Paper versus screen: The impact of annotation tools on reading strategies among university students

Su carta o su schermo? L'impatto degli strumenti di annotazione sulle strategie di lettura degli studenti universitari

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ABSTRACT Previous research has shown that many students still prefer reading and annotating academic material in print form rather than on a screen, despite the increasing availability of digital reading material provided by instructors. This study aims to investigate the mediating effect of an Annotation Tool on digital reading as notetaking and underlining can enhance the capacity to understand and memorize digital written material by reducing cognitive load and facilitates comprehension. It involved 112 first-year students of a Master's Degree Course on Educational Technologies. The results confirmed that most students prefer academic texts on paper and that the use of a social annotation tool with digital academic texts can positively change perceptions of digital reading and comprehension. A significant correlation exists between reading others' annotations to summarize concepts, clearer content understanding, and satisfaction with digital academic texts, suggesting improvements for academic teaching practices in digital material provision.

KEYWORDS Digital Reading; Social Annotation Tools; University Students.

SOMMARIO Numerose ricerche hanno dimostrato che molti studenti preferiscono ancora leggere e annotare materiale accademico in formato cartaceo piuttosto che su uno schermo, nonostante la crescente disponibilità di materiale digitale fornito dagli insegnanti. Questo studio mira a indagare l'effetto di mediazione di uno strumento di annotazione nella lettura in digitale: prendere appunti e sottolineare può migliorare la capacità di comprendere e memorizzare materiale riducendo il carico cognitivo e facilitando la comprensione. La ricerca ha coinvolto 112 studenti del primo anno di un Corso di laurea Magistrale all'interno dell'insegnamento di Tecnologie Educative. I risultati hanno confermato che la maggior parte degli studenti preferisce testi accademici su carta e che l'uso di uno strumento di annotazione sociale con testi accademici digitali, può cambiare positivamente la percezione della lettura e della comprensione dei testi sullo schermo. Sono emerse una correlazione significativa tra la lettura delle annotazioni altrui per riassumere concetti, una comprensione più chiara dei contenuti e la soddisfazione per i testi accademici digitali; tali risultati possono essere utili per il miglioramento delle pratiche di insegnamento accademico quando si utilizzano materiali digitali.

PAROLE CHIAVE Lettura Digitale; Strumenti di Annotazione; Studenti Universitari;

1. Theoretical overview

1.1. Reading on screen and reading on paper

Study texts have always played an important role in the university curriculum. Today, many of these texts are provided in digital format. Many past studies has suggested that reading on digital screens can impair comprehension compared to reading on paper (Lenhard et al., 2017; Delgado, 2018), even though more recent meta-analyses have shown mixed results (Clinton, 2019; Li & Yan, 2024).

This activity of reading on a screen is often made difficult by multiple factors: among the most obvious physical ones we can mention for example "computer vision syndrome", which includes eye-strain, dry eyes, headaches, and neck pain (Al Tawil et al., 2020; Mowatt et al., 2018). From a cognitive point of view, texts read on the screen of a PC, Smartphone or Tablet seem to make the process of reading and interpreting the content less effective. Different reading media therefore would seem to possess different physical characteristics that enable different sensorimotor experiences and affect the cognitive processing of the reading text. One of these is the size of the device screen, which is a relevant factor if it is too small and is capable of displaying a few lines of text that are broken between multiple pages: this negatively affects reading comprehension and speed by overloading working memory (Sheen & Luximon, 2021) (Elliott et al., 2020).

It's important to note that the relationship between reading medium and comprehension is complex and can be influenced by various factors. Li & Yan (2024) found that digital reading can be more effective when readers use specific reading strategies or when the digital text provides interactive features. The layout and representation of text on screen can also play a role. Studies have shown that when the on-screen representation of the text is similar to the layout of the text on paper, perceived difficulties are reduced (Mangen et al., 2019).

However, the process of reading and interpreting a text is not only a purely cognitive or visual act of perception but is also multi-sensory physiological (McLaughlin, 2016; Spence, 2020). For example, the physical handling of books constitutes a sensory experience that connects as much on an emotional level as it does on a rational level (Griffiths & Starkey, 2018), also utilizing the nonvisual senses in the reader's experience. Indeed, digital texts to date have not been able to successfully reproduce the sensation associated with haptic contact with the paper or a book (Hou et al., 2017). Many factors contribute to the difficulty in perceiving and comprehending digital text, including how the reader moves through the text itself. For instance, there are two common methods: scrolling and paging. Studies have shown that readers, especially students, tend to have better comprehension when reading page by page rather than scrolling through the pages (Haverkamp et al., 2022). Page structure is important: in print reading, our brain builds a cognitive map of the text, with precise landmarks in the layout; in digital reading, the map becomes dynamic and variable, and easily causes visual landmarks (spatial cues) to be lost, requiring more effort from our working memory (Hou et al., 2017).

Some research confirms that if the on-screen representation of the text is similar or equal to the layout of the text on paper, the perceived difficulties are less (Hou et al., 2017; Porion et al., 2016). Then, if the text contains distractors such as hyperlinks connecting it to other texts, this hinders the reader even more in the construction of the cognitive map, generating disorientation (Payne & Reader, 2006). Generally, therefore, it appears that reading on paper is associated with better comprehension than reading on screen, and the effect size was greater in studies that used longer or more complex texts, as well as in studies that used a within-subjects design, in which participants read the same text in both media (paper and screen). In particular, the effect size is greater when the text is expository (Delgado et al., 2018).

Other authors also suggest how the mode of reading digital content to which we are now accustomed on social networks or the Web has become extremely fast, superficial (Annisette & Lafreniere, 2017) and distracting, now also capable of affecting the reading of all other kinds of digital texts, including those without the potential distractions generated by hypertext links and beyond (DeStefano & LeFevre, 2007). Screen reading is inherently distracting because of frequent multitasking activities. When people read a text on a digital medium they are always connected to the Net anyway and are constantly dealing with external distractions such as social media notifications, email alerts, and pop-ups (Rosen, 2017; Luke & Jensen, 2022) (Mangen et al., 2019) or internal distractions when the decision to switch between tasks can be decided independently, as people feel compelled to constantly check their devices for fear of missing something (Dontre, 2021). According to this cognitive "shallowing" hypothesis, study texts would also be subject to it, requiring more concentration and more careful processing of content (Delgado et al., 2018; Latini et al., 2019).

Other elements may influence reading in a given medium whether digital or print, such as time, the level of difficulty required for reading, motivation, interest, and emotionality aroused by the topic (Kaakinen et al., 2018). The results of an experimental study highlight that printed texts were more likely to activate areas of the brain involved in emotion processing (Venkatraman et al., 2016) while the time available for reading seems to affect comprehension and supports the hypothesis of superficial processing of information on the screen especially under time pressure (Delgado & Salmerón, 2021).

Concerning motivation, there seems to be a strong connection between intrinsic motivation for reading and text comprehension: for example, many college students lack the motivation to read assigned academic texts even though they recognize their importance and are driven rather by extrinsic motivations such as grades and deadlines for completing assignments (Mokhtari et al., 2009; Ihara & Del Principe, 2018). In this sense, the development of intrinsic motivation for academic reading is critical for text comprehension (Andrianatos, 2018; Boakye et al., 2014). Other recent research has explored the role of teacher support and guidance in promoting students' motivation to read academic texts: providing explicit guidance on reading strategies and engaging students in discussions about the text can increase their motivation to read (Muñoz, 2016; Pelletier, 2022).

1.2. Study strategies on print and digital academic texts

Generally, academic texts are considered a difficult read because of the complex content expressed in technical vocabulary and because of the way they are presented, although the overall perceived degree of difficulty might depend on the type of discipline: for example, Pecorari et al. (2012). textbooks are evaluated differently by engineering students and humanities students: the former rated their textbooks negatively for readability but positively for the quality of the content, and the latter found their textbooks very readable but not visually appealing. Digital texts are mostly enjoyed through a device connected to the Net and thus benefit from many affordances: for example, it is easier and more immediate to search for the meaning of specialized terms, which improves the text comprehension process (Wright & Cervetti, 2017).

One element that seems to be crucial to the improved ability to comprehend and memorize texts are the study strategies adopted by students such as note-taking, underlining, or highlighting. Many studies point out that underlining a keyword and adding notes minimize cognitive load and facilitate comprehension of content and its retrieval during the rereading process. However, students highlight texts and annotate much more when reading a printed text than when reading a digital text (Schugar et al., 2011; Goodwin et al., 2020), and this is probably one of the reasons why college students seem to prefer read-

ing academic texts in paper format (Baron et al., 2017) precisely because they can use highlighting and note-taking more easily on paper (Mizrachi et al., 2018). This is because the corresponding digital marking/noting activity on screen is perceived as manually more difficult and more time-consuming than the action of annotating or highlighting with highlighters or pens/pencils directly on the paper text. Not surprisingly in this context, memory retention is significantly higher among students who take notes by hand than among those who take notes directly on their notebooks or tablets (Smoker et al., 2009).

In the university context, materials provided in digital format are often used by faculty precisely to support active teaching strategies, for example by making it easier for students to then find/copy parts of the text to discuss and reflect on by reporting them in specific Forums (Foasberg, 2014). However, Forums have acknowledged cognitive criticalities: for example, the threads certainly allow sufficient space to generate long and articulate comments, but they are often rich in digressions and thus constitute a potential obstacle to students' ability to gain an in-depth understanding of texts. In addition, the chronological and topological/hierarchical organization of posts in very long threads causes a dispersion of attention due to the difficulty in maintaining focus on the most important topics (Sun & Gao, 2017). The traditional forum does not make it easy to visually manage the discussion structure and relationships between posts in different threads (Wise et al. 2013; Marbouti & Wise, 2016).

1.3. The Social Annotation Tools

Annotation software is often used to try to solve these difficulties. The interface of such software offers the possibility of highlighting individual words or phrases in the document and displaying in adjacent space discussions constrained to those specific parts of the text, thus overcoming the cognitive overload typical of traditional Forums (Chen et al., 2014). Here the social and collaborative component is very important since annotation and highlighting have a significantly greater impact on text comprehension when conducted together with others and not alone (Johnson et al., 2010).

The use of annotation tools also has critical issues, such as when cognitive overload is created due to a large number of comments fixed on a single part of a text or perceived limitations if there are possible constraints on the number of comment lines that can be inserted. Finally, one may experience visual/cognitive fatigue due to the effort of interpreting text when it is marked with very strong colors and/or by underlining. It should be said that these collaborative annotation tools are not to be considered as a better alternative to traditional Forums, but rather as the most appropriate tool for interactive activities that teachers can use to stimulate students to critically read and comment on study texts in digital format. The combination of reading strategies and interactive functions provided by this tools may positively moderate the understanding effect of digital reading (Li & Yan, 2024). This aligns with our findings on the positive effects of social annotation tools, which will be discussed in detail in the results section. This explorative research aims to verify the results of similar studies and in particular to understand whether the use of collaborative annotation software can change students' perceptions of reading and comprehension of digital texts.

2. The research background, objectives and method

2.1. Research questions

Given the premises set forth in the theoretical part, the research therefore sought to answer the following questions:

1) Which format, print or electronic, do students prefer for reading academic materials provided by faculty during courses?
2) How do different digital media (e.g., desktop, laptop, tablet, smartphone) affect students' perceptions of reading preference?
3) Do students annotate and engage with paper-based academic materials differently compared to digital materials?
4) Can the use of the NowComment social annotation software have a positive impact on students' perceptions of digital reading comprehension, compared to traditional digital reading methods?

2.2. Participants, method and data collection

This study employed an exploratory mixed-methods approach that involved 112 first-year students of a Master's Degree Course (M= 29, F= 83) on Educational Technologies, with an average age of 23.6 years (StDev=2,7). The students came from a university population of predominantly middle-class: this is an important factor that can be a powerful predictor of study skills and text comprehension, even when mediated by digital technologies. All participants either had a predominantly humanistic academic background (Kulo et al., 2014). This orientation is particularly relevant to our study, as this may influence the generalizability of our findings to other types of academic texts, that use images, graphs or formulas, for example.

The study tried to gather both quantitative and qualitative data through a structured questionnaire designed to assess students' perceptions of digital and paper-based reading formats. It included both Likert scale questions and open-ended responses that allowed students to elaborate on their preferences and experiences and give detailed feedback. To provide a deeper understanding of how the NowComment tool influenced learning behaviors, we also tracked and logged detailed interaction data within the software including 1) metrics such as time spent on each page, 2) number of annotations made, 3) types of annotations (e.g., highlighting vs. commenting), and the interaction between students within the tool (e.g., responses to others comments).

Both printed text and digital texts in PDF format were provided during the Course. All texts covered similar topics. There were four digital texts, and they had a total length of 21,000 words with an average length of 5,250 words each, while the printed text was 50,000 words. The four digital texts were entered into NowComment and then opened to student comments. Each student was required to enter at least two comments per digital document for a minimum total of eight comments to be made asynchronously within two months. It was left free to use any device to complete the task (Desktop PC, Tablet, Notebook, Smartphone). Comments required for the social annotation task could be either new comments or feedback on comments already entered by other students. Finally, as specified in the limitation section, it was not possible to have a control group, and this means that while our findings can suggest associations and potential effects, we cannot make strong causal claims.

2.3. Software tool

NowComment was selected as the annotation tool for this experiment due to its straightforward interface and specific functionalities suited for our study goals. NowComment is an online collaborative platform that facilitates discussion and annotation on various formats such as text, Word files, PDFs, images, and videos. This software was selected instead of similar tools like Perusall to avoid

introducing complex variables related to the scoring of student comments: NowComment allows to focus on direct interactions with the text, rather than on peer-to-peer evaluation, which can complicate the analysis of individual comprehension and engagement.

The tool enables users to highlight specific sections of text with different colors—each representing a distinct response type (e.g., red for disagreement, green for agreement, blue for uncertainty), simplifying the process of tracking cognitive and affective reactions to the content. Users can comment directly on the text with a simple click, and these comments become a focal point for further discussion. Importantly, the instructor can control the visibility of comments, delaying their display to manage the flow of discussion and to moderate the influence of dominant voices, thereby minimizing performance anxiety among students and promoting a diversity of perspectives.

2.4. The questionnaire

In an attempt to answer the research questions, a questionnaire adapted from the Academic Reading Format Questionnaire by Mizrachi et al. (2018) was developed and consisted of 26 closed-ended items for which participants were asked to select an answer (or multiple answers) and 4 open-ended questions. A 5-point Likert scale from 1 (strongly disagree) to 5 (strongly agree) was used. At the end of the Course, students were asked to complete the questionnaire only after the exam, which required studying the materials in both formats and completing the annotations on the NowComment site. The questionnaire investigates students' perceptions of their reading preference for academic materials provided by faculty in digital and hard copy formats. Specifically, the questions explored a total of four dimensions:
- the reading format preference and the reasons for it,
- the types of devices most frequently used for digital reading and any physical or cognitive problems that may make reading difficult (i.e., the need to wear glasses/contact lenses),
- the potential distractive effects of reading on screen versus on paper,
- the perceived effect of using NowComment in reading/commenting on digital texts, and concentration and comprehension of specific concepts.

The open-ended questions allowed participants to clarify why they had reading preferences and how using the NowComment social annotation tool changed their perceptions of on-screen reading. Statistical elaborations were then carried out with Jamovi v. 2.3.22 software and text analysis ones with Voyant Tools 2.2.

3. Analysis of results and Discussion

3.1. Reading medium preferences

The following results should be interpreted as preliminary findings due to the exploratory nature of this study; anyway most students (66%) confirm the findings of the literature on the subject and say they prefer reading academic texts on paper, and as many as 55% would like to have the texts in both formats (Tab. 1). If they are provided only digitally as many as 73% say they would still print course materials on paper rather than read them on the screen. The choice also seems to be a function of the length of the digital text: it will definitely be printed if it is longer than 5 pages by 75.9% of students and if longer than 10 pages by 85.8%.

Responses to the corresponding open-ended question asking them to explain why they prefer one format or the other, or both, highlight that students give different answers based on their personal

Table 1. Students' preference for reading academic texts. Likert scale 1=not at all, 5=very much.

	1	2	3	4	5	M	StD
All texts on paper	7.1%	5.4%	21.4%	33.9%	32.1%	3.79	1.17
Texts on screen and on paper	6.3%	18.8%	19.6%	22.3%	33.0%	3.57	1.29

needs and study modes, but still reflect perceived positive/negative affordances for the two formats. Printed academic texts are more convenient to read for extended periods and offer an embodied reading experience, but they can be heavier to carry (if they are books) and more expensive to purchase, while in digital format does not have these problems and allows for utility features such as searching for key terms. The most significant categories of reasons for preference that emerged from the textual analysis of the responses are six. We report them here along with some of the responses:

Readability and accessibility

The majority of participants, as we have seen, are for reading on paper because they find it less tiring especially for their eyes and because they feel they have more control over the content and without being distracted by interruptions that come from online connected Apps. Conversely, others prefer to read on screen because they can enlarge the text, change the background color, and use other accessibility tools to make reading easier.

"*I find it easier to read text on screen because I can adjust the font size or use accessibility features.*"

"*on the screen my eyes get tired more easily.*"

"*Reading a book on paper is more comfortable for me because I can concentrate better on the text without being distracted by notifications.*"

Searching, Selecting, Organizing, and Copying Information

Within this category, digital texts are favored because they allow you to copy and paste the most important parts, quickly search for terms that define important concepts, and easily add links to other content.

"*I prefer the paper format, but the electronic format is more convenient for searching for information.*"

"*In paper documents I can mentally fix concepts better, while those in electronic format make it easier for me to retrieve key words to quickly find a specific concept.*"

"*I work with digital texts when I need to do copy-paste or cut-paste to arrange my notes on the computer.*"

Annotation

Here most preferences for annotations are for paper because it is perceived as an easier and more immediate medium to use. Others prefer digital texts because they can be easily copied and pasted and are always available.

"*I would want both because I would be able to take notes and underline on the paper text, but I would also always have the electronic format available for quick reference at any time.*"

"*I like taking notes and being able to underline, cross out, mark or stick post-it notes on texts when I read and study. Although there are applications that allow you to do this kind of work on the computer for me it will always be better to have a piece of paper at hand.*"

Portability, availability, space

Here most participants find it useful to have a choice between the two formats depending on their preferences and contextual needs at the time.

"*…I find myself far better off studying on paper but sometimes it is convenient to have the materials in digital format so that I always have them at hand.*"

"*electronic texts I can consult and they don't take up space in the bookstore. The paper ones I use to study but then I am forced to give them away because of lack of space*".

"*I would like both to be able to consult the book even from my PC or Smartphone when I don't have the paper book at hand.*"

Translation from/to other languages

Some students pointed out the importance of the digital format when there is a need to read and study materials in a foreign language.

"*The digital format is useful in case there are foreign language texts that can automatically translate with an App.*"

Ecology and sustainability

Students often express environmental concerns but also the desire for a more tangible reading experience.

"*I would prefer the texts to be in electronic format for an ecological issue, but then I would feel the need to summarize the content on paper because it makes it closer to me.*"

"*I prefer the digital format because it reduces environmental impact and paper consumption.*"

3.2. Devices used for digital reading between vision difficulties and portability needs

The responses are interesting in that much research shows how the limited screen size of devices can affect reading difficulty and consequently content learning. The first preference is for reading on Desktops and Notebooks but those for Tablets and Smartphones are also consistent. The fact that many students still use portable devices with small screens for reading academic texts probably indicates that in their life context portability is perceived as more important, or at least equal, to readability. In this sense, students also report using multiple devices for reading: the most frequent combination is Desktop PC & Smartphone (14.3%), followed by Notebook & Tablet (8.9%), and finally Notebook & Smartphone (7.1%).

One unexpected result concerns those with physical vision problems that force them to wear glasses or lenses (Tab. 2), these do not seem to significantly influence students' reading preferences, when asked whether reading on paper is less stressful than reading on a screen, participants with aids such as glasses or lenses answered very or very much at 76 percent, while those without vision problems answered with a higher 84 percent. This difference of almost ten percentage points could be an indication of undiagnosed vision problems in the group not wearing visual aids or also from other factors such as reading habits or type of text.

Table 2. Reading preference on paper in relation to visual problems. Likert scale 1=not at all, 5=very much.

	1	2	3	4	5	M	StD
With Glasses/Lenses	4.5%	4.5%	14.9%	28.4%	47.8%	4.10	1.10
Without Glasses/Lenses	4.4%	4.4%	6.7%	35.6%	48,9%	4.20	1.06

3.3. Distraction, stress and boredom in digital and paper-based reading of academic texts

Responses to questions about the perceived level of stress and boredom associated with reading on screen or on paper (Tab. 3) reveal that nearly 80 percent of students tend to perceive reading on screen as more stressful than reading on paper, while 60 percent perceive it as more boring. In this context, boredom refers to the level of emotional engagement and ability to maintain attention while reading, while stress refers to the level of emotional and physical tension experienced while reading (Weinerman & Kenner, 2016). Regarding boredom, one possible explanation is that screens offer fewer tactile experiences than reading on paper, such as holding a book and flipping through its pages while physically interacting with the text to take notes or highlight important parts. If the text is then perceived as long, other factors come into play related for example to visual stress.

Stress can be generated by distractions from notifications or other online-connected Social Apps that are present in the same device used for reading: these force multitasking actions and thus a feeling of less engagement when reading academic texts (Baron et al., 2017) The feeling of stress can also be felt due to physical effects such as increased visual tension due to prolonged screen fixation (Mowatt et al., 2018). This condition of visual fatigue is generally characterized by prolonged use of digital devices: factors such as brightness, contrast, and possible flicker can contribute greatly to visual stress. In this sense, students' responses on the effects of the length of the text, and thus the time required for reading, are significant: if it exceeds 5 pages, 65 percent of students would like it printed, while if it exceeds 10 pages, the percentage rises to as much as 86 percent.

Significant in this regard is the preference of more than 80% of the participants in re-reading to review academic texts on paper rather than on screen: this behaviour seems to correlate significantly with "ease of memorization on paper" (Pearson r=0.611, p-value <.001) and "more concentration on paper" (Pearson r=0.618, p-value <.001) and could also be due to the length factor as indicated by the correlation index between the "preference to read on paper if the text is greater than 10 pages" and the propensity to "re-read on paper to review" (Pearson r=0.518, p-value <.001).

Table 3. Preference for reading: students' perception of stress, boredom and interruptions reading academic texts on screen and on paper. Likert scale 1=not at all, 5=very much

	1	2	3	4	5	M	StD
Reading on paper is less stressful than on screen	4.5%	4.5%	11.6%	31.3%	48.2%	4.14	1.08
Reading on paper is less boring than on screen	5.4%	8.0%	25.9%	35.7%	25.0%	3.67	1.10
Reading on the screen, I sometimes interrupt myself to surf the Web to understand more on some important point	4.5%	14.3%	43.8%	27.7%	9.8%	2.44	1.18
Reading on the screen, I sometimes interrupt myself to use some App or browse the Web on sites that have nothing to do with the study	28.6%	24.10%	25.9%	17.9%	3.6%	3.24	0.97

3.4. Social Annotation and the facilitation of the comprehension process

During face-to-face classes, 45.1% of students say they use their Notebook to take notes and 54.9% of students on paper. Interestingly note, 23.2% of those who take notes on paper, however, also state that they later report their notes in digital format. While studying academic texts, almost all (92.9%) underline and annotate them if they are in paper format. The question whether the NowComment social annotation tool helped in understanding study texts in digital format had 63.6% positive responses (very much or very much). The question of whether it was easier to focus on important concepts in the digital text on NowComment than in the printed text received a positive response from 78.4% of the participants (very much or very much).

This result was also substantially confirmed by the response to the question of whether using the software made it easier to discuss important concepts than in a traditional forum, with 82.4 percent responding positively. The annotation process involves multiple possible actions for interacting with the text: highlighting, underlining, note-inserting, and note-reading: some students used all of these features, while others used only the last two since many significant passages in the text had already been underlined or highlighted by their peers.

Regarding the perceived effects of using the NowComment software, 61 percent of students claimed to have read all or most of their classmates' annotations, and 62 percent confirmed that the annotations made by others helped a great deal in better understanding concepts and extrapolating the most important ones. Analysis of variance indeed showed a significant positive correlation between responses on the "usefulness of annotations made by others" and "ease in focusing on specific concepts" (Pearson r = 0.589, p-value < 0.05). Tab.5 represents a correlation matrix showing the strength of the association between some variables related to the use of NowComment particularly regarding the feature of inserting annotations.

We can observe that:

1) the ease of focusing on specific concepts compared to reading on paper has a Pearson coefficient r =0.724 (p < 0.001), indicating a strong positive correlation between these two variables. This suggests students find it easier to focus on specific concepts when using annotation software to read digital texts than when reading on paper;

2) the usefulness of other students' digital annotations to better understand a concept has a Pearson coefficient r=0.662 (p < 0.001), indicating a significant positive correlation. Thus, students find it useful to read others' annotations to improve their understanding of concepts;

Table 4. Correlation Matrix of NowComment's Impact on Students' Perception of Textual Understanding and Annotation Enhancement.

	1	2	3
1 Helped me in understanding the texts in digital format	-	-	-
2 Has made it easier to focus on specific concepts than on paper.	r= 0.724 p-value <.001	-	-
3 Digital Annotations from other students have made it easier for me to better understand a concept.	r= 0.554 p-value .007	r= 0.662 p-value <.001	-
4 Digital Annotations from other students have made it easier for me to summarize important concepts	r= 0.551 p-value .008	r= 0.567 p-value .006	r= 0.853 p-value <.001

Notes. * p < .05, ** p < .01, *** p < .000, df=20.

3) the usefulness of other students' annotations to summarize important concepts has a Pearson coefficient of 0.853 (p < 0.001), indicating a strong positive correlation, and this suggests that students find it useful to read others' annotations to summarize concepts and get a clearer view of the content of the text.

In their open-ended responses, many students clarify in this regard that the Social Annotation Tool has helped them greatly in understanding the study materials especially because the comments summarize the important parts and because the NowComment interface allows them to see all the comments visually ordered and in the exact place in the text to which they refer:

"*Reading colleagues' comments is like reading a summary of a text, so it made comprehension more immediate.*"

"*The interaction with peers and the ability to annotate in a more orderly manner seems to me to have facilitated the learning of some concepts.*"

"*One can refer to a specific part of the text in a simple way, as well as comment and discuss with several people while keeping the key concept being discussed firmly in mind.*"

"*Knowing that I had to pertinently comment on the articles with notions learned in the classroom and beyond allowed me to maintain a constant attentional threshold consequently facilitating reading.*"

Few students, however, responded that NowComment did not help them with reading, such as because they have "vision problems and reading on the screen is always difficult" or that the software helped them only partially without specifying why. These findings align with recent meta-analysis results from Li & Yan (2024), which showed that when students use reading strategies or when digital reading devices provide interactive functions, the understanding effect of digital reading can be better than that of paper reading. In our study, the social annotation tool provided both a platform for employing reading strategies (through annotation and summarization) and interactive functions (through peer comments), which may explain its positive impact on perceived comprehension and engagement with the text. This aligns with Li and Yan's finding of significant benefits when these features are present in digital reading.

4. Conclusion

The mixed results in the recent literature on the topic, underscore the complexity of comparing digital and paper reading and highlight the need for further research in this area. Anyway, the results of this study confirm those of most of the literature: the majority of students would like academic texts on paper. Even when they only have access to their digital version, they still prefer to print it, and this seems to be related to the length of the text: the longer it is, the greater the propensity to read it on paper especially if it has to be re-read several times to facilitate memorization of the content (Baron, 2021). These preferences generally reflect their personal needs based on the perceived positive/negative affordances of the two formats, especially regarding readability, accessibility, text searchability and editing, and annotation. Most participants say they read digital texts on large screens, but a significant number also prefer to use portable devices such as Tablets and Smartphones because of their greater portability while admitting that small screens can negatively affect reading and learning of content. However, reading on screen is always perceived as more stressful also because of the "multitasking" distractions generated by notifications or social apps that can reduce concentration while reading on a device that is now always connected online (Liu, 2022).

In this highly paper-oriented context of reading academic texts, the use of a Social Annotation Tool such as NowComment had overall positive effects on students' perceptions of understanding academic

texts in digital format. In particular, one's annotations and especially those made by others, played an important role in the stated ability of focus and attention (Delgado & Salmeron, 2021) especially when it comes to identifying and memorizing concisely the most important concepts and thus facilitating their comprehension. The collaborative dimension and thus the ability to see and intervene in the annotations made by other students is certainly one of the factors that favored enjoyment in screen reading, probably interaction with others is an essential factor affecting the students' reading motivation (Li & Li, 2022).

The results of this research may lead to suggestions for improving academic teaching practices when it is necessary to provide study materials in digital format. Given that screen reading results in higher cognitive loads and inefficient learning strategies (Ackerman & Lauterman, 2012) (Delgado et al., 2018) it would be useful to provide students with the opportunity to read study texts consisting of many pages on paper, and at the same time provide an active reading activity with a Social Annotation Tool in which digital texts broken down in chapters or parts of the academic text not exceeding 10-12 pages (1,500-2,000 words). Students should also be reminded of the importance of limiting or eliminating distractions from Social or Web browsing as much as possible while engaged in on-screen reading. In this way, the benefits of both reading modes can be had while avoiding their criticalities.

5. Study Limitation

While our results are encouraging, they do not allow for definitive causal conclusions about the effectiveness of annotation tools in improving digital reading comprehension: in this explorative research it was not feasible to have both an experimental group using the software and a control group reading the digital texts without the software: this would have allowed for a comparison of perceptions of reading. This will be a focus for future research.

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