

# A Comparison of Paper-Based and Online Annotations in the Workplace

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**Abstract.** While reading documents, people commonly make annotations: they underline or highlight text and write comments in the margin. Making annotations during reading activities has been shown to be an efficient method for aiding understanding and interpretation. In this paper we present a comparison of paper-based and online annotations in the workplace. Online annotations were collected in a laboratory study, making use of the Web-based annotation tool SpreadCrumbs. A field study was out to gather paper-based annotations. The results validate the benefits of Web annotations. A comparison of the online annotations with paper-based annotations provides several insights in user needs for enhanced online annotation tools, from which design guidelines can be drawn.

**Keywords:** Web Annotation, Online Collaboration, e-Learning, User's Behavior, SpreadCrumbs.

## 1 Introduction

Learning has become an integral part of many people's everyday working life. Due to a more knowledge-based society and rapid changes in technology, one often has to search for and read information in order to keep up-to-date. Each individual presents a set of cognitive strategies that involve the learning process: each person learns in her own way, style and pace. At the same time, the character of learning at the workplace has shifted from a solitary, paper-based activity to a Web-based activity, making use of various resources, including discussion forums and social networking sites [1]. As a result, one ends up with a large collection of scattered digital resources; due to limitations of the Web, annotations – if any – are typically made separately (in a word processor or on a paper sheet). By contrast, annotating paper documents is a natural activity that involves direct interaction with the document and that is known to support understanding and memorization [2].

The term *annotation* comprises several methods, including underlining and highlighting text and writing additional comments in the margin. These activities are shown to stimulate critical thinking in a process that can be called *active reading* [3]. All additional writing done by the reader can be considered a variety of annotation, irrespective of its form - formal or informal, implicit or explicit, permanent or

transient - or its function - signaling for future attention, memory aiding, interpretation, memory aiding or even reflections out of the subject.

In order to understand how to better support active reading and annotations in the digital context, we carried out a study to compare how people annotate online with how people create paper-based annotations. Specific attention is given to the type of annotations, their function and perceived difficulties in creating and using these annotations. Before presenting the comparative study, we present some theoretical underpinnings. In section 2 we describe background research on annotations in the learning process – including a categorization of annotation types and a comparison of screen-based reading with paper-based reading. Specifics of annotation in the e-learning context are discussed in section 3. We continue with our comparative study, which consisted of a laboratory study making use of an online annotation tool – SpreadCrumbs – and a field study in which we investigated common annotation habits in the paper-based context. We end this paper with a discussion of the results and their implications.

## 2 Annotations in Learning

In this section we provide an overview on the role of annotations in learning. First we discuss a classification of different forms of annotation. We continue with a categorization of reasons why people annotate while learning. At the end of this section we explore various impediments for the take-up of annotation in the online context.

Based on an extensive field research on textbooks, Marshall [4] categorized the different kinds of annotations by forms and its functions. Below, we will discuss the forms of annotation that are relevant for learning purposes and their functions during the learning process:

- *underlining or highlighting titles and section headings*: this kind of annotation serves as signaling for future attention. Drawing an asterisk near a heading or highlighting it will remind the reader that there is something special about that topic, something to be considered or explored in more detail.
- *highlighting and marking words or phrases and within-text markings*: similar to above, the main goal is signaling for future attention – from themselves or from collaborators. The annotated pieces of text typically carry important and valuable observations. The act of highlighting text also helps in memorizing it.
- *notation in margins or near figures*: any kind of diagrams, formulas and calculations that structure and elaborate the document contents. This type of annotation is specifically meant to serve comprehension. An example is a calculation near an equation or theorem presented in a text, to quickly check its meaning and correctness.
- *notes in the margins or between lines of text*: these descriptive annotations are usually interpretations of the document's contents. These can be phrases in the margin that summarize or comment upon a section or a page. Single

words are typically general terms, keywords and classification of a section. Such annotations help the interpretation of the whole text where the reader better establish the topic of the content of each part of the text creating his own mental structure and decreasing the overall cognitive load.

In all of these cases the value of annotations are for both annotators and future readers. Memory adding, signaling attention, problem working and interpretation annotations definitely benefit the annotator but may also benefit other readers – provided that the annotations are explicit, readable and understandable.

In collaborative group work, students typically work on the same content, but this content is extracted from different resources: for example, they all have their own copies of the obligatory textbook. This is a limitation inherent to paper-based annotations. Even though the annotations are still useful for personal use, they fail to play a role in the communicative and collaborative learning processes, which is a barrier for the leverage of learning by social constructivism [5]. Web 2.0 technologies explicitly facilitate these processes and their benefits on knowledge gathering and construction have been lately discussed [6]. Moreover, by exchange of documents, including annotations, remarks and insights, does not only serve the direct, content-related goals, but also contributes to motivation and enjoyable professional relationships [7].

Despite the many potential benefits of online collaborative environments in comparison with traditional paper-based annotation, there are quite some issues related to migrating reading and annotation to the computer. There is a vast body of research [8, 9, 10, and 11] that discuss the many issues when moving from paper-based reading to screen display reading:

- *tangibility*: in contrast to a text displayed on a computer screen, paper offers physical tangibility. Readers can hold the paper as they like, they can move it around to adjust their perspective and distance [9] – in order to improve legibility [8] and even to facilitate handwriting [12]. Paper is also superior to electronic devices in terms of legibility. Further, while reading one page, readers can use another page for writing notes.
- *orientation*: paper documents give readers a better sense of location within the text, by physical cues, such as the thickness on the sides of a book or different paper materials in a magazine [10]. These cues support text skimming and cross-reading and they are instrumental when trying to relocate some text [13, 14]. Digital documents do not hold these characteristics [8, 10], an issue that needs to be overcome by increased attention for usability in device design and interface design.
- *multiple displays*: paper provides a single canvas for each page of text [15]. Each one holds unique properties of physical tangibility, text content, modifications and additions from the readers. The virtual pages simulate this on the single device screen, but in some cases supporting concurrence reading from several documents turns to be an unwieldy task [10].
- *cooperative interaction*: by circulating a piece of paper, more than one person can interact with the content and build upon each others' annotations [11]. Whereas groupware facilitates simultaneous revisions, versioning and collaboration, it does not yet reach the intuitive interaction as provided by circulating paper-based documents [16].

In addition to these usability issues, there are several technical issues that have been examined [14] to understand the challenge of digital reading. In the context of this paper, we are mainly concerned with the implications for annotations. A major question is whether – given the required progress in terms of technology and interface design – electronic annotations will be used in the same manner as the traditional paper-based annotations. From the above there is evidence that due to inherent differences when moving from the paper-based world to electronic devices, the character of annotations will necessarily change.

Paper-based annotations have been used for centuries and can therefore be considered a highly developed activity, one that represents an important part of reading, writing, and scholarship. Annotation occurs in a wide variety of forms and it is applied for many different purposes. Annotations not only add substance to the text but also implicitly may reveal the reader's engagement with the material [4]. Previous research has verified that no matter the form or purposes of the annotations, the benefits are immediately clear to the future reader [17]. Further, some researchers state that people's needs for making annotations in the Web environment do not differ significantly from their needs in the paper environment [18]. In section 4 we shed some more light on this discrepancy by empirically comparing these situations. Before we continue to this section, we shortly discuss the role of annotations in Web-based interaction and e-learning.

### **3 Web Annotations in e-Learning**

The benefits and opportunities of electronic and automatic annotations, elaborating on their paper-based counterparts, have long long ago envisioned by Vanevar Bush in the Memex [19]. Bush envisaged that by relating all documents that users have read and attaching their annotations to these documents, individuals could organize and re-find information resources in an associative manner, together with any earlier annotations. Whereas the original rich forms of annotations in Hypertext systems – with different categories, directions and even multi-links – allowed for these associative trails, in the Web as it is today this functionality is not totally fulfilled, as readers have limited possibilities for sharing comments or questions by writing back to the pages. As a result, users spend a lot of effort trying to comprehend the different formats of how people comment on-line resources using coping strategies such as sending comments via e-mail [20].

Recent Web 2.0 technologies provide an open resource environment where individuals can freely collaborate. Nevertheless, these technologies typically only cover just a slight portion of the Web or one specific kind of annotation. These technologies are typically implemented as Web servers or browser enhancements.

The basic idea of a Web annotation system is that the user has the ability to change, add or attach any type of content to any online resource, similar as she would do it with a paper document. An application (usually a browser plug-in) enables the user to modify the Web pages, highlight parts of it and add tags or comments, while the back-end of the system just need to check these annotations and associate them with the specific user and the specific URL.

As discussed in the previous section, by actively being involved with the text, users can better memorize and understand it. By contrast, annotating on a computer-screen is an activity that competes with the reading itself, due to the lack of direct manipulation. However, users will do so when the benefits are higher than the costs in terms of effort. These benefits may include the saving of time needed for re-finding, summarizing, organizing, sharing and contributing online annotations. A rather economical view on the balance between the drawbacks and benefits has been given by [21]'s information foraging theory, in which he described the above activities as *information enrichment*.

Today, both companies and academia institutions train learners to complete tasks and solve problems through project-centered learning. Since it may not be feasible for all participants involved in the projects to meet on a regular basis, they must be assisted by information and communication technology. To support this collaboration there are specific methods for Computer Supported Collaborative Learning (CSCL) provided by learning environments and other platforms can be adapted to fit this need. For the best results of the learning process, the methods should help each learner to *act individually* to reach her own goals and to *cooperate* by sharing and discussing ideas to accomplish an assignment.

As discussed in the previous section, in the same way annotations contribute for memory aiding, text interpretation and information re-finding, Web annotations provide the same functionality in the online environment. Web annotations are accessible anytime and anywhere, with diverse sharing possibilities, clearly enhancing workgroup collaboration [22] for cooperative tasks and learning processes. However it is important to remark that the full richness of paper annotations will only be achieved if the digital annotations hold the same beneficial feature of being '*in-context*'. 'In-context' annotations are visible within the original resource, enhancing it with the observations and remarks of the annotator, which are likely to help in individual tasks in similar ways as is the case with paper documents [10].

Despite the limitations in terms of usability and tangibility, advantages of Web annotation tools go far beyond the advantages of regular paper annotations. In addition to the sharing capabilities within online communities, digital annotations can be indexed, ordered, rated and searched. These benefits are confirmed by several studies on annotations tools [e.g. 18], in which participants have remarked that search the annotations is a very desirable feature.

Even though there are currently systems that support annotations, studies have shown that users often resort to different strategies for simulating annotation tools, making use of e-mails and messages to self and separated text documents. The main reason for this phenomenon lies mainly in the necessary effort required for creating and organizing annotations: "*If it takes three clicks to get it down, it's easier to e-mail*" [2]. As users will inevitably resort to other strategies if annotation tools require too much effort, it is necessary to have a lightweight capture tool, with flexible organizational capacity, visibility and practical reminding. In particular if one takes into account that many annotations are primarily meant as temporary storage, or a means for cognitive support or as reminders, it becomes clear that these factors need

to be better taken into account in annotation tools for personal information management and learning systems.

#### 4 A Comparative Study on Paper-Based and Online Annotations

In order to better understand the real use of annotations and Web annotations, we have implemented a straightforward online annotation system, SpreadCrumbs. SpreadCrumbs provides a minimalistic interface for adding post-its notes, crumbs, to any point within a Web page. Crumbs are used as personal reminders, for information re-finding and for collaboration and social navigation support [26]. With SpreadCrumbs, users can add annotations to any Web resource creating a collection of bookmarks, add comments to the resources, visualize the annotations on the page (in-context) and share these annotations. The post-it note contains the author, the other users that can see this annotation, the topic and the comments – as shown in Fig. 1. To add a annotation, the user just has to select the option “Add Crumb” from the right-click context menu. This action will pop-up a window where the user just need to fill the topic and comments. Further, the user can choose some friends from her social network to share this annotation with.



Fig. 1. Annotation with SpreadCrumbs on EC-TEL 2009 Webpage.

Using SpreadCrumbs, we have conducted a number of experiments. In the next section we report a selection of the results, which provide insight in how users create annotations for their personal use and for sharing. This laboratory study is complemented by a field study in which we investigated in which situations users chose to print documents, how they annotate them and whether and how they share

these annotated documents. The main goal of this research is to investigate the types of annotations encountered online and on paper, and to find differences between these two situations. The results of this study are expected to provide insight in differences between these two situations and to provide design guidelines for the design of annotation tools and the way they are used.

#### 4.1 First Study: Annotation on the Web

The experiments with our annotation tool were conducted with 18 participants, who all stated to be very proficient working with computer and internet technology. From those, 16 are working in the field of computer science.

At the beginning of each session, in which only the participant and the experimenter were present, the tool was introduced to the participant by giving a brief overview of the usage of it. Following the introduction, we asked the participants to answer a set of 10 questions by writing down the answer and annotating the resource. These questions were specific information finding tasks that could be solved by a brief internet search with any popular search engine. We ensured that most of the questions were very specific domain questions or numerical in nature to reduce the possibility of the participants to know the answers – an example: “*What is the estimate percentage of Chinese among the population of Brunei?*”. The experiment setup enforced the participant to annotate useful but hard to memorize information for future reference – in fact, in a second round, we will ask the same participants to actually re-find the information by making use of the annotations provided in the first round.

During the experiment, the participants created a total of 207 annotations, covering 81 different Web resources. The average number of words per annotation was 4.1. An important observation was that the participants in general carefully positioned the annotations in the context of the Web page: from the 18 participants using SpreadCrumbs, 16 placed the annotations of each question near the text, table, or paragraph where they found the answers. This type of behavior is not supported by the simple bookmarking functionality of regular browsers.

We noticed that out of the 18 participants who used SpreadCrumbs, only six of them included the answers in the annotations while the majority opted for using keywords of the respective question. Just one participant typed explicit full sentences when annotating the pages: “*There seem to be different walks - I'm not sure whether the 9.4km walk brings us to the top, but I think so.*” ; “*.. made 35 homeruns in 2005. Yes, I think this should be the right answer.*”

Although the participants were very proficient with the computer, all of them stated that they regularly print digital documents for reading, even when these documents are relatively short (up to 8 pages). All of them confirmed that they usually annotate those printed documents in one way or another, by means of highlighting text and adding their own comments or insights in the margin.

This somehow contradicts a very interesting observation during the experiment. One of the answers consisted of a short passage from a book (2 sentences with less than 40 words). However, all of the participants demonstrated laziness when having to write down the quote on paper. All of them asked the same question: “*Do I have to*

*write the whole sentence?*". We allowed them to write down only the reference for the passage (page and paragraph), a suggestion that was followed by all of the participants. The contradiction arises since the participants do not desire to write if they have the option of typing (or copy and paste) still they keep annotating with the pen even though several means of digital annotation exist.

None of the users demonstrated problems regarding the usage of the tool. After the short introduction, all of them performed the tasks of annotating and consulting annotated resources without any effort or mistake. The participants demonstrated enjoyment with the tool interface and functionalities. The direct manipulation and the 'in-context' features were the most appreciated. After having conducted the tasks, the participants were handed over a questionnaire in which they had to choose terms from a list of adjectives gave us a data set of the user perspective over the tool. This questionnaire<sup>1</sup> measures usability and satisfaction with a list of 118 adjectives, positives and negatives. This methodology gives the participants more confidence to be critical to the system choosing negative terms. The top 10 terms chosen were: *Easy to use, Usable, Useful, Collaborative, Helpful, Convenient, Connected, Friendly, Innovative, Straight Forward*. These results show us that the participants would be willing to use such tool on a more regular basis.

**Regular use of SpreadCrumbs.** In addition to the laboratory study, we collected and analyzed log files from users that were not involved in the experiments. The results show some interesting differences that distinguish two behaviors when annotating. Examining 177 shared annotations, we identified an average length of 10.35 words per annotation, whereas from 371 personal annotations we found an average of 4.56 words per annotation. With the permission of the users we extracted some examples of annotations that illustrate these numbers and the difference between the linguistic structures of the notes – see Table 1.

The examples of personal notes show that these private annotations in many cases contain a rather short, cryptic message. These annotations typically just consist of keywords or some sort of reminders for the authors, of which the purpose often is only understandable by the users themselves. It should be noted that these keywords should not be mistaken for tags. While tags have a descriptive nature, these keyword-based annotations carry additional (sometimes implicit) information. By contrast, shared annotations are very explicit and well-described with full meaningful sentences, in form similar to chat or text messages.

**Table 1.** Example of personal and shared Web annotations.

| Personal                            | Shared   |
|-------------------------------------|--|
| "Conference Deadline: October 29"   | "All artists are from Sweden, I think, and do Jazz music (quite soft) but nice..." |
| "Flat 64m 2 rooms windthorststr. 8" | "Let me know if there's anything else to be done."                                 |
| "TO DO!"                            |  |

<sup>1</sup> <http://www.userfocus.co.uk/articles/satisfaction.html>



## 4.2 Second Study: How People Annotate on Paper

To compare annotations in the online context with paper-based annotations, we visited the working place of 22 PhDs students and pos-Docs. We asked each one of them to take a look at the last 3 research papers or articles that they have printed and read. In total we have collected 66 articles, covering a total of 591 pages of text.

We found 1778 annotations and an average of 3.08 annotations per page. The table below shows the average of each type of annotation per page.

**Table 2.** Annotations found by type.

| Annotation types                     |      |       |
|--------------------------------------|------|-------|
| Highlighting/Mark sections headings  | 153  | 8.6%  |
| Highlighting/Mark text               | 1297 | 73%   |
| Problem solving                      | 2    | 0.1%  |
| General notes (Notes in the margins) | 326  | 18.3% |

The far majority of the annotations (73%) involved the highlighting and marking of text. Some participants had the tendency to only highlight main words within a sentence or paragraph. In these cases we counted the collection of highlighted words belonging to a continuous block of text as one piece of annotation.

9% of the documents discussed with the participants turned out to be part of collaborative work in which two or more people were involved. All except two participants reported that they shared their comments via email or some online communication tool; only two participants shared the same sheet of paper, which contained annotations from both parties.

Another valuable observation is that all of the participants who share annotations said that they do annotate in a different (more careful) way when they annotate concerning another reader.

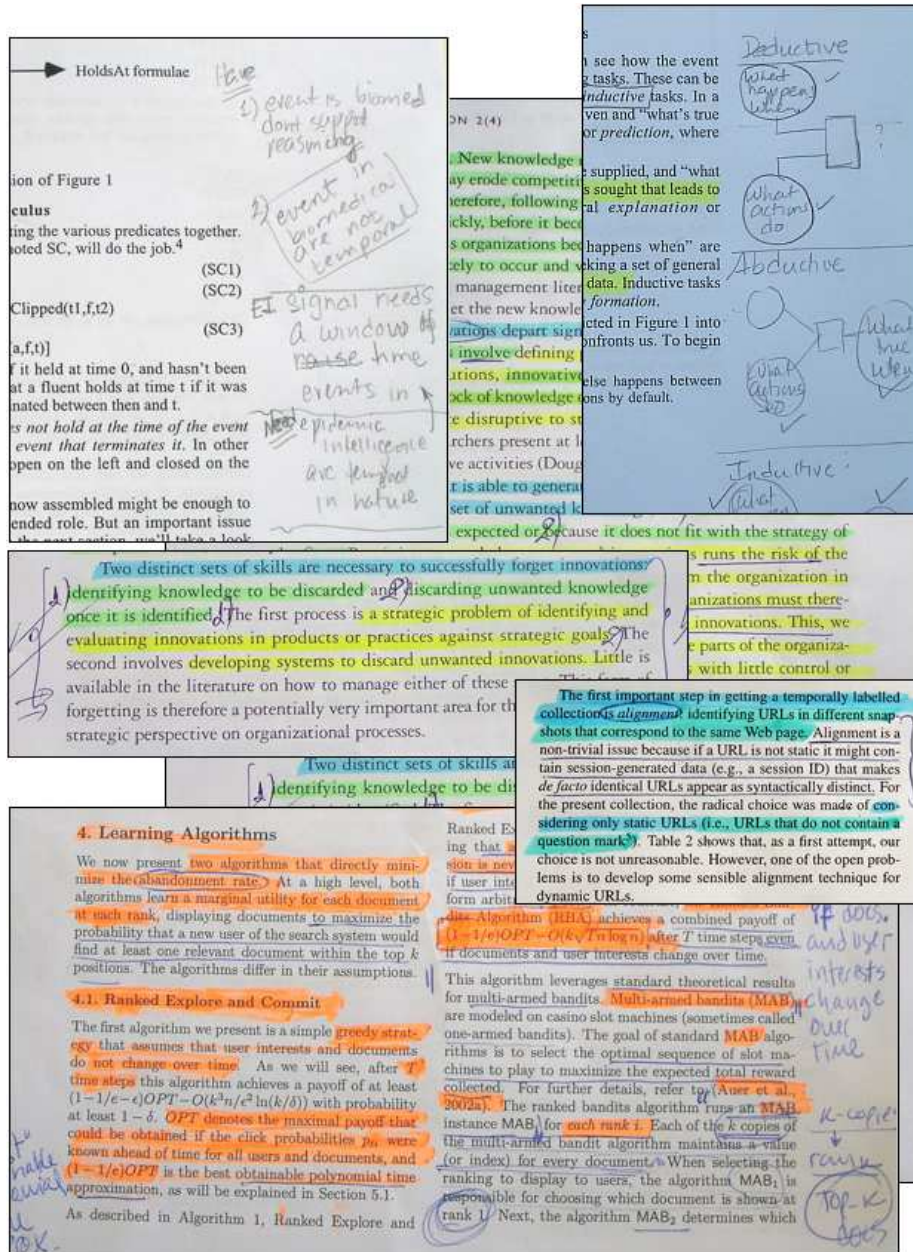


Fig. 2. Examples of annotated papers examined during the field research.

To examine in more detail the annotation strategies, we asked our participants to classify the goal of reading the paper. We distinguished between the following categories: *reading for writing*, *reading for learning*, *reviewing* and *other*. *Reading*

*for writing* is the common activity of reading related articles to extract ideas and references specifically for propose of writing. *Reading for learning* includes the act of getting updated in some particular field, read about new publications or learning some new approaches to apply in some other activity, such as solving math problems or implementing algorithms. *Reviewing* consist exclusively of reading papers to give feedback to the author. Finally, any other type of reading was categorized as *other*. The table below shows some numbers of the field research by the type of reading activity.

**Table 3.** Results by reading goal.

|                                      | Writing | Learning | Review | Other |
|--------------------------------------|---------|----------|--------|-------|
| Articles                             | 31      | 23       | 9      | 3     |
| Articles annotated                   | 28      | 16       | 7      | 3     |
| Annotations/Page                     | 2.36    | 4.7      | 1.11   | 6.3   |
| <b>Annotation types</b>              |         |          |        |       |
| Highlighting/Mark sections headings  | 10.5%   | 7.5%     | 9.4%   | 4.8%  |
| Highlighting/Mark text               | 66.0%   | 82.9%    | 40.6%  | 72.2% |
| Problem solving                      | 0.1%    | -        | 0.9%   | -     |
| General notes (Notes in the margins) | 23.3%   | 9.6%     | 49.1%  | 23.0% |

In addition to comments directly put on paper, three participants also used the technique of attaching annotations to the original document with post-its that were attached to the paper. From the 66 articles analyzed, 10 (15%) did not contain any annotation. One participant that did not have any annotation in any printed paper said that she keeps her annotations in a separated file in her computer for each digital article. Two other participants said that they first do a very quick reading on the computer to check the relevance of the text, and if it is relevant than they print it. In their own words: “*First I read on the computer to see if I really need to print*”. We have noticed that in many cases participants also used different marking colors for highlighting with the purpose of attributing different levels of importance. From the annotations we identified many different ways of signaling important parts on the text. As an example, one participant created her own symbology for annotating: *squares* around the terms means new terminology, *underline* means definitions and *circles* means open question or issues over some topic. Those annotations symbols were used combined with highlighting (importance) and many times they even overlapped. One last interesting observation was the behavior of one of the participants who keeps two printed versions of every paper: one with annotations and one clean print. As stated, the clean print is for a future reading when she may want to get the idea without influence of her previous readings. Although the vast number of highlighting annotations on the papers, none of the participants use such mechanisms that allow persistent highlighting on digital documents or web resources.

In summary of the observations we identified two main clusters of annotations: *relevance adjustment annotations* where implicit highlight and signaling indicate

different levels of importance in the text and *contributive annotations* where explicit readable remarks are added attached to the text.

As a last part of our interviews we asked the subjects to describe how they arrange their papers that lay on their desktops. The relevant categories described were topic, quality, importance, date of reading and task. This simple observation may guide us to design better metaphors of the possible dimensions when trailing online resources.

## 5 Discussion

From the results presented above we can sketch some impressions on some user's behaviors. Apparently, the high amount of highlighting/markings signifies "laziness" of the annotators. This laziness is in fact a way to reduce cognitive overload (because of switching between tasks) and to keep focused on the main task (the reading itself) while still providing meaningful cues.

The higher amount of annotations per page for the "learning" papers shows that these annotations have a clear function for memorizing certain parts of the text (by actively doing something with it).

The category of "review" papers shows a higher frequency of notes in the margin comparing to the other categories. These are almost certainly comments to be included in the review. Additionally, the low number of highlights clearly shows that the readers are not concerned about signaling for future attention. Out of this we draw the conclusion that there is indeed a significant difference between the goals and behaviors of papers based and digital online annotations. The papers that had higher amount of notes and the lower number of highlight (as explained before an action that means signaling for future attention) indicate a non-concern of the reader about a future reading. In the other hand, online annotations (notes in the margin as used in the experiment) are mostly used on resources that are meant to be reused and found in a future work session. We conclude that, although online annotations are similar in its structure to margin notes, its scope is more comparable to highlighting where the real main goal remains in signaling for future attention and facilitation for re-finding.

Within the collected data of online annotations, the average number of words (4.56) in private annotations does not cover the average length of short sentences while the shared annotations (average of 10.35 words per annotations) fit the average of short and medium sentences statistically measured in plain text documents [27]. We deduce that private annotations, in general, don't contain full sentences and as in the paper based texts they are just a perspective over the topic context or keywords and classification of a section (or resource) – in the digital environment mostly used for re-finding. The shared online annotations clearly hold more explicit meanings where the authors tend to be clearer when sharing their thoughts. This evidently shows the different behavior and concerns of the individual when writing personal or shared annotations. Although differences have been found between paper and digital annotations, if we use the same reading goals classification for online readings and translate the annotations meanings, we find out that in-context notes annotations are the optimized form for attention signaling, summarization, interpretation and improving bookmarks search, in both personal and shared environments.

The sum of our two studies suggests some design implications for annotation systems. First of all the annotation action must be effortless in all senses – easy to access and visualize, as few interactions as possible and in-context interactions to minimize the lose focus. Online resources can be used for all sorts of reading tasks, thus annotation systems must supply all forms of annotations, not by similar representations but by providing the means to achieve the same goals. The necessary effort still requires some engagement from the user, however the benefits discussed should overcome and become in hand to the users: re-finding tools, easy manipulation and organization of the annotations and resources and sharing capabilities.

## 6 Conclusions

In this paper we discussed the role of annotation in learning in general and in e-learning in particular. From the background research it has become clear that the act of annotating supports the learning process in paper-based situation. However, when it comes to online learning, annotation becomes an additional cognitive burden, due to the lack of suitable tools and intrinsic problems related to reading from a screen and interacting via keyboard and mouse.

From the comparison of online annotation with paper-based annotation it becomes clear that there is a difference between both types. Online annotations were typically short and had a certain purpose in terms of re-finding, sharing or commenting. The high amount of highlighting in paper-based annotations has an intrinsic value. Based on the results we conclude that emphasis in the development of annotation tools should be put on added value by better exploiting the annotations (for example for enhanced re-finding tools, visual overviews, grouping, sharing, collaborating) rather than to try and mimic the ‘old-fashioned’ paper-based annotation. At the same time, writing an annotation should cost as little effort as possible, as otherwise people will inevitably resort to other ways of getting their things done [2].

This poses a design challenge for the development of annotation systems and provides an explanation why these kinds of systems have not found an audience yet. Furthermore, we think that the development of added value for annotations will provide many more opportunities for personalizing the learning environment and for facilitating communication and collaboration between learners.

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