Multimedia Simulation and Comprehension Aid for Complex Technical Documents: a Course for Crane Drivers

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Abstract

We present the design and the experimental test of a cognitive aid tool based on multimedia simulation constructed to help illiterate crane drivers to understand documents about crane transport limits.

1 - Introduction

The aim of this paper is to report the designing process and the experimental evaluation of a cognitive aid tool constructed to help experienced illiterate crane drivers to understand complex weight charts and tables indicating the limits within which a crane can function. Crane men perfectly master the crane at work, but they need to obtain a compulsory certificate of security driving (legal recommendation), which includes a theoretical test in reading and processing weight-distance function graphs (figure 1). The course given to prepare for the exam is short (one week). Crane drivers fail massively in reading traditional graphic media (fig. 1). But, for the exam traditional charts and tables need to be used, since they are reference documents for cranes.

![Figure 1- Graph of the loading limits](image)

The purpose is to link two mental models: the functional representation with the symbolic one. The concrete elaboration of the steps of this link is realized through the construction of an external “hierarchy of abstraction” which relies on the ecological interface approach ([1] Christoffersen, Hunter & Vicente, 1996) and on multimedia learning principles ([2] Mayer, 2001). Simulation and multimodality make quite possible to create an integrated link between an analogical representation of the crane functioning (which is related to the internal functional representation of the crane men) and an external weight graph. A such cognitive tool should improve documents understanding.

2 - Method

We took a three stage general procedure of cognitive ergonomics of learning ([3] Pastré, 1997). The first step was to bring to the fore the internal functional representation of the balance of cranes in illiterate professionals. We lead a cognitive analysis of the work of 10 experienced crane drivers, and diagnosed their knowledge available on the topic. Audio and video recordings (careens’ head movements and eye focus they work in their crane) were made. Starting with the results from the first step, we built a learning simulator for weight charts and tables. Finally, we evaluated how efficient it was to learn with this simulator in two experiments.

3 - Results

First, cognitive analysis showed that crane drivers have a procedural representation of the weight-distance function, organized by the technical indications of the system (horn, speed limits, circuit breakers). This implicit knowledge of the distance-mass relationship, which is strongly “incorporated” in everyday action, can be expressed with an analogical presentation format of the weight-distance function.

3.1 - “Cognitive” principles in designing the training simulator
Using the results of the work analysis, we designed a multimedia screen simulator with a specific learning scenario (19 exercises for a total of 60 items or tasks). We have chosen to simulate the main function of the crane, (with movements and direct interaction with the computer mouse), in order to link two types of representations of how the machine works: the analogical shape ( picturing the concrete behavior of the crane) and the written symbolic form (chart and weight) which appear under the jib of the crane (figure 3).

Figure 3 - Two illustrations from the interface

The principle of the task given to the crane driver is to look for the limits of the crane by concretely carrying loads (with the mouse) along the jib of the crane, presented in profile. The crane can really fall down. The movements of the crane are thus linked “on line” to two other forms of representation. The first one is materialized by the dials indicators (weight, distance and momentum); the second one by what happens under the crane. During the learning sequences, the exercises where operators carry loads to build their own chart under the crane (figure 3) are very progressively (hierarchy of abstraction) replaced by exercises where operators look for limits on charts, and on more complex tables (several lines). The design of the software was meant to overcome the difficulty in processing written text: analogical formats, animations, short messages given auditorily.

3.2 - Experimental evaluations of the simulator

To study the effect of training with the simulator on the comprehension of weight charts and tables by illiterate crane drivers, two experimentations were designed in real traditional learning situations preparing the exam given at the end of the course. The overall procedure of the two experiments was the same: a pre-test (reading eight traditional written weight charts and tables), a training session with the simulator and a post-test similar to the pre-test. In the first experiment, 31 illiterates crane drivers took part. We compared a control group (without simulator training) with two experimental groups (one, who works with simulator before the beginning of the traditional training and the second, who works with simulator after the traditional training). The results exposed on table 1 have shown a significant effect of the work with the simulator, for the experimental groups only.

Table 1 - Mean rates of right answers (*: p < .001)

<table>
<thead>
<tr>
<th></th>
<th>Pré-test</th>
<th>Post-test</th>
</tr>
</thead>
<tbody>
<tr>
<td>Control group</td>
<td>.04</td>
<td>.05</td>
</tr>
<tr>
<td>Experimental group 1</td>
<td>.09</td>
<td>.78*</td>
</tr>
<tr>
<td>Experimental group 2</td>
<td>.63</td>
<td>.96*</td>
</tr>
</tbody>
</table>

In the second experiment with 39 other illiterate and literate crane drivers, we compared traditional learning with simulator learning, using two post-test steps. The post-tests are performed either before the traditional training begins, (group simulator training - St - and traditional training - Tt -) or after it ends (group Tt and St). The results (table 2) have shown a significant effect of the simulator for illiterate crane men. The contribution of the simulator (St) was superior to the contribution of the traditional learning (Tt).

Table 2- Mean rates of answers (*: p < .005)

<table>
<thead>
<tr>
<th></th>
<th>Prétest</th>
<th>Test 1</th>
<th>Test 2</th>
</tr>
</thead>
<tbody>
<tr>
<td>Literate : St &amp; Tt</td>
<td>.88</td>
<td>.92</td>
<td>.97</td>
</tr>
<tr>
<td>Literate : Tt &amp; St</td>
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<td>.92</td>
<td>.97</td>
</tr>
<tr>
<td>Illiterate : St &amp; Tt</td>
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<td>.74*</td>
<td>.65</td>
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<tr>
<td>Illiterate : Tt &amp; St</td>
<td>.20</td>
<td>.50*</td>
<td>.76*</td>
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References