AI & Soc (2006)
DOI 10.1007/s00146-005-0021-6

ORIGINAL PAPER

**F. Henri · P. Gagné · M. Maina · Y. Gargouri
J. Bourdeau · G. Paquette**

Development of a knowledge base as a tool for contextualized learning

Received: 29 September 2004 / Accepted: 10 August 2005

Abstract This project was undertaken to develop a telelearning knowledge base aimed at making specialized telelearning knowledge accessible to non-specialized practitioners in the field. The challenge stems from a rationale related to a user-centered approach for the software design process, which is focused on learning in the context of professional practice, the bridge to be built between expert and practitioner knowledge, as well as the knowledge valorization of the latter. In order to take into account users and their situated actions, a usage study was integrated in the analysis phase. This study allows the creation of procedural and contextual telelearning models, and also lists of needs. These results serve as a basis for formulating guidelines for the development of ontologies, for the design of the telelearning knowledge base user interface and telelearning knowledge base environmental description. This paper presents the guidelines and orientations derived from these models.

Keywords Telelearning knowledge base · Telelearning usage study · Usage study as part of software engineering methodology

1 Introduction

A multidisciplinary team of researchers affiliated to the CIRTA[1] chose an endeavor whose objective was to develop a telelearning knowledge base in order to provide access to the knowledge, developed by the researchers in the field, to

F. Henri (✉) · P. Gagné · M. Maina · Y. Gargouri · J. Bourdeau · G. Paquette
Interuniversity Research Center on Telelearning (CIRTA), Télé-université du Québec,
100, rue Sherbrooke, Quest, Montréal, Québec, Canada, H2X 3P2
E-mail: fhenri@teluq.uquebec.ca
E-mail: pgagne@teluq.uquebec.ca
E-mail: mmaina@licef.teluq.uquebec.ca
E-mail: yassinegargouri@hotmail.com
E-mail: bourdeau@licef.teluq.uquebec.ca
E-mail: gpaquett@licef.teluq.uquebec.ca

[1] The acronym CIRTA refers to the Interuniversity Research Center on Telelearning. http://www.cirta.org/

telelearning practitioners (Paquette et al. 2003). Their main challenge was to bridge the gap between expert and practitioner knowledge. From this perspective, the team decided to integrate in its software engineering methodology a usage study (Henri et al. 2005) on how telelearning is implemented to obtain results that can orient the conceptualization and the development of the telelearning knowledge base, according to the users' perspectives and their contextual learning processes. This paper presents a synthesis of this study on the actual uses of telelearning by teachers and trainers from different educational settings.

2 Theoretical framework

This study is based on a theoretical framework, which relates three main constructs: situated learning in the context of professional practices, cognitive flexibility and the conceptualization of software as a cognitive tool. These theoretical elements emphasize the central place of the user when designing software tools for professional practice contexts and respond to the needs of actively learning a complex domain.

2.1 Learning in action

Telelearning is an emerging domain that puts practitioners in situations where they must learn as they perform their tasks. Social learning theories call this phenomenon "contextualized or situated learning" as it is a function of the activity, the environment and the culture in which it occurs (Lave and Wenger 1990). Situated learning is opposed to the traditional concept of "schooling" that favors abstract and out of context knowledge (Herrington and Standen 2000). Taking place in the field, contextualized learning is more incidental than deliberate, as it happens within authentic contexts, social interactions represent an essential and critical factor for contextualized learning. According to Lave and Wenger (Lave and Wenger 1990), it is through social interactions that the learner commits to a community of practice that holds the beliefs and behaviors to acquire. Brown et al. (1989) stress the fact that situated learning is fulfilled through collaborative social interactions and through social knowledge construction.

2.2 Telelearning: an emerging and complex domain

Any knowledge base aims to systematically organize the elements comprised within a domain by responding to specific domain characteristics. The most salient characteristic of the field of telelearning consists of its emergence at the borderline of many disciplinary fields: instructional technology, communication, computing, cognitive sciences, didactics and many others. CIRTA's proposed definition of telelearning clearly shows this emerging status, the various contributing parent domains and the variety of situations it can relate to: telelearning refers to theories, practices and features of learning and teaching at a distance, and/or supported by information and communication technologies[2].

[2] http://www.cirta.org/eng/presentation.htm

Consequently, telelearning definitions include many related concepts characterized by rather fuzzy distinctions: e-learning, online learning, distance education, computer-assisted learning, computer-assisted communication, etc. Some researchers work on new definitions, up-to-the-minute theoretical foundations, which support the development of the newborn domain while others cope with this new reality in an empirical way. Practitioners learn through actions, using less formalized theories, different approaches and a rapidly evolving terminology. Consequently, a telelearning knowledge base should, on one hand, contribute to structuring the domain, while, on the other hand, it also needs to retain its ability to integrate new knowledge, describe emerging practices and interpret a developing lexicon.

Indeed, telelearning matches very well what Spiro et al. (1991) identify as an ill-structured domain, that is, a domain characterized by conceptual complexity and irregularities from one case to another. According to Spiro's cognitive flexibility theory, to become an expert of a complex domain, such as telelearning, learners must be able to develop knowledge representations by adopting different conceptual perspectives and putting different approaches into practice. They must also be able to produce a set of adapted knowledge units required to understand or solve problems from these representations. In order to facilitate the appropriation of an ill-structured domain, the practitioner's environment and tools must allow learning from multiple perspectives in various contexts.

Conceptual complexity means that each case or example of knowledge application implies simultaneous interactions between many complex conceptual structures (schemes, multiple perspectives and principles). For instance, designing a telelearning environment will bring the expert to consider the interactions between such complex phenomenon as a design model, a learning approach, student characteristics, competencies to acquire, content structure, media properties, etc. Those complex phenomena relate to many concepts, rules, principles and processes. Many domains share such properties, for example, medicine, history, literature or leading edge fields of generally well-structured domains, such as mathematics or physics.

Irregularity from one case to another implies substantial variations of conceptual incidence and interaction between cases otherwise considered as being from the same class. In the design example, two telelearning environment design cases will convince an expert to use and reflect differently upon some related concepts. As in the chaos theory that describes and predicts complex system behaviors, one could say that the equivalent of a "butterfly effect" is present during telelearning: identical actions within nearly identical situations, which present only minor, or even infinitesimal variations, may produce results whose differences are out of proportion to the initial variations (You 1993), hence the difficulty to represent and make available usable knowledge to solve a particular problem.

To illustrate this variability among cases in the field of telelearning, one can simply refer to the multitude of practices, which correspond to several techno-pedagogical realities, from the basic integration of telecommunication multimedia in a traditional classroom, to more advanced interactive multimedia models. Paquette (2002) identifies six main paradigms for telelearning instructional settings.

- The technological classroom model is identical to that of the traditional classroom. It is equipped with technology that is constantly located and used onsite. The classroom is open to outside information although it is not distributed over several places.
- The distributed classroom, a technological classroom distributed over many remote places, is equipped with a videoconference system and a variety of peripherals connected to a computer.
- The distributed hypermedia paradigm is related to individualized, autonomous and self-managed learning. Generally, it is free from trainer interventions and interactions with other learners. The course content and its multimedia instructional material are prefabricated and broadcasted locally, online through internet or in a hybrid fashion.
- Online training is another paradigm that relies on the internet. Managed by an instructor who presents material and coordinates asynchronous activities, it allows a group of learners to progress at their own pace according to the steps defined by the instructors. It also provides users with custom-made instructional material and the possibility of interacting with one another.
- The community of practice is based on the voluntary participation, the exchange of information and discussions concerning a task conducted in a work environment. It gathers experts from the same field who share common concerns. The activities undertaken by the community are supported by a group leader rather than a traditional instructor. The members of the community acquire knowledge and skills through discussions and the production of artifacts.
- Electronic performance support systems are centered on professional tasks, such as the ones described in the aforementioned model, although in a different manner. Training is individual- and closely linked to the learner's professional activities. Electronic performance support systems can be used before, during or after a task is completed.

2.3 Conceptualizing software as cognitive instruments

As a component of the software engineering process, the analysis and specification of needs represents a crucial step in the life cycle of the software. However, one criticism addressed to developers is that they view the development of tools only in terms of "human factors," considering the user as a simple, universal beneficiary, instead of thinking in terms of "human actors" as independent, creative users of the tool (Bannon 1991). Moreover, Rabardel (1995) suggests that developers should focus on users and involve them in the tool design process, prompting the user to see it as a cognitive instrument.

The tool acquires the status of cognitive instrument once it is integrated in the users' mental schema when they can proceed to the functional integration of their internal and external resources, in other words, when the mind and the cognitive instrument are free from functional boundaries (Kaptelinin 1996; Kuuti and Kaptelinin 1997). The cognitive instrument is thus an entity that includes two components: the technical object, or the artifact, and the associated utilization schema constructed by the user. The cognitive instrument is thus considered a usage action tool created by the user during an activity. The global tool creation thus falls into a loop instrumentation process: designers define operating modes by observing the schema constructed by the users before they determine new operating modes from the schema. The cognitive instrument developed and refined throughout its usage in a specific situation is consequently embedded in the user's context and developed by the user while performing a set of tasks. Thus, the notion of use is closely associated with the concept of the cognitive instrument.

In Bélisle et al. (2002), the notion of use is considered "a social activity, defined by its frequency, which consists of exploiting something, in order to use it for a specific purpose and to apply it in order to satisfy a need. In usage studies, the object [no tag]usage' refers not only to practices, but also to behaviors, habits or attitudes. A practice is a set of established habits and concrete ways of behaving. The behavior (task performance) covers in part the practice since it is composed of all of the individual's reactions, which can be observed objectively. Speaking of use, rather than talking about practices or habits, focus on possible measurable regularities regarding the way a user uses a tool or a service" (op. cit. pp 9–10)[3].

2.4 Using ontologies to build a telelearning knowledge base

From a philosophical perspective, if the user must be moved to the forefront of the design process of a new telelearning knowledge base, from a technical point of view, knowledge representation and modeling are at the heart of the system. An ontological engineering approach was chosen in order to develop knowledge models that constitute shared references by the members of a community, experts and practitioners together. The ontology stems from a consensual description of a specific domain and assists communication. It allows human–machine collaboration by making sure that everyone shares the same understanding and uses the same terminology to reflect the same meaning (Guarino and Giaretta 1995). For further discussion on the notion of reference, see M.-L. Bedbetter, P. Cottier, C. Schmidt and P. Tchounikine, in this volume.

In this specific case, ontologies will allow developers to reflect on how users structure, understand and depict their knowledge related to the field of telelearning. Thus, a domain ontology elaborated by experts, linked to a task ontology, which reflects the complexity of practices may allow the usage of a telelearning knowledge base to stimulate genuine contextualized learning.

3 Methodology

In order to take into account the potential users and focus on the nature of the tasks they need to perform, it was decided to integrate a telelearning usage study into the analysis of the knowledge base design. The data collected would provide information about the practices and the cultural environment where they take place. Telelearning uses were investigated in an attempt to determine practitioners' schemes, needs and expectations. This approach allowed a deeper understanding of telelearning practices, to bring out their complexity and to formulate a hypothesis on potential telelearning knowledge base use.

[3] Translator's note: this consists of an unofficial translation.

The usage study coupled with cognitive results analysis appears to be an appropriate combination of methods. The first method provides sufficiently reliable results on which to base the software tool design, while the second allows their presentation as models, which are usable in the later steps of the developmental process.

Due to the span and complexity of telelearning, it was decided to limit the focus of the study to the design and production of telelearning courses and material. This decision was induced by a focus group of telelearning practitioners and subsequently confirmed through recommendations of a steering committee composed of representatives from both secondary and higher education experts and practitioners. The study was carried out with a group of five practitioners, namely one trainer from an industrial setting, one high school teacher and three instructors of higher education. Two of them were experienced telelearning users and three were intermediate users. The five participants were assigned to one of the five cases, two of them concerning telelearning applications in a distance education mode, while the other three involved telelearning in a mixed mode, combining both distance and presence situations (Table 1).

The following section presents a brief description of the five cases under the microscope.

In Table 1, the letter A refers to an education instructor in a university setting who is involved in a subsidized inter-university project whose goal is to elaborate a shared computerized instructional environment involving several universities in order to offer an instructional theory course at the bachelor level. Letter B pertains to an instructional technology university teacher who publishes an online course for graduate students in the field of education. This course uses a mixed formula where live meetings alternate with work and study periods all centered on a custom-made Website. Letter C takes place in an industry where the informatics VP chose to experiment with e-training. An instructor was asked

Table 1 Case distribution according to three criteria

Education Setting								
High School		College		University		Industry		
								Beginner (Familiarity with TA)
		E			A	C		Intermediate (Familiarity with TA)
	D				B			Experienced (Familiarity with TA)
Distance Education	Mixed Mode	Distance Education	Mixed Mode	Distance Education	Mixed Mode	Distance Education	Mixed Mode	
Types of Situation								

to use the LearningSpace environment in order to develop a personalized course for factory personnel concerned about a specific manufacturing process. In the case of letter D, a French teacher in a private secondary school accepted to carry out a school project designed to integrate computers in the learning process where all students have their own laptops. Finally, the letter E is related to a development project that involves a group of colleges who wish to broadcast complete study programs online. This case involves a teacher with a 1-year contract who is developing a general chemistry course online.

Data was collected during structured interviews, which were analyzed by the ATLASti software for data qualitative analysis, from categories established a priori as well as those emerging from the analysis. A first set of models derived from the analysis was submitted to the practitioners for validation. For each of the five cases, three conclusions emerged: a contextual model, a procedural model of the activity (task model) and an organized list of needs. Inspired by the notion of situated negotiations of meaning (Deschênes 1988), the contextual model describes the organizational contexts where the activity takes place. The procedural model was created using an object-oriented modeling program called MOTPlus[4], a solution, which allows graphical representation of procedures, concepts, principles, input and output. Finally, generic, contextual and procedural models were created from the specific models.

4 Results

Contextual and procedural generic models, and also a list of needs constitute the results of the study and serve as a basis to formulate the orientations and guidelines for the development of telelearning ontologies, the design of the interface and the description of the telelearning knowledge base user environment.

4.1 Generic context model for instructional design

This context model includes five factors intervening, which guide the practitioner who designs the telelearning system. They are the factors related to the task, the environment, the production of working documents, the actors involved in the process and the sources of information. The following section offers a summary of the generic context model.

The telelearning practitioner acts within a formal training system. They are either hired on a fixed-term contract to develop a telelearning teaching/learning unit or assigned as part of regular personnel member to carry out a telelearning project within a flexible time frame. This often consists of adapting an existing course for a well-known student population, and in some cases, a secondary target group of learners with similar needs. The practitioner acts in a specific situation, considering the organizational and academic constraints concerning various elements, such as the human and financial resources available to conduct the project, a set of rules and academic processes to follow, some academic and professional freedom regarding content, learning objectives and the telelearning process, and also the access to telelearning training. During the course of his activity, the practitioner produces various types of documents, which are used to

[4] MOT^Plus http://www.licef.teluq.uquebec.ca

obtain administrative approbations, to deliver draft versions of the final material, but mainly to communicate with cooperating colleagues. Indeed, the practitioner often works with a team and constantly interacts with representatives, colleagues and sometimes potential users of the telelearning environment under construction. All practitioners do not possess the same degrees of the skills required for their project and these skills are enhanced through training activities or meetings with experts and other actors who possess such skills.

The practitioner also takes on the roles of project manager and resource coordinator. Three types of actors are involved in his project: the officer who commissioned the project (director or administrator), the colleagues or teammates (instructional and computer professionals and instructors) and the learners (end users). The project commissioner is involved in selecting the design process, the task constraints as well as the project contents when the designer is a consultant. The colleagues are involved in four design elements: content, instructional choices, media and broadcasting. In spite of being responsible for the project, most of the time, the practitioner does not have a level authority. As for the learners, their role consists of providing feedback, either during the actual courses or during prerelease testing.

Practitioners tap into various sources of information to accomplish their work. They interact with several people, especially those involved in the project, who provide them with information pertaining to the content, the instructional design process and the software used in order to develop or broadcast the course. They also work with a variety of documents, for example, various reference materials, design and production specs, sample instructional activities, material currently being used in the course and students' assignments.

The context model shows that certain aspects can vary: the duration of the project (unspecified or determined in a contract), the employment pattern (full or part time), the material and software used (different types of environments, technological tools and resources), and participants' autonomy while using the technological tools required for the project. All things considered, three main characteristics describe the practical context of instructional design: time-specific projects with variable geometrics, the intervention of several people from various trades who are not necessarily supervised by the designer, as well as the recourse to various sources of information.

4.2 Generic procedural models for instructional design

The key elements of the procedural model are related to the level of consistency between the practitioner activities and the instructional design models[5], the

[5] For the purpose of this study, the instructional engineering methodology, MISA (Paquette 2002) divides design into four-axes (i.e., knowledge, pedagogy, media and broadcasting), which are developed into six phases (i.e., project definition, initial solution, design of the learning system architecture, design of instructional material, material mediatization and implementation of the learning system). This exhaustive planning method excludes the implementation of four other "external" processes [i.e., (1) design and (2) production of instructional material; (3) project management and (4) management and implementation of broadcasting]. As the design activities are always associated, if not interwoven, the processes, which are external to the design were nevertheless included in the analysis when courses were broadcasted and used for testing or course improvement activities.

importance of designing knowledge content, the resources required to carry out instructional design and computer productions, the need for teamwork and competent project management. This indicates the emergence of a new model for instructional design.

In general, practitioners do not use formal design methods. Nevertheless, their work covers many of the tasks planned in the reference method, although not in a systematic way. Thus, they mesh together the various design phases, casually switching from one to the other.

In the initial phase, the practitioner does not systematically formulate problem definitions. The basic data pertaining to the design decisions are therefore not explicit nor are they justified. Practitioners also disregard the formulation of learning objectives. On the other hand, in the initial phase, they make two decisions, which become the basis for the design. In general, they initiate the design by formulating a media and broadcasting solution rather than addressing specific learning problems. Moreover, their activities are focused on organizing knowledge, which becomes thereafter the main theme of their activities.

The second phase is characterized by the emergence of decisions, along with those regarding media and content, pertaining to instructional orientations and the program proposed to the learners, although this last dimension is not detailed in a systematic way nor is it considered a distinct design object. In the subsequent phases, the planned elements are implemented through the development of a prototype or a mock-up, the production of instructional material and the validation of the course.

4.3 The needs of the practitioner

Practitioners formulated several types of needs. The first category concerns the competencies pertaining to instructional design, mainly planning skills (analyze contents, identify training problems, assess feasibility). Practitioners wish to enrich their repertory of solutions to telelearning design problems while remaining creative. Other competencies pertain to the mediatization of documents, from the mastery of the rudiments of ICT technology to Website development. Two other competencies are related to the knowledge of instructional approaches generally associated with telelearning: integrating material, teaching through projects and exploiting cooperative pedagogy.

To develop these competencies, aside from the autonomous learning activities designed to help learners to master development tools, practitioners appeal to telelearning experts and colleagues. They also wish to have access to telelearning activity repertories in order to stimulate their ideation. Moreover, from their affiliated institutions, practitioners expect to obtain financial support and flexible work schedules to allow them to pursue learning activities.

Aside from training issues, practitioners brought up other conditions necessary to perform their telelearning activities. Indeed, they wish to take on assistants, such as media and computer specialists, and in particular people who can service the equipment. They would like to obtain more peer feedback regarding their products and ideas. Practitioners are also concerned with the stability of human resources, as support must remain available after the project starts up or from one project to another. As for the technological resources, practitioners would like to have access to collaborative computer tools. Finally, regarding organizational resources, practitioners are concerned with the protection of their intellectual property, access to funding not only for the start-up, but also for project maintenance, the standards, which facilitate collaborative work and the exchange of productions, recognition of the specificities of their workload from their institutions, regular upgrading of their production equipment, and also a flexible organizational work structure.

5 Discussion

The following statements summarize the results of our study.

- Practitioners do not seem to respect the rules defined by pedagogical engineering experts. Thus, the results of this study indicate that the approach to teaching design with sequential and ordered phases is bygone. The current technology (online course platforms, Web and multimedia production tools) makes it possible to carry out these steps simultaneously. However, the fusion of these procedures does not make it possible to determine which activity is related to which step, as the roles are amalgamated and consequently become less evident. The complexity of the tasks is thus enhanced and the need to master a wider set of competencies and an approach, which is not as systematic as the instructional design does not favor the coherence and quality control sought by experts.
- In several cases, an online course is gradually built (work in progress). This never ending work evolves with the content, the learners, and the needs and competencies of the practitioner. In this evolutionary process, the practitioner manages the course components and broadcasts these components online, section by section, as they are actually built. Following the learners' evaluation, provided that they have the required competencies, the practitioner modifies these elements without necessarily resorting to an intermediary. They remain in charge of the course and the institution plays a minor role, solely managing the technical operations pertaining to the actual broadcasting.
- Practitioners develop or adapt their working process according to each project, in terms of their knowledge and the situation at hand, juggling as many different processes as the number of projects. Consequently, there is a substantial irregularity from one situation to another, a characteristic of ill-structured domains.
- In theory, when reflecting upon their practices, practitioners wish to further refine their competencies by accessing other points of view from experts or other practitioners. Thus, they demonstrate an opening to other perspectives on problems that they have been confronted with.
- In practice, the practitioner often looks for specific answers to questions that contain a reliable guiding principle. They do not necessarily make conscious attempts to increase their levels of competency.
- A frequent question often requires a precise and prompt answer due to situational constraints. They call for declarative and procedural information (what to do, how to do it) and rarely for contextual answers (why this, when to do it).

All in all, it seems that the practitioner's (Gibbons 2001) activity can be explained with Gibbon's phases of progressive acquisition of design competency [16]. The design activities reported correspond to the two first phases, which highlights the prevalent importance of the media and content. According to Gibbons, the two other phases, which are centered on strategies and models are generally reached through experience, when they understand that the media and the content must be considered within a context and a duly justified pedagogical framework, and that design modeling, a more systematic approach, prevents them from having to reinvent the wheel.

As for the collective dimension of design, these results seem to indicate that the telelearning knowledge base will be used by individuals who, at least, will have to negotiate new knowledge with other people.

- In a punctual or continuous manner, the practitioner negotiates with other actors (representatives, colleagues and learners) on all aspects of the process as well as its content. This implies that the new knowledge acquired using the telelearning knowledge base would benefit from negotiations with other actors.
- The practitioner wants to interact with telelearning experts and other practitioners, more precisely within a community of practice setting. This finding implies that the telelearning knowledge base should give access not only to documents, but to people as well. Thus, this analysis highlights that through the use of this new knowledge base, the practitioner's perspective of telelearning will be confronted with the experts' vision of the telelearning ontology. Moreover, it can be derived that designing telelearning is a collective practice and the telelearning knowledge base should support practitioners' collective learning.

Taking these considerations into account, what guidelines and constraints can be formulated for the design of a telelearning knowledge base in regards to the harmonization of the language used by experts and practitioners and the collective learning dimension of telelearning?

The diversity of processes observed and the different levels of knowledge and skills demonstrated among practitioners indicate a gap between the language used by the experts developing the ontology and the language used by the practitioners who search through the knowledge base. How will the base understand practitioners' requests? How will the practitioner decode the conceptual organization of the expert? More fundamentally, the telelearning knowledge base must allow users to formulate questions and exploit the task ontology. Furthermore, the information provided by the telelearning knowledge base in response to the users' questions must fit within the conceptual telelearning map. The answers also have to generate in-depth clues for further information, other points of view and progressively allow the user to construct a more complex understanding of the field of knowledge. For example, the categories emerging from the usage study can be used to index the information contained in the telelearning knowledge base. Thus, the telelearning knowledge base knowledge models could be linked to different telelearning contexts and processes. In return, conceptual maps could allow the telelearning knowledge base to give a view of the domain areas related to the information provided.

Moreover, these telelearning knowledge base developmental guidelines may support two types of learning sought by practitioners. First, practitioners in action need "just in time" and "just enough" types of learning, without anticipating the conceptual complexity of the domain and the multiplicity of possible answers. Secondly, when away from the action, practitioners appear to be ready to spend more time and effort to learn how to formulate problems from other perspectives and to find consistent solutions. In this manner, the telelearning knowledge base could become a cognitive instrument that allows users to build their own conceptualization of the telelearning domain. It could be a basis for reflexive thought allowing for the development, extension and reorganization of the user's mental domain model.

Basically, telelearning is a collaborative practice. Thus, the knowledge acquired by the telelearning knowledge base user should be negotiated with colleagues in order to ensure practical knowledge transfer. This invites software designers to make the telelearning knowledge base not only a simple consulting system, but also a support tool for social learning (Wenger 1999). Designers should combine their usage with other tools that favor the emergence of a community of practice, such as group communication, knowledge-sharing software, tutoring and community support tools.

The content of the exchanges and the community's productions created around the telelearning knowledge base would permit the evolution of the domain ontology by taking into account how the users understand and represent telelearning. It would then favor the emergence of an open ontology representing the multiplicity of contexts built on the users' conceptualization. These guidelines may allow the telelearning knowledge base to become a contextual tool, from a distributed intelligence perspective (Pea 1993), where the intelligence is not only in the minds of the practitioners, but distributed among the members of the community in the form of activities, tools and practices they develop.

6 Design of a prototype

The first prototype of the telelearning knowledge base was designed according to the conceptualization of a system that is adapted to the users' profile, context and needs. However, this design has certain limits since the small number of participants who took part in the study prevents the development of all of the use cases associated with the plethora of situations and needs for the potential users. Other use cases must be elaborated according to the use of the system and the needs that will be detected in the future.

6.1 A strategic design of the system

The telelearning knowledge base must provide field practitioners with contextualized knowledge that is closely linked to the task. At the right moment, it must also be able to suggest various opinions and perspectives regarding a specific problem or task. Thus, the system was conceptualized as a device that searches for information through a relatively constrained dialogue with the user.

Influenced by the knowledge representation of the field and sub-fields of telelearning, it was designed with the use cases and data that resulted from the usage study. The dialog prompts users to describe their profiles and context, leading the system to acquire adapted, relevant information and knowledge that is integrated into a bank of learning resources (learning objects repository) in order to respond to users' requests or current needs. The dialog can act as a tutorial, in so far as it uses the ontological representation of the sub-field while taking into account the users' responses. Occasionally, the system requires users to determine their position within a formal representation of relevant sub-domains (ontology, diagram, etc.) (Fig. 1).

Users can thus reflect upon the way they structure, understand and perceive the domain and reflect upon its complexity and its multiple perspectives. Moreover, the dialog can be interrupted at any time in order to use the search engine and consult information related to the problem encountered by the system. Once the information is collected, users return to the same location where the dialog was interrupted. The system saves the information associated with the users' responses for the entire session (Fig. 2).

New dialog scenarios will be developed in response to the most frequent requests submitted to the system and the most recurrent problems encountered. This implies a joint operation, which consists of enriching the telelearning ontology while refining and enhancing conceptual networks.

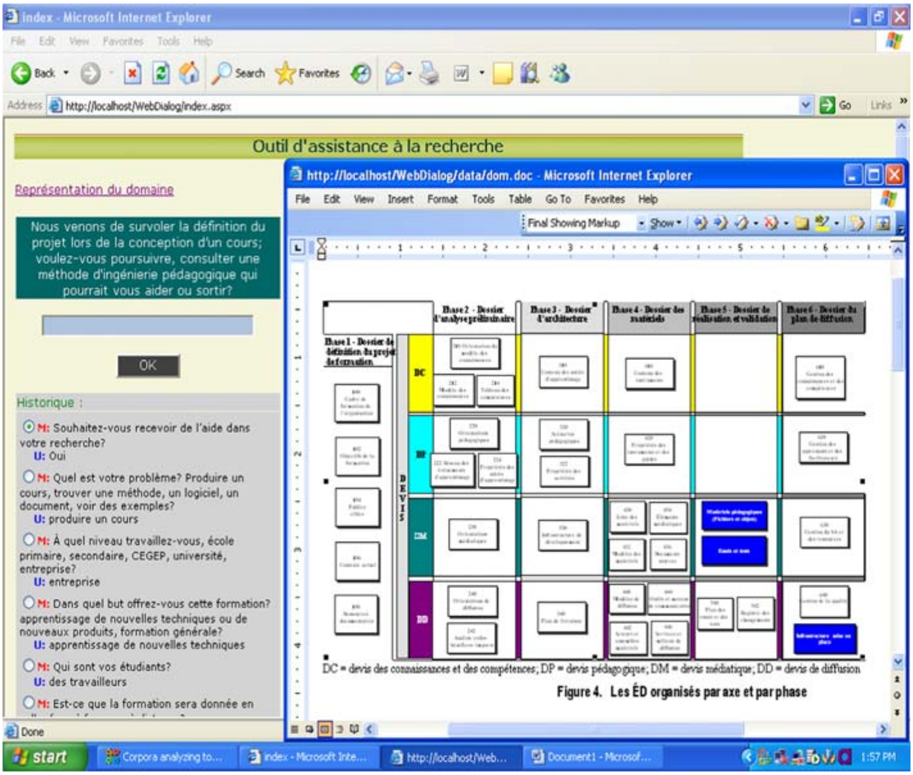

Fig. 1 Trace of dialog and associated knowledge map

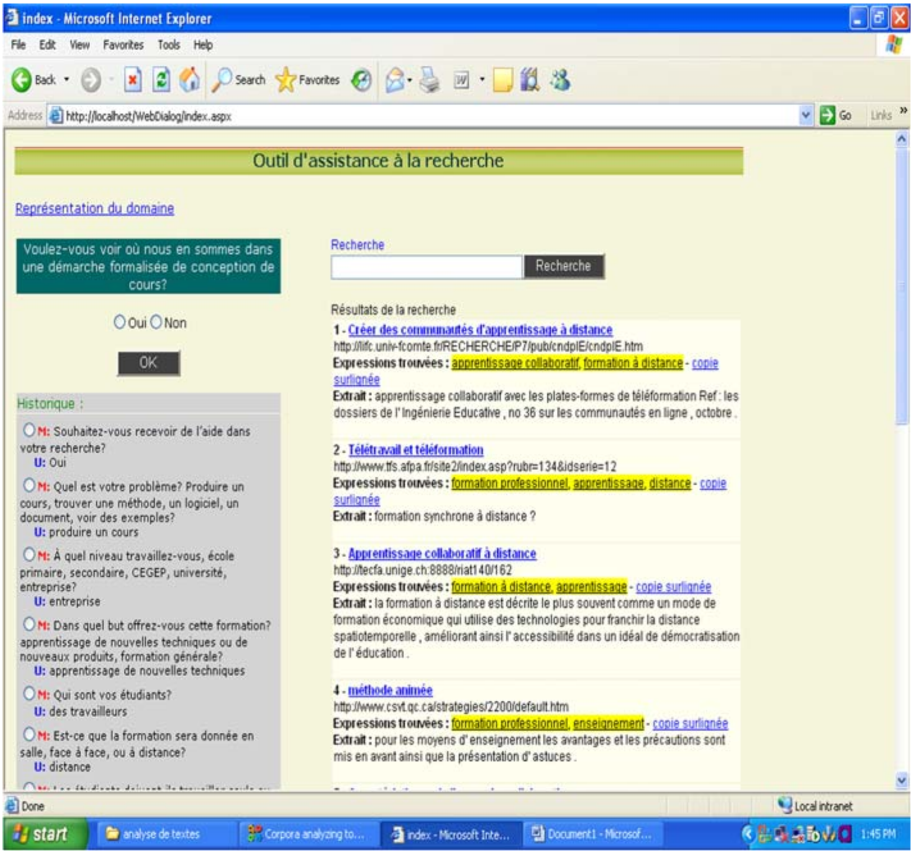

Fig. 2 Trace of dialog and suggested list of relevant resources

6.2 System operation mode

The system primarily comprises of four components: an ontology linked to a terminology bank, a dialog creation device, a bank of resources (research studies, scientific papers, reports, bibliographies, catalogs, learning objects, software, etc.) and a resource repository, which includes descriptive files of the resources (Loms collected via LomPad) and a search engine.

The ontology was created with the software MOT + . It is also supported by a tool, which allows users to search relevant corpus (provided by both experts and users) to find concurrent terminology and calculate the semantic distance that separates these terms. To harmonize experts and practitioners' language, a lexicon of relevant concepts, objects and procedures takes into account the vocabulary used by both actors. It includes true synonyms, quasi-synonyms (terms specific to a usage context, for example, "learning system" and "training device") and common expressions (e.g., in an industrial context, "to learn about new products" would point to "task training").

Dialogs are created with the help of a special device that responds to users' answers (Fig. 3): it can launch the search engine in order to explore descriptive files accessible through various search fields; it can continue the dialog or request to display the graphic representation of the sub-domains (ontology). The dialog creation device can handle a certain number of inferences, a feature, which prevents users from having to repeat certain information.

6.3 Ongoing developments

In its current state, the system solely supports a personal mode of usage, disregarding the collective dimension of telelearning practices and the practitioners' needs to belong to a telelearning community where discussions, knowledge acquisition and the development of competencies take place. Once this first prototype is further validated, the next stage of development consists of designing a second version that integrates components, which support teamwork, discussions and interactions in the communities. However, it seems obvious that the telelearning knowledge base can only evolve in so far as groups of users will be able to negotiate its use and learn to exploit this new system in a collective manner.

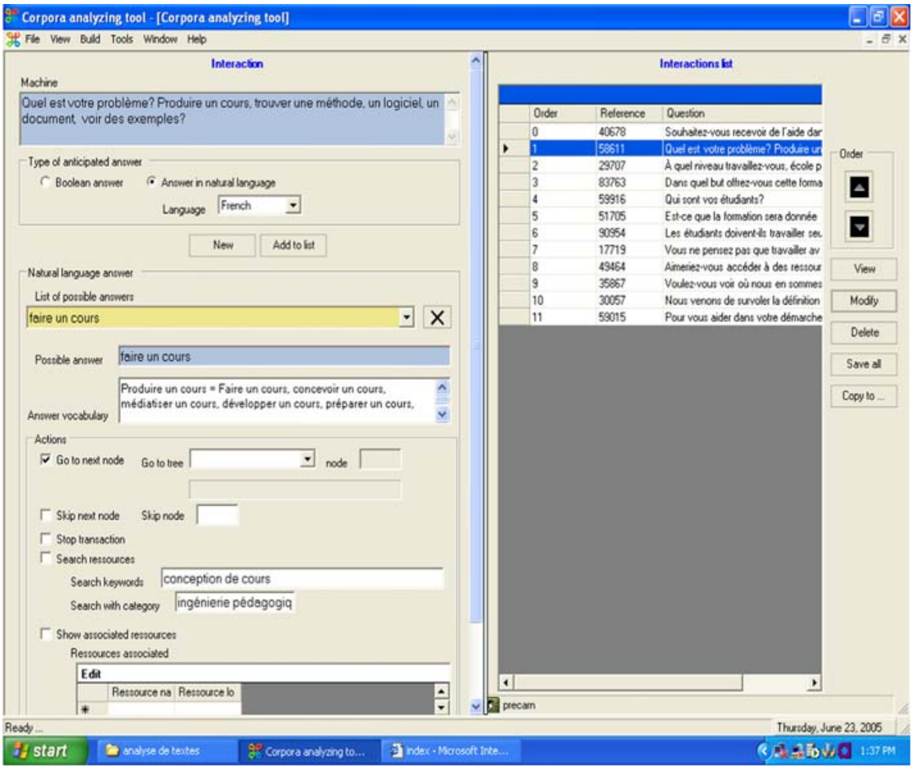

Fig. 3 Interface of the dialog creation device

7 Conclusion

The fundamental challenge of this ongoing project consists of providing non-specialist practitioners with access to specialized telelearning knowledge. It stimulates the elaboration of a theoretical framework herein exposed, related to learning in the context of professional practice, bridging the gap between the experts' and practitioners' knowledge spheres, and the valorization of the practitioners' knowledge.

The design and the development of this software creates a gap between the two types of logic. The user's logic—that expresses needs in a way that is closely linked to a specific situation and that is not always directly applicable to the design of the tool—confronts the developers' logic—that wants to take on a technological challenge. Negotiations between the two may lead to a consensus. This approach to software development suggests that a cognitive tool is by definition in constant evolution since mental schemes applied to the utilization of the tool are modified during usage which, in turn, stimulates the designer to continuously transform the tool according to new applications, the usage artifact. This ongoing work aims to emphasize the user role in the genesis of a software tool. The strength of this approach lies within the usage studies coupled with cognitive modeling generating valuable results as input to the software engineering process.

References

Bannon L (1991) From human factors to human actors. In: Greenbaum J, Kyng M (eds) Design at work. Cooperative design of computer systems. Lawrence Erlbaum Associates, Hillsdale, pp 25–44

Bélisle C et al. (2002) Étudier les usages pédagogiques des technologies de l'information et de la communication: une pratique de recherche ou/et de légitimation ? Étude PNER N°3, Maison des Sciences de l'Homme Lyon, 34 p http://www.pner.org

Brown JS, Collins A, Duguid S (1989) Situated cognition and the culture of learning. Educ Res 18(1):32–42

Deschênes AJ (1988) La compréhension et la production de textes. Presses de l'Université du Québec, Québec, 136 p

Gibbons AS (2001) Model-centered instruction. J Struct Learn Intellt Syst 14(4):511–540

Guarino N, Giaretta P (1995) Ontologies and knowledge bases: towards a terminological clarification. In: Mars N (ed) Towards very large knowledge bases knowledge building and knowledge sharing. NL. IOS, Amsterdam, pp 25–32

Henri F, Gagné P, Maina M (2005). Base de connaissances sur le téléapprentissage. Cadre de développement et résultats d'une étude d'usages du téléapprentissage. Rapport technique. Centre de recherche LICEF, Télé-université, Montréal

Herrington J, Standen P (2000) Moving form an Instructivist to a constructivist Multimedia Learning Environment. J Educ Multimedia Hypermedia 9(3):195–205

Kaptelinin V (1996) computer-mediated activity: functional organs in social and developmental contexts: In: Nardi B (ed) Context and consciousness: activity theory and human–computer interaction. The MIT Press, Massachusetts, pp 28–32

Kuuti K, Kaptelinin V (1997) Cognitive tools reconsidered: from augmentation to mediation. Paper presented at the Cognitive Technology, CT'97, Aizu, Japan

Lave J, Wenger E (1990) Situated learning: legitimate peripheral participation. Cambridge University Press, Cambridge, 138 p

Paquette G (2002) L'ingénierie pédagogique : Pour construire l'apprentissage en réseau. Presses de l'Université du Québec, Québec, 490 p

Paquette G, Bourdeau J, Henri F, Basque J, Léonard M, Maina M (2003) Construction d'une base de connaissances et d'une banque de ressources pour le domaine du téléapprentissage. Sciences et Technologies de l'Information et de la Communication pour l'Éducation et la Formation, vol 10, 17 p.http://sticef.univ-lemans.fr/num/vol2003/paquette-01s/sticef_2003_paquette_01s.pdf
Pea R (1993) Practices of distributed intelligence and designs for education. In: Salomon G (ed) Distributed cognitions: Psychological end educational considerations. Cambridge University Press, Cambridge, UK, pp 47–87
Rabardel P (1995) Les hommes et les technologies. Approche cognitive des instruments contemporains. Armand Colin, Paris, 239 p
Spiro RJ, Feltovich PJ, Jacobson MJ, Coulson RL (1991) Cognitive flexibility, constructivism, and hypertext: random access instruction for advanced knowledge acquisition in ill-structured domains. Educ Technol 31(5):24–33. http://www.ilt.columbia.edu/Publications/papers/Spiro.html
Wenger E (1999) Communities of practice. Learning, meaning, and identity. Cambridge University Press, Cambridge, UK, 318 p
You Y (1993). What can we learn from chaos theory? An alternative approach to instructional system design. ETR&D 3(2):17–32