of the box. Therefore, the idea of the pen.

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Appendix

Questions of the online-semi-structured interview

RQ1: How and why do university students use highlighting and note taking techniques in academic digital reading?

Questions	Suggestions
How do you your note taking and highlighting on academic digital texts? (How)	Do you copy and paste them, Do you highlight them on the text, Do you paraphrase? • - Where they keep their notes? If not what to assume? • In an application • In a notebook • In photos
What do you do with the highlights and notes made on academic digital texts? (What)	Do you highlight on the e texts? Do you take notes on e-texts?
What time during the day do you read academic digital texts? **Where do you read academic digital texts? Locations, places.** (When and where)	Schedule for reading academic texts? Morning, night, afternoon Place?
What technological device do you use to read digital texts? **What software do you use to highlight and make annotations?** (With what)	Desktop computer Laptops iPad/tablets, cell phones, others_____ e-reader --- Adobe Reader Mendeley
Do you share your notes and highlights? (With who)	Friends?
Why do you highlighting and note-taking (Why)	What are the reasons to do highlighting and note-taking on electronic texts

	To recall information for an oral or written assignment • To recall information for an oral or written assignment • To study for an evaluation • More to write What are the assignments you have to do To study for an evaluation More to write

RQ2: How can highlighting and note taking practices inform design for academic digital reading technologies?

What are the challenges university students have when highlighting and note-taking on digital texts?/E-readers

Digital probing using the prototype. What are your opinions about the reader software?

Consent form using Google Forms

Note-taking and Highlighting Software Interface Design for Digital texts

Researcher: Dayane Proaño. IT and Learning master student at the University of Gothenburg
Contact email: gusproada@student.gu.se Personal email: dayaneptoonia@gmail.com
Phone contact (+46) 764445050

*Required

PURPOSE OF THIS EMPIRICAL RESEARCH WORK

I am inviting you to be part of a design research project. This form gives you the information you will need to participate in the research. Please read the form carefully.

The purpose of this study is to understand how and why students make highlights and take notes from academic digital texts. Also, I will investigate your highlighting and note-taking practices when you read digital texts such as PDF, EPUB, DOCX documents. You do not need to change the way you read or study.

Your input is valuable to design an e-reader software interface to help students in academic reading. The interface aims at facilitating highlighting and note-taking in PDF, EPUB, DOCX documents.

INFORMATION I WILL COLLECT

a. Data collection of your highlights and notes. Collection of PDFs, EPUBs, or any other type of digital/electronic text with highlights and notes you have made. Minimum of 5 digital texts, they can be more (From March 11th to April 11th).

b. An interview about your highlighting and note-taking practices in academia. I will also present e-reader design interfaces as part of usability testing to receive your feedback. (From April 12th to 18th, duration 25 minutes)

Note: If you already have digital texts with notes and highlights, these resources can be used as part of the data collection (a)

HOW DO YOU MAKE NOTES AND HIGHLIGHTING FROM DIGITAL TEXTS? *

These options have been mentioned by participants. Add "other" if your highlighting and note-taking practices do not show here.

- [ ] If you collect your notes on paper: there will be a google drive folder connected with your university Gmail account to upload your digital texts with highlights and photographs of your notes.
- [ ] If you collect your highlights and notes on a reader software: there's a high probability that I can get access to them if you add my email to collaborate in the software.
- [ ] If you copy and paste your highlights and notes in word processors. There will be a google drive folder to upload your documents
- [ ] Other:

Next

Never submit passwords through Google Forms.

Note-taking and Highlighting Software Interface Design for Digital texts

*Required

Your participation

PRIVACY

Your electronic texts with notes and highlights and the interview will be anonymous. This means your name and identity will not be linked in the research work to anything you say or do.
If you want to withdraw your consent, both the google drive folder and the interview will be destroyed. After the thesis project is over, you can withdraw my accessibility to the reading software of your preference.

PARTICIPANT'S STATEMENT *

This study has been explained to me. I volunteer to take part in this research. If I have any questions or feel I have been harmed as a result of this research, I can contact the researcher on the front page of this consent form. I accept to participate in this empirical research work. Click the following boxes

- [ ] a. To share a minimum of 5 digital texts with highlights and notes b. For the interview to be recorded and used as part of the design project.

Your name *

Your answer

Your institutional email *

Your answer

Your study programme *

Your answer

Back Submit

Never submit passwords through Google Forms.

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