IMPROVING THE USABILITY OF ELEARNING TOOLS: 
THE IFEL MULTIFUNCTIONAL ANALYSIS AND ITS APPLICATION IN DISTANCE 
TEACHING

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Summary

ICT technology offers a multitude of possibilities in the construction of educational software which, however, on the side of the user introduces new sources of difficulties. Users very often are overstrained in handling sophisticated eLearning tools or realizing their potential, while designers and authors do not realize the restricted scope of the end user and the many ways how to make errors. Usability analysis is an approach aimed at discovering the users’ needs of a tool, recognizing the difficulties and optimizing the ease of handling it. A sample of participants is observed and interviewed during the usage of the tool, and conclusions are drawn for its improvement.

Within a framework of goal-directed human action, we propose an approach which takes into account different functions of human information processing which are in interaction with each other:

1. Eye gaze analysis (measuring attential control),
2. Verbal reports (measuring cognitive processes),
3. Logfile analysis (assessing human computer interaction),
4. Retrospective interviews (measuring acceptance and emotional reactions)
5. Performance characteristics (achievements, errors, failure, success).

An example is presented where users perform a task in an eLearning module on the moodle platform.
Introduction

Progress in ICT technology offers a multitude of possibilities in the construction of educational software which, however, on the side of the user introduces new sources of potential difficulties. Users very often are overstressed in handling sophisticated eLearning tools or realizing their potential, while designers and authors very often cannot imagine the restricted view of the end user and the many possible errors in handling a program. Usability analysis is an approach aimed at discovering the users’ needs of a tool, recognizing the difficulties and optimizing the ease of handling it. Typically, a sample of users, representing the whole range of future users, is observed and interviewed during the usage of the tool, and conclusions are drawn for its improvement.

First of all, good usability is a goal pervasive through the entire process of system development. Checking the usability of a finished product is inadequate because it is more difficult or impossible to reverse errors in design and implementation of a finished product. According to Pressman (1992), if in the definition phase the cost of change is one unit, there will be 1.5-6 units during the development phase, and it will increase to 60-100 units after release (Pressman, 1992). Therefore for an eLearning tool it is of central importance to continuously check and improve usability in all stages of the system development (Figure 1).

![Figure 1](image-url)

*Figure 1: Usability tests in three different stages of the life cycle of a system (based on Groner, Raess & Sury, 2008. © Rudolf Groner & Simon Raess)*

The core concept for any usability analysis is *attention*. The user is exposed to an abundance of information and has to monitor his or her activity and select the relevant information (for an overview see Groner & Groner, 2000).

Within a framework of goal-directed human action, we propose an approach which takes into account different functions, each of them representing an area of human information processing and being measured independently (although it is acknowledged that these levels are in interaction with each other and cooperate closely in actual human behavior):

1. eye gaze analysis (measuring attentional control),
2. verbal reports (measuring cognitive processes),
3. log file reports (assessing human computer interaction), and
4. retrospective interviews (measuring acceptance and emotional expressions)
(5) performance characteristics (achievements, errors, failure, success).

Figure 2 illustrates this approach.

**Figure 2: Levels of operation in human information processing during eLearning activities, each level representing a different psychological function.** (Based on Groner, Raess & Sury, 2008. © Rudolf Groner & Simon Raess)

**Illustrative example**

To demonstrate the IFeL multifunctional analysis we show how the different methods can be integrated in a case study. In the following sections we will illustrate the approach by an own pilot study in the field of eLearning. The main focus in the case study is on the learner’s navigation and orientation in an eLearning module, which is part of the Moodle learning management system (http://moodle.org). A good navigation scheme in an eLearning module should allow users to find and access information effectively and efficiently. This can also have an effect on the learning process (Hohenstein & Wilbers, 2005). Today, there are many usability guidelines for good navigation on web pages. For example:

- “Clearly differentiate navigation elements from one another, but group and place them in a consistent and easy to find place on each page.”
- “On long pages, provide a ‘list of contents’ with links that take users to the corresponding content farther down the page.”
- “Provide feedback to let users know where they are in the Web site.”
- “Place the primary navigation menus in the left panel, and the secondary and tertiary menus together”
- “Ensure that navigation tabs are located at the top of the page, and look like clickable versions of real-world tabs.”, „Do not require users to scroll purely navigational pages.“ …

(U.S. Department of Health & Human Services, 2009)

Often these guidelines are very general and unspecific with respect to content. Usually they are created by usability experts and do not have an explicit empirical foundation. In our empirical pilot study we used the moodle eLearning module „Leadership and Change Management“ (Zürcher, 2008) and we applied the IFeL multifunctional analysis for evaluation¹. We set up several small tasks. The following example shows the instruction to the user in one of the tasks:

¹ In contradiction to our principle of continuous application of usability analysis already in the system development process, our demo-example concentrates on the retrospective evaluation.
With such a task we can investigate the user’s orientation and navigation within the module. In the following sections we present some examples of the multifunctional analysis.

Methods

1. Eye gaze analysis

In our Usability Lab we do eye tracking with a Tobii X120 (Tobii Technology AB, 2009). It uses near infrared diodes to generate reflection patterns on the corneas of the user’s eyes. Eye tracking generates a continuous data stream. There are different possibilities to analyze data. A meaningful analysis is dependent on the research question. In our pilot study, we are interested in the user orientation in an eLearning module, so we want to observe how the user interacts and navigates with the platform. One possibility is illustrating the allocation of attention over the total time. This can be visualized in a heat map plot. The heat map plot shows the eye fixations of several users as colour-coded hot spots superimposed on the stimulus material. A heat map can be created based either on the fixation count (number of fixations) or fixation durations. Figure 3 shows a heat map plot based on the fixation durations, included are data from five subjects. Figure 3 shows that subjects look for a long time at the navigation board on the left side.
Figure 3: Heat Map Plot based on the fixation durations, data from five subjects.

Another possibility is to illustrate intra- and inter-individual differences in the sequential order of fixations. This can be illustrated in a gaze plot. Each fixation is illustrated with a dot where the radius represents the duration of the fixation. Figure 4 shows a gaze plot. The first fixation starts in the centre of a page (see Figure 4).
These two plots (heat map plot and gaze plot) are interesting for the illustration of the data. For the statistical analysis we define areas of interest (AOI). Without areas of interest we can only compare inter-individual eye movement parameter like fixation duration, saccade length, time to first fixation, but we cannot localize the scan path. Figure 5 shows the AOI selected for analysis. The blue boxes show the navigation tools at the left side, the green boxes show navigation tools at the right side, the orange boxes show title and main text.
Figure 5: Areas of interest. For explanation see text.

The AOI allow us to calculate the allocation of attention in relation to a certain part of the module. For example we can calculate the frequency of fixations on the navigation board and can compare it with the frequency of fixation on the main text. With AOI we can also calculate intra- and inter-individual differences in frequencies, durations and order of fixations in relation to the pre-defined areas. In our pilot study we noticed that there is a high frequency of fixations on the navigation board at the begin of the test.

The advantage of eye tracking data is that, in contrast to questionnaires, they are relatively resistant against social biases like social desirability. But we also must realize that eye tracking data does not give a sufficient explanation of the usability of an eLearning module (Bente, Eschenburg & Fürtjes, 2007). The data show the learner’s allocation of attention, but they are ambiguous with respect to higher cognitive processes. “Eye tracking tells us what users look at, it does not tell us why.” (Hyrskykari, Ovaska, Majaranta, Räihä & Lehtinen, 2008) We learn more about those by analyzing verbal reports.

2. Verbal reports

A method to supplement eye movement data is the verbal report, also called think-aloud method (TA) (Nielsen, 1993; Van den Haak, De Jong & Schellens, 2003). It is a method, which offers a possibility to gain insight into a user’s cognitive processes during application. There are two ways to survey a TA: During the application (concurrent think-aloud (CTA), Hyrskykari et al. 2008), or after the application (retrospective think-aloud (RTA), Hyrskykari et
al. 2008). Table 1, column B shows a section of a CTA protocol. The advantage of RTA is that it doesn’t affect other measurements or the normal behaviour. The advantage of CTA is that it can collect the thoughts just in time, which sometimes are forgotten afterwards. It has been shown that CTA helps to find real usability problems (Ebling & John, 2000; van den Haak et al., 2003), but it can affect the primary process or prolongs it (Rhenius & Deffner, 1990). A study, which compared CTA and RTA, showed that RTA produces more verbal data and that the RTA data are more informative than the CTA data.

In our approach we use both, CTA and RTA. Parallel to the eye tracking, we generate an audio file, which we transcribe afterwards. We give subjects the possibility to think-aloud during testing, but we do not force them to talk. In some situations it is important that subjects say special insights aloud, that help us to interpret other data. There are also inter-individual differences: Some subjects like thinking aloud and they are allowed to talk as much as they like, while for other subjects it is disturbing and they talk very little. We use RTA as a supplementary method. After testing we confront subjects with video material (as an example see figure 4 to 7) and asked them to recall their thoughts during the test. Missing information can be added in this way.

Table 1 (A - E): Multifunctional test protocol

<table>
<thead>
<tr>
<th>Time stamp (min:sec)</th>
<th>Emotion</th>
<th>Subjective observation (think-aloud protocol, CTA)</th>
<th>Objective observation (log-file)</th>
<th>Figure</th>
</tr>
</thead>
<tbody>
<tr>
<td>00:05:00</td>
<td>neutral</td>
<td>(mute)</td>
<td>start page</td>
<td>6</td>
</tr>
<tr>
<td>...</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>00:20:00</td>
<td>little</td>
<td>upset</td>
<td>&quot;I cannot find the file, there is no link to the file&quot;</td>
<td>7</td>
</tr>
<tr>
<td>...</td>
<td></td>
<td></td>
<td>&quot;Veranstaltungen&quot;-page: scrolls up and down (rescrolling)</td>
<td></td>
</tr>
<tr>
<td>00:30:00</td>
<td>wondering</td>
<td>&quot;I'll try it with the search tool&quot;</td>
<td>opens the browser search tool and insert the file name</td>
<td>8</td>
</tr>
<tr>
<td>...</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>01:10:00</td>
<td>laughs</td>
<td>&quot;Yes, here it is&quot;</td>
<td>finds and opens the file</td>
<td>9</td>
</tr>
</tbody>
</table>

3. Log file analysis

The log file analysis is an important element in our multifunctional concept. We track eye position, selected web page and clicking behaviour which together form the user pathway. With these data we can quantify the efficiency of user behaviour. We count how many clicks a subject makes to finish an exercise and we count how many detours a subject makes. These data can be analyzed statistically, but we also can use them for a qualitative analysis in combination with the verbal reports. Column D in Table 1 shows a section of a transcribed log file in the multifunctional test protocol. As an example, the log-file at time stamp 00:30:00 shows that the user does not open the search tool of the eLearning module site, but he opens the browser search tool. Why the subject does not use the site search tool cannot be answered based on the log file only, neither with the CTA alone. For that, we use retrospective interviews.
4. Retrospective interviews

With retrospective interviews we collect subjective data after the learning session. One part of the retrospective interviews are the RTA, another part are usability questionnaires. Questions to be asked can be yes/no questions, open-ended questions, multiple-choice questions, etc. The most popular type of questions for usability evaluation is Likert type questions (Piyasirive, 2008). Users are given a statement and asked to rate their agreement with the statement. For example in our pilot study we used a five-point Likert scale from 1 = strongly disagree to 5 = strongly agree (Ong, Lai & Wang, 2004). Another questionnaire we used in our case study is the FEW (Fragebogen zur Evaluation von Webseiten) (Brimah, 2003). In this study we used the scale “navigation and orientation”. Standardised questionnaires are good as a guiding principle, but in usability research there is often a need for specific questions depending on the test site. Each web site has a specific topic and questionnaires have to be tailored to the testing material. Data from questionnaires give information about different subject items like emotion, satisfaction, acceptance, etc. Those data form an important framework in combination with the other subjective and objective data.

5. Performance characteristics

In addition to the log file analysis we measure objective performance characteristics. Here we measure the time to solve the exercise and the scrolling behaviour, we count the failures and we make a video analysis of the user’s behaviour. During the test, a video camera is focused on the user’s face. Thus we can rate different emotional reactions, which we can integrate in our multifunctional test protocol. Of course it is difficult to interpret facial expressions. We do not code facial expression in detail, we do only interpret some basic emotional characteristics like laughing, being upset, etc. Additionally, we can include other data like RTA data or CTA data in our analysis to get a reliable interpretation of the emotional reactions. Figures 6 to 9 shows four screen shots of a video stream. The interpretation is integrated in the multi-method test protocol (Table 1, column B)
Conclusion

The last five sections show different methods of measuring usability of an eLearning module. Every single method can describe processes on different areas of human information processing, but it is ambiguous with respect to the entire ongoing process. For a profound usability analysis it is important to combine these different data. Table 1 shows a multifunctional test protocol; where the data from the different methods are put together based on the time stamp. In our pilot study first results showed that users have navigation problems in the moodle eLearning module “Leadership and change management”. There is too much visual information presented on one page, and the users do not find the relevant pieces. The following suggestions can be deduced from the multifunctional analysis: The start page should contain less content, including a table of contents with direct links, and here and in subsequent pages there should be a static navigation tool around the dynamic and scrollable content.

In the past years, usability research was dominated by qualitative studies. The IFeL multifunctional analysis enables the possibility to combine qualitative and quantitative data based on a comprehensive psychological model of human action.

References


