An analysis of a user’s exploration and learning of a multimedia instruction system

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Abstract

In a situated-cognition framework, this article takes an ergonomic approach to describing and interpreting a user’s activity on a computer-assisted interactive learning environment. The environment was designed to improve sports instructors’ knowledge and understanding of some of the major issues in sports training. By focusing on the dynamics of the user-computer interaction, this exploratory study was aimed at validating the system prototype and proposing effective, user-friendly enhancements. The meaning the user grants to his/her actions and the organization of those actions are studied in reference to course-of-action theory. Observation data for a user was collected on-line and supplemented a posteriori by self-appraisal verbalization data. The results present a description and an explanation of the local and global organization of the user’s course of action. They demonstrate the complexity of his exploration and learning activity, how he activates and constructs knowledge during action, and his emotional states that alternate between feelings of apprehension, enjoyment, and effort. The implications of these results for the design of computer-assisted learning environments are discussed. © 2001 Elsevier Science Ltd. All rights reserved.

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The development of computerized learning environments has grown considerably within the past decade. The worldwide technological explosion has facilitated this upsurge. However, problems
persist in areas such as designing specific tools for different fields of instruction, mediating the learning of complex material, and promoting distance education and telelearning (Linard, 1996). Computer scientists, psychologists, education specialists and ergonomists are conducting research to gain insight into these problems and to better understand the type of activity required in learning environments of this type (Baron & La Passardièrre, 1991). The present study is part of this research trend. It takes an ergonomic approach and has two interrelated goals that are pursued in a recursive way: (1) design and develop a multimedia system; and (2) analyze the activity of the system’s users in a real learning context. The results of the analysis are then used to improve the system, and so on. To develop our instruction device, this recursive technique was applied at each stage of the process, including programming, design, implementation, and maintenance (Pinsky, 1992). Our approach is based on the situated-cognition paradigm (Kirshner & Whitson, 1997; Suchman, 1987), which no longer views individuals as mere “operators” that decode signals, solve problems, and perform tasks, but as autonomous, intentional and motivated psycho-affective and social “actors” who set meaningful goals for themselves and produce actions in interaction with their environment. This article presents a case study of an interaction between an actor and a multimedia system prototype (the design stage of an ergonomic experiment). The user is a certified sailing instructor currently preparing for a competitive exam to become a sports professor. Our aim was twofold: test the tentative specifications drawn up in advance during the programming phase, and foresee the ways the system would be used in the future in order to propose ergonomic, user-friendly improvements (Pinsky).

1. Principles behind the design of the multimedia system

In the present approach, tools of knowledge are conceived of as “anthropocentric” instruments, as true aids at the user’s disposal, and a crucial role is granted to the human being (Norman, 1993a; Rabardel, 1995). The learning instrument under study here combines hypermedia (Leblanc & Gombert, 1998) with a computer-assisted conceptualization system called Modélisa (Viens, 1996).

The hypermedia environment was designed to provide individuals involved in sports education — whether team managers, instructors, coaches, or otherwise — with a framework for thinking about some of the major issues in sports training. Addressing over 20 key topics for instructors, it is based on a concrete case study, many theoretical considerations, and information obtained from physicians, researchers, instructors, and athletes in various sports. Learning objectives as well as evaluation questions suited to each topic are proposed. The computer-assisted conceptualization software breaks down the learning process into four main areas (“I Know”, “Questions”, “Vocabulary”, and “Model”) that allow users to (1) check the initial state of their knowledge, (2) put the questions they want to ask into words, (3) identify the important keywords or concepts for the subject matter being approached, and (4) organize these keywords into a conceptual network. On-line help explaining the interactive techniques needed to run the hypermedia and computer-assisted conceptualization systems is available to the user at all times.

This learning environment is an open-ended one that offers users the possibility of choosing their navigation course in the information network, and drawing up a genuine cognitive
map (Levy, 1990). Its many capabilities allow users to construct their own meanings in the course of their interaction with this environment, where meaning is not confined to symbols (Winograd & Flores, 1986). This environment does not supplant the user’s intelligence. It proposes a system that assists the user with the various conceptual functions, including sorting, organizing, storing, comparing, validating, correcting, and recomposing information (Linard, 1996).

In our approach, high priority is placed on individualized instruction and metacognitive progress (Carré, 1992). Multimedia systems are individualized technical means that enable self-instruction by providing guided or semi-guided access to learning resources. But using them does not automatically instigate independent learning: in certain cases, the user’s attention shifts away from the learning process. That is why it is important to look into the self-teaching properties of such tools as they are being designed. In order for users to increase their learning autonomy, such an environment must elicit the ability to reflect in action, problemize, and conceptualize.

To reflect in action (Schön, 1983) is to learn how to learn, i.e. to take advantage of past experiences, plan the learning process, set realistic goals, structure problems, select resources, and devise effective action strategies.

To problemize is to think up and produce an original set of questions that serves as a guide for delineating and solving problems. The idea here is to assist the user in constructing problem situations from the inside (Lerbet, 1992) by triggering heuristic processes. Three levels are foreseen: (1) defining the underlying problems in reference to situations experienced in the past; (2) defining the underlying problems in reference to the situations proposed by the instructor; and (3) assimilating the concepts and using them in a variety of situations.

To conceptualize is to organize and structure knowledge. Conceptualization is the result of a motivated, intentional activity that may lean on external concept maps but requires more than just copying them. The creation of mental concept maps by the learner promotes progress because it supports the synthesizing process. This in turn enhances the retention of domain-specific structural knowledge (Tochon, 1990).

2. State of the art

Several surveys on the effects of equipping schools with personal computers have shown that these tools are no better at triggering learning than traditional teaching methods. They only seem to offer a true cognitive aid to atypical populations such as the gifted and the learning-disabled (Dubuc, 1987). Although these quantitative surveys offer an overall picture of the academic effects of using computers, they do not give any reasons for those effects. This dimension is better grasped through the qualitative analysis of learning and/or searching for information in a hypermedia environment.

The hypermedia literature provides some information about the difficulties users encounter in this type of environment and the nature of their activity. The critical problem of getting lost during hypermedia navigation (Conklin, 1987) is rooted in two difficulties: situating oneself in the hypermedia network structure, and processing all available information. Users’ difficulty building a mental model of how the environment is organized prompted some authors to simplify the structure of hypermedia databases and/or to combine a hierarchical structure with a
network structure (Gray, 1990). The heavy cognitive load needed to manage the dual task of navigating and learning in hypermedia poses a particularly bad problem for novice users (Foss, 1988). The “usability” of hypermedia nevertheless remains a function of the learner’s interest in the content and his/her familiarity with the computer environment (Baird & Percival, 1989).

Research so far has pointed out some of the dimensions of hypermedia use, and encourages hypermedia developers to put more effort into designing the structure of hypermedia in a way that will help users locate and process information. Various studies have focused on the key aspects of user adaptation to such systems, but they are not comprehensive or detailed enough to be very useful in the actual design process, nor in understanding the exploratory and/or learning activity of a particular user, working in a particular hypermedia environment. The large majority of these “psychological” studies deal with only one constituent of the user’s activity (perception, interpretation, decision making, problem solving, etc.) during interaction with hypermedia or hypertext, and the analyses are conducted without regard for the actual production context. Yet as Norman (1993b, p. 16) noted, “The fact of examining a task in its entirety can give rise to results that are often very different from those one would obtain by examining the various constituents separately.” Moreover, these studies have not paid any attention to the meaning users give to their activity, nor to the specifics of the situation under analysis. In short, the available research has its limitations when it comes to the real activity of users, especially if we hope to propose useful improvements for hypermedia environments. We shall thus defend the idea that the kind of assistance that needs to be provided to hypermedia users must be truly integrated with the information search process as a whole. The present article deals accordingly with the user’s overall activity, and attempts to describe and supply fine-grained explanations of the exploratory and/or learning process of an actual user on a multimedia system.1

3. The course of action as a theoretical object

In order to take the roles of the situation, the computer environment, and the user’s culture into account, we shall refer to the concept of cognitive artifact, defined as an artificial device for improving performance. Artifacts are assumed to cause progress not only by increasing the capacity of human thought but also by changing the nature of the task the person is accomplishing (Norman, 1993b). From a user’s point of view, cognitive artifacts lead one to learn new things and to relinquish or modify already acquired procedures and knowledge. Our main concern here is how such artifacts are used.

To study this activity in its entirety, in a real situation, we shall rely on course-of-action theory and methodology (Pinsky, 1992; Theureau, 1992; Theureau & Jefferoy, 1994). As a theoretical object, the notion of “course of action” is approached through the general hypothesis that autonomy is a fundamental characteristic of all living systems (Maturana & Varela, 1987; Varela, 1980), and in the terms of situated-action research (Suchman, 1987). In this perspective, called

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1 The expression “the multimedia system” is used here to refer to our learning environment, which includes the hypermedia environment and the computer-assisted conceptualization system Modélisa.
“situated cognitive anthropology”, an action and its meaning (for the actor) are considered to be inextricably linked. They emerge from the coupling between the actor and his/her context, in an autonomous cognitive domain. This coupling has an intrinsic organization that cannot be approached by studying only the constituents of the task or the objective constraints of the situation (Theureau, 1992).

A course of action is “the activity of a given actor engaged in a given physical and social environment belonging to a given culture, where the activity is meaningful for that actor, that is, he can show it, tell it, and comment upon it to an observer-listener at any instant during its unfolding” (Theureau & Jeoffroy, 1994, p. 19). The definition of this theoretical object is based on the assumption that the showable and tellable activity in question (i.e. the part that is meaningful from the actor’s point of view) takes place at a level of organization which is relatively independent, compared to other analysis levels, and which can give rise to valid and useful observations, descriptions, and explanations (Theureau, 1992).

This framework for analyzing the course of action is a semiological one rooted in the thought sign hypothesis (Peirce, 1931–1935), which postulates that man thinks (and acts) through signs and that these signs emerge from the interaction between an actor and a context. Describing and analyzing an activity implies reconstructing the process through which meaning was constructed in action. A course of action is made up of elementary units of meaning, and the flow of activity is a succession of discrete units which are meaningful to the actor. These units are called elementary units of meaning (EUM), and they can be actions, communications, interpretations, focalizations, or feelings. Condensed narratives can be produced to account for the sequence of EUMs in time. Each EUM emerges from the dynamic articulation of three constituents: the object, the representamen, and the interpretant (Peirce; Theureau, 1992; Theureau & Jeoffroy, 1994). An EUM is thus the product of a three-part sign.

The first part of the sign, the object, emerges from the actor’s involvement in the situation. It opens up a field of possibilities for the actor. These possibilities are not objective ones: they characterize the ongoing relationship between the actor and the situation, and depend upon the judgments he/she makes about the situation. Our analysis attempts to describe the “search” objects that come out of the user’s involvement in the multimedia system. These objects are related to the user’s preoccupations about theoretical problems, and they are useful in describing and explaining those stages of reasoning and learning where the user tries to discover, appropriate, and validate new laws or procedures (Theureau, 1992).

The second part, the representamen, is the element of the situation being considered by the actor: it is a judgment, whether perceptual (“I’m perceiving this”), mnesic (“I’m remembering this”), or proprioceptive (“I’m doing this”). The representamen is anchored in the element selected in the situation (present or past). It is the outcome of the subjective appropriation of an event by the actor in connection with his/her involvement in the situation. This notion highlights the selectiveness of perception in human cognition and represents how it fits into the dynamics of the construction of meaning by the actor.

The third part, the interpretant, is the translation of the activated knowledge that allows the actor to interpret the current situation and act in accordance with past experiences. It refers to elements of generality: types, relationships between types, or general principles of interpretation derived from earlier experiences. One kind of interpretant, called a meta-interpretant, is defined in terms of the search principles used to find information or interpretations.
4. Method

4.1. Participant

This study was conducted in collaboration with a 28-year-old, nationally-certified sailing instructor\(^2\) who is currently preparing for a competitive examination to become a sports professor. He demonstrated an interest in the individualized instruction program proposed here, and volunteered to test the multimedia prototype being developed. He chose to work on the topic of early sports specialization, a topic he had already addressed in his studies but wanted to learn more about. He had many ideas on this subject, and about training in sailing. He also had good computer skills (2 years of personal computer use in the home and on the job).

4.2. Procedure

The activity of this user was studied during a single, independent work session (without a teacher) that lasted an hour and a half. The device was a prototype consisting of a hypermedia environment and a computer-assisted conceptualization program called Modélisa. The researcher gave the participant a 2-minute presentation of the device and then let him work on his own.

4.3. Data collection

Two types of data were gathered: (1) observation data from the work session, and (2) self-appraisal data during post-session interviews. The observation data was recorded on videotape throughout the entire work session. The camera on a tripod was located behind and to the side \((45^\circ)\) of the user’s head. The screen was filmed in close-up. The frame speed was adjusted so that screen refreshing was not visible on the video recording.

The self-appraisal data were collected after the work session via two interviews conducted by the researcher. The interview setup was such that the user had the time and opportunity to think back over his actions, recall his work, and come to an agreement with the interviewer (Theureau, 1992). The first interview, in which the user was presented with the videotape of his work in its entirety, was the first self-appraisal level. It was held 24 h after the work session, in the same room, and lasted 2 h. During this interview, the user was asked to take each instant that was meaningful for him and explain his actions and navigation choices on the multimedia device. The questions asked by the interviewer during this viewing prompted the participant to describe what he was doing, what he was thinking about, what he took into account in deciding how to act, and what he felt, so that his actions, focalizations, interpretations, and feelings in the situation could be reconstructed. The questions pertained to descriptions of the actions taken and the events experienced on the device. Questions requiring interpretations and generalities were avoided (Theureau; Vermersch, 1994).

The second interview provided the second self-appraisal level. It was conducted a month later and required the participant to comment upon a narrative description of the sequence of EUMs

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\(^2\) This instructor holds the French “Brevet d’état sportif deuxième degré” (Second-Level National Sports Certification).
that made up his work session. After reading and thinking about the description on his own, the user had to state his point of view about it and express any disagreements. He was asked to state the reasons for the choices he made on the multimedia system. Unlike the first interview, the user was encouraged to make comments of a general order and to give his interpretations of his own functioning mode. The two interviews were recorded in full.

4.4. Data processing

The intrinsic organization of the user’s course of action during the work session was analyzed in three steps: (1) construction of two-facetted protocols; (2) labelling of EUMs and their underlying constituents; and (3) labelling of sequences, macro-sequences, and series.

4.4.1. Constructing two-facetted protocols

This operation consisted of transcribing the audio and video recordings in order to obtain a fine-grained reconstruction of the course of action representing the temporal features of the user’s activity, the events that occurred on the multimedia device, and the user’s cognitions.

The first protocol facet pertained to the observation data taken from the continuous video recording of the screen during the work session. Two stages were required here. First, four observation criteria were defined to account for the visible activity of the user on the computer screen: (1) moves and locations of the mouse arrow; (2) messages output by the computer; (3) the user’s overt behavior and personal productions; and (4) his location in the multimedia device. With these elements, the user’s activity could be described using action verbs, without making any assumptions about his intentions. Second, the video recording was coded in its entirety using these four criteria.

For the second protocol facet, the user’s verbalizations during the self-appraisal interviews were transcribed verbatim from the recordings. The self-appraisal data was mapped along the time axis to the observation data representing the user’s actions and navigations (Table 1).

4.4.2. Labelling elementary units of meaning and their underlying constituents

The EUMs were labelled based on the joint analysis of the two-facetted protocols and the videotape. The goal was to answer a series of questions about the user’s actions, interpretations, inferences, and feelings, as they showed up in the protocols (Table 2): what is the user doing? What is he thinking? What is he feeling? The underlying constituents of each EUM were identified in the excerpt for that EUM by mapping and making inferences about it in relation to the corpus as a whole and by answering a series of more specific questions: what is the user involved in here (what object)? What is he concerned about? What element of the situation is he considering? What element is he recalling, perceiving, or interpreting? What knowledge is he using?

A total of 129 EUMs were identified for the work session as a whole.

4.4.3. Labelling sequences, macro-sequences, and series

The EUMs were grouped under meaningful units of a higher level. Three levels were found in this analysis: sequences, macro-sequences, and series.

Sequences are composed of one or more EUMs that exhibit sequential coherence relations. They reflect a meaningful concern for the user in the situation and associate the EUMs in ques-
tion. Two EUMs were taken to belong to the same sequence whenever one was partly determined by the result of the other and they both referred to the same topic. For example, EUMs 1, 2, and 3 below present a sequential coherence relation and make up the sequence labelled “Find an entry point into the system” (Table 3). The 129 EUMs formed 34 sequences.
Macro-sequences are composed of one or more sequences linked to each other by sequential coherence relations. They represent a broader topic that is meaningful to the user. A series is composed of one or more macro-sequences. It reflects the user’s concerns and links EUMs and/or sequences to each other via serial coherence relations (Table 4).

The 34 sequences formed 7 macro-sequences, which in turn formed 3 series. This step was completed by drawing a graph representing the four levels in the overall structure of the course of action.

5. Results

The results describe the global and local organization of the user’s course of action as he interacted with the multimedia system.

5.1. Global analysis

The analysis pointed out the organization of the user’s exploration and learning activity at the three description levels defined (sequences, macro-sequences, and series). The discontinuity of the meaningful units at these different levels revealed the complexity of this activity. The results are presented in three parts: (1) relationships between the three series; (2) user organization of the work space; and (3) following the proposed steps and searching for automated procedures.

5.1.1. Relationships between the three series

The analysis brought out meaningful structures of different levels that formed three series. In these series, there were three basic types of concerns that oriented the user’s activity throughout

<table>
<thead>
<tr>
<th>EUM and underlying constituents</th>
<th>Sequence</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>EUM 1: Read entire home page</strong></td>
<td></td>
</tr>
<tr>
<td>Representamen: Early sports specialization. Modélisa software</td>
<td></td>
</tr>
<tr>
<td>Object: Find out where to go in the system</td>
<td></td>
</tr>
<tr>
<td>Interpretant: To find an entry point, you have to read everything first</td>
<td></td>
</tr>
</tbody>
</table>

| **EUM 2: Scroll down the page several times** | Find an entry point into the system |
| Representamen: A full page, many sentences one after another |          |
| Object: Look for what to read first |          |
| Interpretant: What I read first is a “good entry point” |          |

| **EUM 3: Open the on-line help** |
| Representamen: On-line help |
| Object: Get help |
| Interpretant: The on-line help must tell you how to proceed |
his course of action: (1) “Learn how to use the computerized device”; (2) “Learn about the topic under study”; and (3) “Organize and format one’s production.”

Learning how to use the computerized device took up a substantial amount of the user’s time: 24% of the work session was devoted to this endeavor. This activity was spread over the entire session, even if more time was spent on it at first, as illustrated in this excerpt: “To begin, I didn’t know how to proceed. I really just took it step by step. Because I was tempted, what I would have done if not, was uh . . . to look at the page, click a little, look some more, get an overall idea, and then shut down.” This series, “Learn how to use the computerized device”, contained three macro-sequences: “Organize one’s work space”, “Follow the steps proposed in the help”, and “Search for automated procedures”.

Learning about the topic under study was the user’s main activity, taking up 64% of the session time. This activity consisted of three macro-sequences: “Do some independent thinking”, “Improve one’s production”, and “Build one’s own model”. The following excerpt demonstrates this overall underlying concern: “In fact, in the end, it’s going to be a synthesis of what I read, what I knew already, and what I saw; that’s what it’ll be in the end, and the idea of building a general model, I still have a long way to go.”

Table 4
Nesting of sequences within macro-sequences and series

<table>
<thead>
<tr>
<th>Series</th>
<th>Macro-sequences</th>
<th>Sequences</th>
</tr>
</thead>
<tbody>
<tr>
<td>Learn the computerized device</td>
<td>Organize one’s work space</td>
<td>Find an entry point</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Find out from the on-line help how to use this work space</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Find out where you are in Modélisa</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Operate Modélisa</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Get materials organized for writing</td>
</tr>
<tr>
<td></td>
<td>Follow the steps proposed in the help</td>
<td>Understand the first instruction proposed in the on-line help</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Do points 2, 3, &amp; 4 in the on-line help</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Remember the first points in the proposed steps</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Get an overall picture and understand the steps proposed</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Remember point 5 in the on-line help</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Evaluate your work with respect to your initial goals</td>
</tr>
<tr>
<td></td>
<td>Search for automated procedures</td>
<td>Search for cut-and-paste procedures among the various menu headings in Modélisa</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Search for cut-and-paste procedures in hypermedia and Modélisa</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Look for ways of linking one’s different productions using hypertext links</td>
</tr>
</tbody>
</table>
Producing a personal, reusable document took up 12% of the session time. This task involved organizing the user's notes and correctly formatting the document, including eliminating typographical errors and misspellings. The following excerpt illustrates this activity: “Here, I really intended to keep a final document. I would have liked to print that; I would have liked to get something out of it.”

Each of these series was made up of one or more sequences, as shown below in the graph of the overall organization of the user’s course of action (Table 5).

### Table 5
Graph of the overall organization of the user’s course of action at the macro-sequence and series levels

<table>
<thead>
<tr>
<th>Series</th>
<th>Macro-sequences</th>
<th>Sequences</th>
</tr>
</thead>
<tbody>
<tr>
<td>Learn how to use the computerized device</td>
<td>Organize one's work space</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Follow the proposed steps</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Search for automated procedures</td>
<td></td>
</tr>
<tr>
<td>Learn about the topic under study</td>
<td>Do some independent thinking</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Improve one's production</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Build one's own model</td>
<td></td>
</tr>
<tr>
<td>Organize and format one's production</td>
<td>Organize and format one's production</td>
<td></td>
</tr>
</tbody>
</table>

| Time | 0 | 1h30' |
5.1.2. User organization of the work space

The macro-sequence “Organize one’s work space” was composed of five sequences (Table 6).

The user’s first concern was to “Find an entry point” in the multimedia system so that he could quickly get involved in the learning process. The user searched for this entry point using an exploratory approach consisting mainly of a sequential, thorough reading of the home page, as illustrated in the following excerpt: “Here I’m reading the topic, I’m roughly reading the whole page actually... Uh huh. So I’m reading everything. I’m trying to see where all this is leading me. I’m asking myself the question anyway, where to start, to get at what? I’ve been looking for a while now... The page is full, so, but I don’t really know what’s going on. There are lots of sentences in a row and I can’t figure out where to start.” Faced with the problem of choosing an entry point into the system, the user consulted the on-line help to find out how to “use this work space”: “Because I didn’t know where I should go to get in, I could see the Modélisa system, but, well, I didn’t know how to use all that very well.”

During the next sequence, the user tried to “Find out where you are in Modélisa” by exploring the different menu headings in the navigation bar: “Here I’m opening Modélisa just to see... I think I must have taken a closer look at the first statement saying ‘Try to express what you know.’ I couldn’t see where in Modélisa I was supposed to put it.” After getting a feel for the Modélisa software, the user tried to “Operate Modélisa”, for example, by deleting the contents of a task already tried out at the beginning of the sequence: “There I had a little table; there I was having trouble erasing that. I didn’t know how to do it.”

In the next sequence, the user, who was reluctant to use the keyboard outright, attempted to “Get materials organized for writing”: “Here I’m getting a sheet of paper, because I’m telling myself I should write down what’s in my head, right away, I don’t really want to do it on the keyboard so I’m looking for a sheet of paper... I said to myself, it’ll be easier to jot down what... to organize what I’m thinking on paper, before writing there, and in fact, I didn’t write on the paper at all!”

5.1.3. Following the proposed steps and searching for automated procedures

The user’s first concern was to make use of the computer-assisted conceptualization software, Modélisa, in interaction with the hypermedia environment. His intentions were: “to use... to learn about what I could do with Modélisa, you know, the capabilities it had...” Faced with the complexity of the multimedia system, the user quickly decided to read the on-line help and to refer to it each time he felt the need. He tried to find some guidelines, both as to what actions to

<table>
<thead>
<tr>
<th>Series</th>
<th>Macro-sequence</th>
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</tr>
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<tbody>
<tr>
<td>Learn how to use the computerized device</td>
<td>Organize one’s work space</td>
<td>Find an entry point</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Find out how to use this work space from the on-line help</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Find out where you are in Modélisa</td>
</tr>
<tr>
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</tr>
<tr>
<td></td>
<td></td>
<td>Get materials organized for writing</td>
</tr>
</tbody>
</table>
carry out and what strategies to use, as illustrated in the following excerpt: “Here I must be in the ‘on-line help’, there it is . . . Because I didn’t know where I should go to get in, I could see the Modélisa system, but, well, I didn’t know how to use all that very well.” This macro-sequence, “Follow the steps proposed in the help”, contained seven sequences (Table 7).

During this macro-sequence, the user alternated between trying to understand, and recalling different points in the on-line help. He followed the proposed procedure step by step, as illustrated in this excerpt: “I did everything, in fact. I ended up doing ‘knowing’, ‘referring to a book’, ‘drawing up a short summary’, and, that, I mean, I’d do it on paper, but here, it was a lot more fun to do it like that. I didn’t have to think any more, it took less time . . .” But, he pointed out a few problems caused by his lack of understanding of some of the operations in the system, as illustrated in this excerpt: “Yes . . . I didn’t get irritated, but it’s true, I could see that I had to understand the logic of the software, which organizes a model in a certain way and prevents you from doing things, and until you understand that, I had my own plan, I wanted to build a model . . . I had to understand how it (the software) wanted things to get done. It’s probably better that way, but then I’d have to understand how the software works.”

In an attempt to save time and take advantage of the computer’s capabilities, the user searched for automatic procedures whenever he moved between the different menu headings in the Modélisa system or went from the hypermedia environment to Modélisa. In the course of his actions, he discovered a new way of working that made it very easy for him to quickly establish the links between the various scattered pieces of information. This macro-sequence, labelled “Search for automated procedures”, was made up of the following sequences (Table 8).

Despite failure on several cut-and-paste operations, the user did not stop searching or exploring the various possibilities for achieving this two-part operation. The following excerpt illustrates his determination:

I’m taking “Vocabulary” words and I’m trying to copy them in there, but it doesn’t work. It’s because it was too long in fact; the max is 25 characters. I don’t think you can cut-and-paste from the “I Know” (menu) to the “Vocabulary” (menu).

Q: So there, you’re searching for awhile, trying to see how . . . ?

Table 7
Nesting of sequences within the macro-sequence “Follow the proposed steps”

<table>
<thead>
<tr>
<th>Series</th>
<th>Macro-sequence</th>
<th>Sequences</th>
</tr>
</thead>
<tbody>
<tr>
<td>Learn how to use the computerized device</td>
<td>Follow the proposed steps</td>
<td>Understand the first instruction in the on-line help</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Remember the first point in the steps</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Do Points 2, 3, and 4 in the on-line help</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Get an overall picture and understand the steps proposed</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Do points 4, 5, &amp; 6 in the on-line help</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Remember point 5 in the on-line help</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Evaluate one’s work with respect to initial goals</td>
</tr>
</tbody>
</table>
A: I could save time! “Copy”, no, that doesn’t work. Here, that doesn’t work either. So there I’m trying to find the paste . . .

Several times, the user was willing to waste time, hoping to save time in the end if he discovered the procedure: “The idea I had . . . that it could be done in the form of a page with an initial model, a model that points elsewhere, that way, it seemed more like when you open a folder. You want to see what’s in a folder, and, from there, you go to three sub-folders and in the three sub-folders you open another and that points to files, that’s what’s intended . . . So you won’t waste time . . . so here I’m trying something . . . and here again I’m trying a lot of things after that . . .”

In spite of various difficulties, the user was positive that it was possible to move information within the multimedia system using automatic procedures, and this feeling opened up new pathways for him, as illustrated in this excerpt: “You actually get the impression you can extract intelligent things and put them in your pocket at a minimal cost . . . it’s really great. I’ll keep that, it’s super; you don’t even have to copy it over by hand . . . for one thing, and the other is that you can really go fast because in the end I still read all the pages quite fast, and I was thinking the whole time . . . I was able to make connections, take an idea from one place, and another idea from somewhere else, and tie them together, although I’ve already tried to do that with books; it’s much harder.”

5.2. Local analysis

The local analysis dealt with (1) activation of meta-interpretants that control the user’s exploring and searching activity, (2) creation of new interpretants revealing a situated learning process, and (3) emotional alternation between feelings of apprehension, enjoyment, and effort.

5.2.1. Activation of meta-interpretants that control the user’s exploring and searching activity

In the sequence examined here, the user first retrieved his own knowledge of the topic under study. After having brought together the main ideas from a term paper he had written in school, he wrote down the important items and arguments he remembered. Even though the on-line help prompted him to consult the database, he decided to develop his ideas by continuing to reflect solely upon his own knowledge. A little later, he attempted to draw additional information from the database. Seeing how much information it contained, he had trouble deciding what to read

<table>
<thead>
<tr>
<th>Series</th>
<th>Macro-sequence</th>
<th>Sequences</th>
</tr>
</thead>
<tbody>
<tr>
<td>Learn how to use the computerized device</td>
<td>Search for automated procedures</td>
<td>Search for cut-and-paste procedures among the various menu headings in Modélisa</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Search for cut-and-paste procedures in the hypermedia and Modélisa systems</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Look for ways of linking one’s different productions using hypertext links</td>
</tr>
</tbody>
</table>
and sorting out the information he wanted to get. These contradictory, problematic events can be interpreted in terms of the activation of different types of meta-interpretants: (1) a meta-interpretant that controlled his learning process; (2) meta-interpretants that controlled his reading; and (3) meta-interpretants that controlled the way he sorted out useful information.

The following excerpt is a testimony to this self-teaching process: “It means going to look at the database, to see what you can do, I think, how you can enrich your knowledge a little, and I don’t feel like going into it right away … I’ll add something … But, here I’m thinking hard anyway, about what I want to say.” This meta-interpretant, “Use one’s own knowledge first before searching for new information in the database”, led him to continue his thinking process in order to develop his own ideas. Thus, the user was going against the proposal in the on-line help and was recalling a certain amount of knowledge without consulting the database. In the following excerpt, he expresses the intention to preselect the excerpts he is going to look at in order to cope with the reading problems he encounters: “I’m going to search for what I want to read, because it bothers me to read so much like that. I don’t like it. I like to read things; as much as I love to read really exciting books, which captivate me, I don’t like to read that much, to be drowned in reading.” He was faced with a contradictory situation where there was a lot to read, at the same time as he did not like “to be drowned” in reading. This contradiction can be interpreted by a meta-interpretant, as this excerpt illustrates: “I’m looking at the titles, the authors, and I’m trying to see roughly what that title might mean.” Using a trial-and-error procedure, the user attempted to strengthen his conviction regarding this new rule by activating another meta-interpretant: “The title tempted me here: ‘Your child’s life is not worth a medal.’ I liked it; I’m going to in there and see what it says.”

After selecting what to read, the user had to figure out how to process the information. Again, the problem that arose was sorting out such a massive amount of data. The following excerpt points out his efforts to consolidate and select the information that interested him: “And I’m going to get all the spans of text … I’m going to get some text, a summary in fact … Here, I’m sorting out what I want.” This situation can be interpreted via a meta-interpretant like the one in this excerpt: “I’m not worrying about sticking to the author’s text. I’m not writing a summary for school where I have to summarize the author’s ideas; I don’t care about that. I’m taking whatever data I feel like taking.” The user did not try to deal with ideas that contradicted or were far-removed from his own, but attempted instead to reinforce and enrich his own ideas. He experimented with this new principle in an attempt to validate it: “Here, there was an outline that was a lot like what I’d done myself … So here it’s a lot like what I said in my term paper … I liked it. So there I’m starting to read what he might have to say using a pretty similar outline.”

5.2.2. Creation of new interpretants revealing a situated-learning process

This analysis deals with the times in the user’s course of action when new events took place or when the interpretations he made were contradictory. The interpretants of the newly created EUMs pertained to three areas of the user’s activity: (1) his working mode; (2) the content of the topic under study; (3) automatic procedures.

5.2.3. Creation of new types pertaining to the user’s working mode

The user had just consulted the on-line help, which prompted him to state the problem differently or in a more precise way, based on his own experience. The help recommended that he work
under the menu headings “I Know” and/or “Questions” in the Modélisa system. After having hesitated between the two menus, he chose “Questions” and wrote down a number of questions about the topic under study. Being dissatisfied with what he produced because his questions did not seem useful to him, he selected the heading “I Know”. These contradictory events can be interpreted in terms of the activation of types related to prior knowledge acquired during school and the evaluation of the relevance of his questions.

The following excerpt demonstrates the questioning process that developed during learning in this new situation: “Because I had questions that came to mind, because we had learned a little about that, about asking questions, about organizing around a topic, what important questions have to be stimulated ... Yes, I hesitated, but the fact that I had written that paper, I knew it was good to put in questions.” After writing down three or four questions, the user realized that his questions were not very important: “... they didn’t amount to much.” The following excerpt reveals the limitations of superficial questions that are not based on a deeper kind of thought process: “To understand the question, make it meaningful, there has to be something behind it, facts, some reality, a story ...” Unhappy with his questions, he decided to formalize “what he really knew”. These interpretations led him to devise a new rule about the order of the steps to follow in formalizing one’s ideas: “You have to begin by writing down what you know before asking questions” (Table 9).

5.2.4. Creation of new types pertaining to the content of the topic under study

The user had just carefully read certain parts of the database. He was attempting to enhance his own production by extracting arguments and wordings from the hypermedia texts. The decision to make such and such a selection was dependent upon his interpretation of what the author was saying. This interpretation was based on the activation of types pertaining to (1) the framing of the thought process, and (2) the relationship between the concepts developed by the author and his own personal experience.

The following excerpt demonstrates how the user framed his decision to choose or not to choose a given passage: “That doesn’t have much to do with that ... That may have some educational merits, for sure, but in early specialization ... I could even say that the guy isn’t talking anymore about what interests me ... This isn’t about teaching anymore and it isn’t really my field anymore.” To make this decision, the user went back to the questions stated at the beginning of the work session and tried to relate them to what the author was saying: “It’s still talking about ideas, the ones I had to start in fact. The questions are: What might be the advantages of starting young in order to become an expert some day in a sport? Well that’s the goal.”

In the following excerpt, the user mentions the possibility of relating a concept discussed by an author, with his own practical experience: “For example, the body schema, and all these things here, this idea here, that’s not what made me decide to take it. Not child socialization either. Those are ideas I like; I believe in them ... That’s connected to, I could talk for a long time about them, I could defend them, prove them, seeing that I taught sailing to school-age children. After all, I taught sailing to kids for 3 years, 7- to 12-year-olds, who grew up after that. You can easily see what it means to talk about socializing children through training in a sport.” The user attempted to get some clear, well-stated arguments about certain concepts that were consistent with his own practical experience: “I think he says it quite well, its something I know, but that I express poorly.”
Table 9
Excerpt of a protocol that demonstrates validation of the rule: “You have to begin by writing down what you now before asking questions”

<table>
<thead>
<tr>
<th>User self-appraisal</th>
<th>Underlying three-part sign structure of EUMs analyzed</th>
</tr>
</thead>
<tbody>
<tr>
<td>I wrote a paper on that; I did have two or three ideas before starting... I'm going to start with questions... Because I had questions that came to mind, because we had learned a little about that, about asking questions, about organizing around a topic, what important questions have to be stimulated, I mean... Yes, I hesitated, but the fact that I'd written that paper I knew it was good to put in questions; it would make me put things in order. In fact, I wasn’t very happy in the end with the three or four questions I’d put down... they didn’t amount to much... So, well, and after that I went into “I Know” and I put in there what I really knew... a question, it’s meaningless. To understand the question, make it meaningful, there has to be something behind it, facts, some reality, a story... questions can have more or less at stake.</td>
<td>Object: Put things in order</td>
</tr>
</tbody>
</table>

EUM 17
Write down general questions via the keyboard about advantages and dangers of early sports training and its effects on performance

Object: Formalize what I Know | Representamen: Questions don’t amount to much | Interpretant: - Meaningless questions do not enhance the thought process - To make questions meaningful, they have to be based on “facts, a reality, a story” |

EUM 18
Disappointed in one’s questions, so go under the heading “I Know” in Modélisa
5.2.5. Creation of new types pertaining to automatic procedures

The new types pertaining to automatic procedures fell into two categories: (1) ones about automatic procedures specific to one of the computer systems; and (2) ones about automatic procedures used to transfer information between the two systems.

Through a systematic exploration of the different Modélisa menus, based on a rational process, the user discovered some of the specific features of the system, as the following excerpt shows: “Because it was too long in fact; the max is 25 characters. I don’t think you can cut-and-paste from ‘I Know’ and ‘Vocabulary’. I found out that it didn’t work, so I started typing, because there was a cut-and-paste, but once in the vocabulary, it isn’t there … I went back to ‘Vocabulary’ and I entered the words by hand.”

Similarly, after extensive exploratory efforts and multiple attempts, the user — convinced that it was possible to transfer information between the two computer systems — discovered the subtleties of the procedure. His knowledge of the computer gave him the incentive he needed to try all existing cut-and-paste procedures and to combine them, as illustrated in the following excerpt: “I didn’t really know how to do a cut-and-paste from one to the other … You have to do a standard ‘copy’ from there and then a Modélisa paste … I figured it out once and then lost it.” The user’s difficulty discovering these automatic procedures cannot be separated from the learning plan. The following excerpt reveals how these discoveries contributed to what the user wanted to do: “As soon as I started the cutting-and-pasting, I was completely into it. I was really concentrating, I was thinking, I was reading carefully. At that point, I really intended to keep the document in the end.”

5.2.6. Emotional alternation between feelings of apprehension, enjoyment, and effort

Three categories of contradictory feelings were intertwined in the user’s course of action: (1) confidence/apprehension; (2) enjoyment/displeasure; and (3) ease/discomfort. These feelings changed as the user interacted with the multimedia system. The interaction generated an “emotional atmosphere” that modified the user’s involvement in the situation.

5.2.7. Confidence/apprehension

The following excerpt illustrates the user’s reluctance to get directly involved in working on the computer: “Here I’m getting a sheet of paper, because I’m telling myself that I should put down on paper what’s in my head, right away, I don’t really want to do it on the keyboard … It’s funny because in the beginning I was afraid to get into it, I needed a sheet of paper.” The fact that the system forced him to write down his thoughts directly under certain menu headings on the computer system got him over his initial reluctance, thereby opening up a new “field of possibilities” for him: “In fact, I didn’t write anything on the paper … After that, I got out, it gave me some confidence and I got out.” The user realized afterwards that this interactive involvement with the computer had an impact on his attention level and how much he applied himself, as the following excerpt shows: “And the fact of writing on the computer, I’m more careful about what I’m putting down … Compared to paper where I write whatever passes through my mind, and poorly on top of that, I have a lot of trouble and I can’t read what I wrote, or barely. Here I’m applying myself, I’m figuring out what my sentences will be. I’m doing it right.”

5.2.8. Enjoyment/displeasure

The user discovered a specific way of working in this computer environment. In the following excerpt, he compares working in this environment to that in a book environment: “Already when
you start writing, you concentrate on what you’re writing, you forget. I have more trouble doing it. I’ve
tried my hand at summarizing books, and in fact, I really get too far into the book and I get swamped . . . I don’t know, the fact of taking an entire passage and rewriting it is hard.” In contrast, the following
excerpt demonstrates the enjoyment he experienced in reorganizing his own ideas supplemented with
what other authors had written: “Nor is it the same quality of work as rewording something and trying
to reorganize it. It’s a lot of fun.” The automatic procedures that spanned the two computer systems
allowed him to conceive of a new way of thinking about a problem while being freed of the constraints
of writing. His enjoyment was drawn from this newly generated meaning. After this successful experi-
ence, the now-more-confident user attempted to explore the possible ways of creating links between his
different productions. The following excerpt points out the difficulties he encountered and the annoyed
state this put him in: “How do you create links with a structure? Well I can’t figure it out at all. And
here I’m wasting time, and in the end I’m going to do something, I got fed up . . . you’ll see, I spent
time on that. Here I spent a lot of time, I wasn’t getting anywhere.”

5.2.9. Ease/discomfort

The user had trouble finding an entry point into the multimedia system and felt that these “3
minutes of wandering” were very unpleasant: “It was hard for me . . . I was struggling . . . it was
obscure, distressing, there was no order in there and I couldn’t manage to start anything.” This
moment of stressful effort gave way to a feeling of freedom, once the user sought assistance in the on-
line help: “In fact, compared to the heavy feeling there was before, it really did the trick to get me
going, to go on in there, to have a stab at it.” At other times, his efforts had a fully positive con-
notation. At these points, the user was completely involved in what he was doing, as illustrated by
this excerpt: “I’m trying to state it in a better way . . . I’m thinking hard about what I’m going to say
. . . I’m concentrating a lot.” In the following excerpt, the user expresses a feeling of ease when he
realizes that an author’s ideas are similar to his own: “It’s easier in a text where the way of
thinking is like mine.” By contrast, when he had to understand a way of thinking that differed from his
own, the user was inclined to stop trying and resort to an avoidance strategy: “It works a lot better like
that. I don’t want to break away from what I know. If I see a text that’s too foreign to me, it’s hard.”

6. Discussion

The results of this study cannot be generalized to the activity of any user in interaction with
any multimedia system. However, they are valid and typical enough to be discussed and related to
those of other studies. Three essential features of the user’s course of action during interaction
with this multimedia prototype were brought out by this study: (1) necessary learning of the
multimedia system artifact; (2) implementation of intellectual abilities in interaction with the
multimedia system; and (3) exploration and search dynamics conducive to learning.

6.1. Necessary learning of the multimedia system artifact

The overall analysis of the user’s course of action pointed out both the complexity of the
learning process and the necessity of learning the system. Two characteristics of this learning
process are discussed below and related to the results of other studies.
First of all, as a cognitive artifact, a multimedia system does not improve a user’s thinking skills but transforms them by modifying the nature of the task (Norman, 1993b). In the environment proposed here, the user could not improve his thinking skills until he stopped organizing his work as if he were in a book-and-paper environment. He was forced to learn how the new device worked. In other words, he had to (1) learn how to interpret the on-line help, locate and remember the different menu headings in Modélisa, and find and memorize the procedures for cutting-and-pasting across the hypermedia and Modélisa systems; and (2) rebuild old procedures and knowledge, such as the standard cut-and-paste operation. This study shows how the user organized his work in this new environment as he tried to learn its basic spatial and functional operations via sequences like “Find out where you are in Modélisa”, “Get an overall picture and understand the steps proposed”, and “Look for ways of linking one’s different productions using hypertext links”. At the same time, the user related the new possibilities offered by the system to his own intentions. He was then ready to search for new work procedures and validate them via multiple trials. This ability to organize one’s work, i.e. to transform one’s intentions into actions, is fundamental in this type of complex learning environment (Linard, 1996).

Secondly, learning in an environment of this kind is dependent upon a user’s knowledge of computers and ability to take advantage of it. Two studies (Joram, Woodruff, Bryson & Lindsay, 1992; Owsten, Murphy & Wideman, 1992) on the effects of being skilled in word processing have shown that the greater the skills needed to use the word processor, the more successful users are in writing compositions on it. The ineffectiveness of certain man-machine interactions, such as difficulty linking the different parts of one’s production, can be interpreted in terms of the gap between “the actant”, defined as the way the user is integrated into the design of the device, and the user’s “posture”, defined as the way the device has become an integral part of the user (Akrich, 1993).

6.1.1. Implementation of intellectual abilities when interacting with the multimedia system

A local analysis of the user’s course of action made it possible to describe the emerging “search” objects of the user’s involvement in his interaction with this multimedia system. Analysis of the reasoning and learning phases where the user attempted to discover, appropriate, and validate new laws and procedures revealed the mobilization of three kinds of intellectual competence: (1) the ability to self-direct the learning process; (2) the ability to generate new knowledge in different domains; and (3) the ability to link concepts to prior knowledge and/or practical experiences.

By identifying a certain number of meta-interpretants in the user’s course of action, it was possible to account for how he controlled the learning process in his own way. These meta-interpretants highlighted some degree of learning independence and initiative. At certain times, the user ignored the system’s suggestions and defined his own learning route, as illustrated by the meta-interpretant “Using one’s own knowledge before referring to the database”. At other times, he took the initiative to search for ways to efficiently process the massive amount of information available to him, and he invented types like “reading selections” and “useful information sorting”. This approach on the part of the user can be likened to self-direction by the learner, defined as the subject’s desire to assume responsibility for his learning (Brockett & Hiemstra, 1991). Studies on self-directed learning readiness (Guglielmino, 1977) consider these abilities to be essential to the self-instruction process.
The creation of new interpretants during the user’s course of action revealed his ability to search for and solve problems. The construction of such interpretants in various areas — working mode, topic content, and automatic procedures — demonstrates both the user’s receptiveness to learning opportunities and his involvement in the act of learning. Because this involvement led to the mastery of new types, it contributed to increasing his confidence in his own capabilities. This confidence partly accounted for the user’s perseverance, even when he was having trouble. Among the reasons noted in the literature for this kind of motivation to learn are the characteristics of the working environment, which in this case not only presents the material in a way that is more stimulating and that requires more direct participation, but also has an interactive power, sends out an invitation to create, lowers the fear of making mistakes, and is void of judgments of the user (Grégoire, Bracewell & Laferrière, 1996).

Finally, a local analysis of the user’s course of action revealed his efforts to relate certain concepts found in the database to his prior knowledge and/or practical experience. This kind of linking process, accompanied by attempts to find anchors within the various dimensions of the person (personal experiences, acquired knowledge), contributed to the appropriation of new knowledge. Researchers in the field of integrated media agree that “non-linear links between pieces of information make it possible to examine a question from multiple perspectives that allow students to organize their knowledge in a way that facilitates its retention and transfer” (Barron & Goldman, 1994, p. 100).

6.2. Exploration and search dynamics conducive to learning

The user’s course of action exhibited a regular exploring and searching activity organized within EUMs like “Search for passages of text about the socialization phenomenon”, within sequences like “Search for keywords in one’s own production”, and within macro-sequences like “Look for automated procedures”. The search for precise, well-worded information and fast, efficient procedures, along with the establishment of relationships between diverse pieces of knowledge, were the user’s main exploratory routes. Two characteristics of this activity are worth noting.

First, the user’s mode of emotional involvement in the situation was tied to the significance he gave to his activity. This involvement opened up a “field of possibilities” and later determined the effectiveness of his work. For instance, directly writing down ideas from the computer keyboard was “unthinkable” for the user until this situation took on significance for him. It became meaningful when his intention changed into “produce something I can keep.” His apprehension about “getting into it” disappeared quickly after he wrote a few sentences, especially since he already knew “how to type with both hands without looking at the keyboard.” This gave way to a feeling of confidence. With this new goal and emotional state, the user was able to explore the system’s capabilities extensively. These results are reminiscent of the experiments conducted by Vygotsky on saturation during task execution (e.g. drawings by children). His studies demonstrated the dynamic interdependence between cognition and emotion, and the importance of meaning in giving an affective dimension to an activity (Clot, 1999).

Secondly, the user’s activity led him to search for new conditions for effective work. For example, he undertook a systematic search for automatic procedures that would save him time. After a few failures and unexpected outcomes, the user became more efficient and developed a
sort of automatic working mode that gave him a sense of direct involvement: “It’s really great to be able to paste. I felt like I was making progress … You select the text in your document and then if it’s no good, you delete it; you insert other things. You put in a few sentences of your own … it’s really great. It’s much faster than doing it by hand …”. Bodker (1989) spoke of a coherent and cohesive “flow of activity” to describe these particularly efficient moments in a course of action. In the above statements, one can find “transitions” from meaning to efficacy, and from efficacy to meaning, which contributed to the efficiency of the user’s activity. These opening-up moments in the user’s course of action are essential, for they constitute what Clot (1995), inspired by Vygotsky, called zones of potential development.

7. Modifications aimed at improving the multimedia system

This analysis of the user’s course of action on the multimedia system prototype allowed us not only to validate the design choices made, but also to propose modifications aimed at improving it.

The design features validated were:

1. the working mode, insofar as it promoted substantial user involvement in a personal thought process;
2. the interactiveness of the two computer systems, insofar as the user was able to retrieve and process various data items across systems; and
3. freedom of navigation within a variety of topics and different levels of abstraction, insofar as it enabled the user to make connections with his experience and knowledge.

The planned enhancements concern:

1. development of two devices geared to different user skill levels (one with a standard word processor instead of the Modélisa system, and the same device with a specific teaching aid for learning how to use Modélisa);
2. reorganization of each instruction topic in the hypermedia, at both the macroscopic (concept maps) and microscopic (titles evoking the key idea in a text excerpt) levels, in order to make it easier for the user to decide what to read;
3. restructuring of the user interface to include a navigation bar and a menu, so as to facilitate entry into the system and navigation; and
4. on-line access to learning goals, the problem space, and evaluation questions associated with the topic, so the user can self-assess the work done.

References


