

## **Electronic messaging in collaborative e-learning environments. A method to assess two key factors of communication quality: HCI and language.**

### **Work in progress**

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### **Abstract:**

In many publications in the field of computer-supported communication / collaboration, participants in their research are required to have a comparable capability to formulate and write down thoughts and to record the resulting text on a keyboard-based computer interface. The combination of event tracking and qualitative content analysis (Mayring, 2007) enhances the quality of the preliminary decision for many experimental and quasi-experimental settings by combining the assessment of one important skill in technoliteracy (Kimber et al., 2007), namely typing efficiency, with the outcome, namely text quality. Our experimental setup uses a JavaScript event logger in a web form, permitting to analyse the typing behaviour of persons responding to different questions. The captured final texts are analysed with qualitative content analysis. The first preliminary experiment conducted with 63 prospective teachers are discussed. All participants were asked to answer two questions about one lesson they had attended.

## Introduction:

Many exploration and experimental settings in the field of Computer-Mediated written Communication (CMC) and Computer-Supported Collaborative Learning (CSCL) act on the assumption that all participants have comparable skills to write text on a keyboard-based computer interface. Different keyboard skills lead to differing experienced usability in all ISO-based dimensions: Effectiveness, Efficiency, and Satisfaction (ISO 9241-11, 1998). The usability of human-computer interfaces expresses the relationship between end users and computer applications (Chou et al., 2006) and is therefore one key factor for the quality of the outcome in e-collaboration and -communication. Successful e-collaboration and -communication implicates the capability to formulate thoughts concisely in adequate length and depth. Both formulating and typing have to be seen as a challenge for e-collaboration and -collaboration, influencing the total cognitive load. Writing speed is normally recorded under experimental conditions. Our method proposes to capture several writing parameters while participants are answering a mail from home or wherever they have access to a computer with internet connection. Apart from the typing speed, the number of different corrections, the pauses within the writing, and mouse movements are recorded as well. It is also possible to record whether participants copy whole sentences or merely text fractions which they fill into their text. The texts are collected and their content is analysed: number of different threads, their (un-)ambiguousness and complexity. Integrating typing efficiency and content quality leads to a co-factor for experimental setups in the field of CMC and CSCL research.

## Description of the Method:

### A) Event-Tracking:

A web page displaying two questions was set up. The same page displays an e-mail client-like form where the students typed their answers to the questions. Key and mouse

events were tracked with JavaScript and stored in a MySQL database together with the message content. Events detectable by means of the JavaScript used were: pressing keys on the keyboard; when which key was pressed and when it was released; mouse clicks, distinguishing left and right mouse keys and the moment of click start and key release; mouse pointer positions. Every event is time-stamped in "milliseconds since 1.1.1970". JavaScript's time interval accuracy is approximately  $\leq 0.1$  sec., depending on the environment in which it is running. One kind of data visualization is sequential key pattern charts showing each key pressed plus moments of user inactivity  $\geq 1$  second. In these charts discarded pieces of text remain visible; so it is the gross text entry versus the net text in the final message. Keys of special interest (e.g. backspace) are marked red:

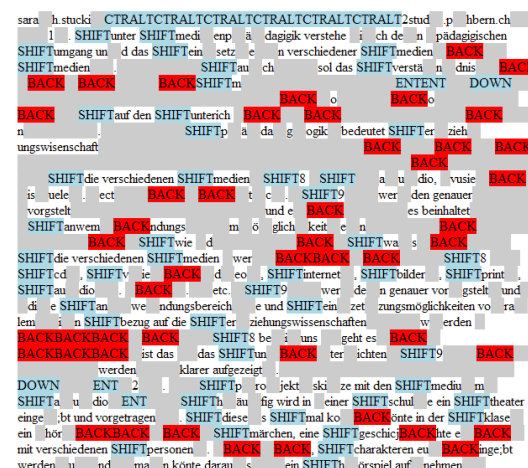


Figure 1: Keyboard usage chart of student #51

While the key pattern charts give a rough impression of text entry flow, data visualization in form of graphs showing the sum of pressed keys in function of time describe typing speed, and graphs displaying the sum of characters present in the text body show the text entry effectiveness and efficiency. Time measurement starts when the first key is hit. The graph "characters in text body" takes off later because the e-mail address of the sender had to be recorded, but does not count toward the text body.

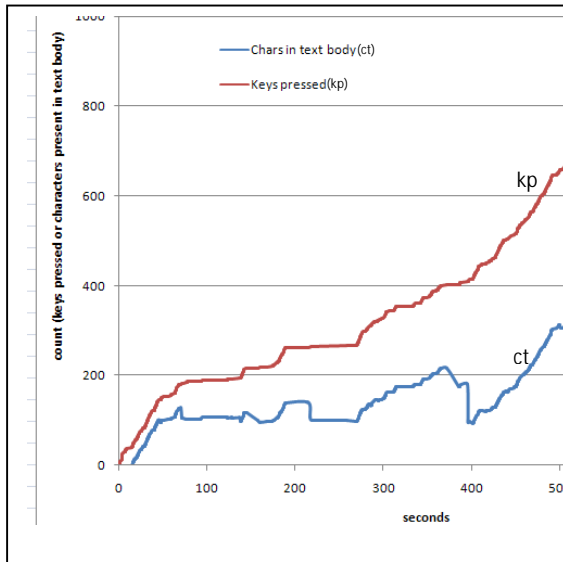


Figure 1: Text composition progress chart of student #51

Text from external sources which is copied and pasted to the text body under investigation will be present in the final message but not in figure 1; in figure 2, a paste transaction would lead to a jump of the ct-graph, and it can even lead to a crossing with the kp-graph (fig. 1). Three messages contained text copied and pasted from external sources; these samples were dropped.

### Typing speed versus typing efficiency

By solving the tasks (answering two questions in a web form), the students are under cognitive load in all categories: intrinsic, external and germane (Sweller 1994). We count the typing activity toward the external cognitive load. According to this model, mental efforts to generate the message content (besides of typing it) will slow down typing because of typing pauses in phases of thinking and reflection. Therefore, net typing time (time between first and last key hit minus all phases of typing inactivity  $\geq 3$  seconds) is the basis for computing typing speed (keys hit per second). Typing effectiveness is expressed as ratio: *total keystrokes / total characters in the final text*). However, this measure inherits the blur that deleting and overwriting text parts lowers typing efficiency, use of the term text-construction-efficiency instead made allowance for this possibility.

Maximum efficiency value equals 1: This is a text written all lowercase without use of keys like backspace, delete, shift, return a. s. o. Using these keys lowers the effectiveness as measured with this method. This results in language-specific differences: The maximum effectiveness (à no corrections, no useless keystrokes but uppercase (shift) and line breaks (return) where accurate) of typing a 31-word long barbecue invitation in English was 0.94, in German 0.92 (because all nouns are uppercase).

Typing speed and typing effectiveness define typing efficiency, so we propose the formula:

$$\text{Typing Efficiency} = C / K + W * S$$

- Ø **C**: Characters present in the final message
- Ø **K**: Keys hit during composition
- Ø **W**: Weighing of importance of typing speed (0.03 for this investigation)
- Ø **S**: typing speed (keys hit per second during phases of typing activity; inactivity are pauses  $\geq 3$ sec).

With this formula and  $W=0.03$ , the efficiency of the mentioned English 31-word invitation typed at maximum effectiveness within 30 seconds is 1.25; we call this value good-secretary-typical. When backspace is used 30 times: 1.04. Or, when typed again at maximum effectiveness, but within 60 seconds: again 1.04.

### B) Qualitative content analysis (Mayring, 2007)

The qualitative content analysis used (Mayring 2007) consists of a bundle of techniques for systematic text analysis which were developed 30 years ago in a longitudinal study about psycho-social consequences of unemployment (Ulrich, Hausser, Mayring et al. 1985). Qualitative content analysis defines itself within this framework as an approach of empirical, methodological controlled analysis of texts

within their context of communication, following content analytical rules and step by step models, without rash quantification (Mayring 2000; June). Two different rules of analysis are proposed by Mayring (2007): inductive and deductive text category application. The deductive coding system fits category application and works with prior formulated, theoretically derived aspects of analysis, bringing them in connection with the text. The qualitative step of analysis consists in a methodological controlled assignment of the category to a passage of text. The quality of a text has quantitative aspects; therefore, the number of threads representing the granularity of thoughts is counted. The quality of their content is assessed in the fields of (un-)ambiguousness and complexity.

Example:

*The sun is shining:*

not complex, unambiguous thread.

*The sun is shining because of the stable high pressure area we are in now:*

complex, unambiguous thread.

The complex and unambiguous thread enhances deeper comprehension rather than the short unambiguous thread. The complex unambiguous thread is usually longer and takes more time to be mentally constructed and typed. We consider a message with many complex unambiguous threads as a good message. Correctness of language and content are not under investigation.

To measure the content quality we propose the following formula:

$$\text{Content quality} = A + (W*B) - C - D$$

Ø **A**: Number of **unambiguous** threads of **low** complexity

Ø **B**: Number of **unambiguous** threads of **high** complexity

Ø **C**: Number of **ambiguous** threads of **low** complexity

Ø **D**: Number of **ambiguous** threads of **high** complexity

Ø **W**: weighing factor for unambiguous threads of high complexity, in this study  $W=2$ ;

### Computer assisted Qualitative Data Analysis (CAQDAS):

Text analysis was done with MAXQDA (<http://www.maxqda.com>). It offers tools for quantitative analysis,.

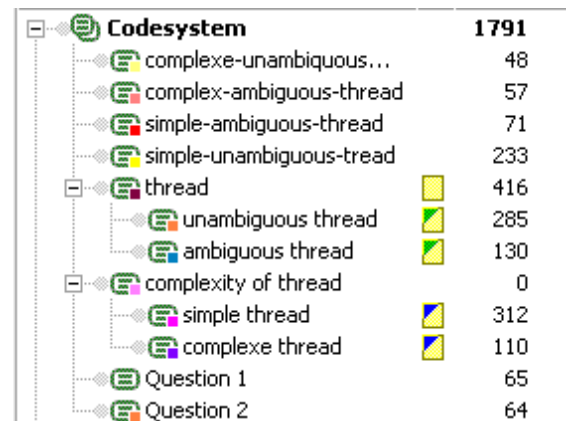


Figure 2: Coding system used with MAXQDA

### C) Event tracking and content analysis

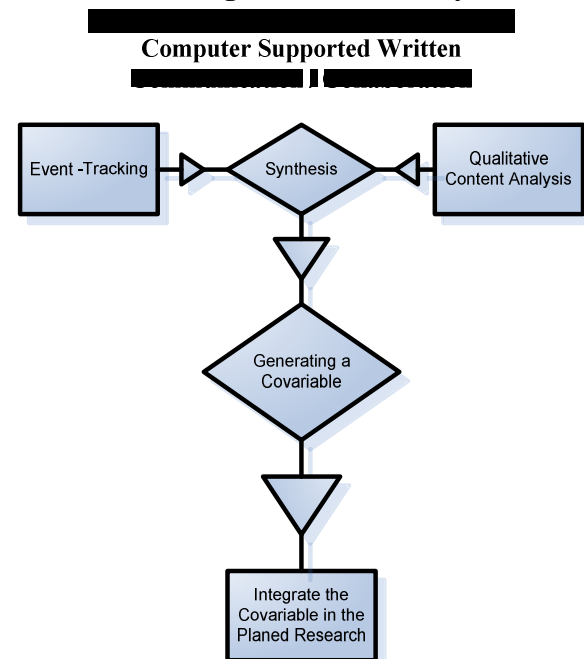


Figure 3: Visualisation of the research method

The event tracking delivers an indicator for typing efficiency, content analysis a content-quality indicator. For future investigations we propose the synthesis of these to parameters to a co-variable for test persons in CMC and CSCL research settings.

## First Testing of and with the Method:

63 prospective teachers participating to an introduction to Media–Media pedagogy were asked to answer questions about one lesson. In one question they were asked to reproduce some content of the lesson; in the second question they were asked to explain the mentioned concept of the management of a media project and to give a possible example of such a media project. In fact, we asked them to reproduce known facts in the first question and to develop personal thoughts within the second question. The participants did not know that we recorded some writing parameters. They were thinking that we would analyse their answers.

## Results:

Of the 63 samples 3 had to be dropped because copied and pasted text-parts from external sources were present. We computed typing efficiency (TE) and the content quality (CQ) as indicators for each of the 60 remaining samples. TE ranged from 0.46 to 1.03 and CQ from -4 to 15. There was no correlation between TE and CQ (Spearman's Rank Correlation (SRC):  $-.085$ ), but a high correlation between CQ and content length (number of characters in the text body) (SRC  $.286$   $p < 0.05$ ), and CQ and total time without pauses  $\geq 3$ sec (SRC  $.353$   $p < 0.01$ ).

Description of the CQ's and TE's range:

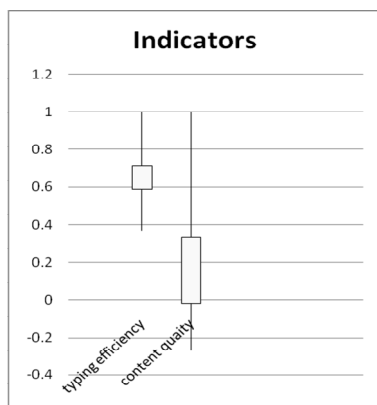


Figure 5: Box Plot of typing efficiency and content quality indicators. The range of the latter is wider. Maximums normalized as value 1.

In the prospective teachers' class under investigation, the range of typing efficiency was more homogenous than the content quality indicator. The boxes represent 75% of the participants around the median. As far as typing efficiency is concerned, they are closer to the best than in respect to content quality.

## Description of two samples:

The text with the highest quality was typed with an efficiency of 0.92 (efficiency rank 11 of 60). Its keyboard usage chart shows intensive use of the cursor keys and backspaces. Shift was not used (all written in lowercase).

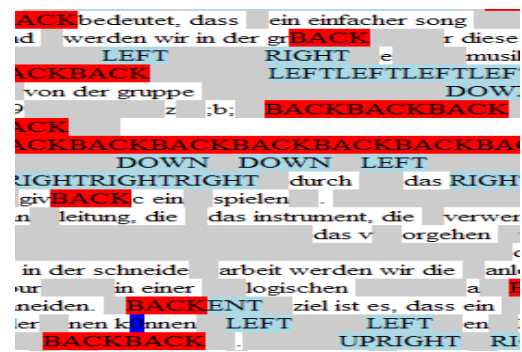


Figure 4: Key usage chart of the text with highest text quality score.

The lowest typing efficiency was 0.46 in a text assessed with a quality score of 4, only 141 characters long, typing activity time 126 seconds (compared to the best text 1323 characters long and 466 seconds typing activity time). The composition of these texts is illustrated below:

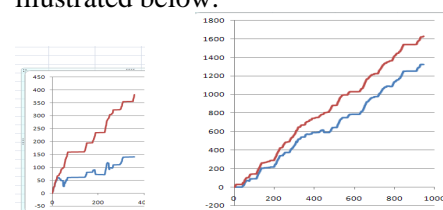


Figure 6: Text with lowest typing efficiency (left) and text with highest text quality (right). The upper graphs show the keys pressed (kp) and the lower the characters present in the text body (ct) in function of time.

## Discussion:

The content quality and the typing efficiency have a wide range and do not correlate. Behind some texts of low content quality a certain typing behaviour can be found: many keys are pressed for generating poor and short text, and often, text parts are deleted (negative slope segments in fig. 6, left, ct). This can represent the overall struggling with the task. Both - mentally constructing the text *and* typing - have to be considered as contributors to the total cognitive load and do impact the potential success in e-communication and e-collaboration for the respective person. We propose that the effects of these factors must be considered in research of e-communication and e-collaboration and therefore should be recorded and applied as co-variable.

When the content quality measured in this study is representing the capability of the test persons to build threads, this factor is more important for the suggested co-variable than typing efficiency. However, the importance of potential struggling in keyboard use differs, e. g. for elderly persons (Pieper et al. 1997).

Points for further discussion:

- Ø Handling of participants who copied a foreign text into the analysed text. The method permits the capturing of the foreign text. We propose to delete the text and treat the rest like all other texts.
- Ø Weighing factors 'W': Further analyses will give more precise references for the chosen weight factors of content and typing efficiency.
- Ø It is planned to validate the presented research method. We will ask researchers in the field of CMC and CSCL if we can conduct our preliminary experiment. Comparing the results with and without co-variables will show the quality of our assumptions.

## Literature:

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