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New Distributed Research Practices and Scientific Immersion of Graduate Students with the Support of Technologies: The Case of Mentor

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Abstract: MENTOR is a multidisciplinary research training program for graduate students in research field of mobility and posture disorders. Its members are distributed in a number of institutions across Montreal, creating challenges for the processes of collaborative research, joint supervision and scientific immersion. The purpose of our research project is to propose new distributed research and supervision practices supported by ICTs. In order to do this, we are designing a model of technological appropriation, taking into account the ongoing adaptation of the technologies and the evolution of the researchers' and students' practices. Collaborative working sessions are being observed in order to identify the pattern of the scientific community's activity. This will lead to the identification of actions and operations which should be supported by technologies and contribute to the development of scenarios which propose new practices of distributed collaborative research activity.

Context

MENTOR is a multidisciplinary research training program for graduate students in the field of mobility and posture disorders research. It was born out of the desire of a group of researchers in this field to further develop new collaborative multidisciplinary research practices for themselves and future fellow researchers. Members of this program form a mid-sized community of approximately forty permanent researchers and a varying number of students who take part in the program for one to three years.

The acronym MENTOR stands for the five objectives its bursary students are asked to meet: multidisciplinary research, team work, use of new technologies, scientific objectivity and the respect of ethical research rules. To reach these objectives, students are supervised by two researchers in complementary fields or in different institutions and often work collaboratively with another student also in a complementary field. They are asked to follow a specific curriculum, but the heart of their learning process comes from scientific immersion in the laboratories of their supervisors who, as mentors, guide them on the path to becoming researchers practicing a multidisciplinary research approach for mobility and posture disorders.

Researchers and students of the MENTOR community are located in five institutions and many more laboratories distributed across the Greater Montreal Area and beyond. This situation creates some clear challenges for the processes of collaborative research, joint supervision and scientific immersion due to insufficient communication means and traveling time to meet.

Purpose of Research

This research is part of a larger project, which aims at developing a renewed doctoral training approach and at facilitating researchers' adoption of new research practices. The latter will then be reinvested in the training of future researchers through the supervision of graduate students. To reach this objective, three levels of practices are being analyzed and modeled; the present project concerns the appropriation of technology by the research community, while two other projects analyze pedagogical and administrative practices.

This project aims at proposing new distributed research and supervision practices supported by Information and Communication Technologies (ICTs). In this first year, the goals are to identify which technologies are apt to support the new distributed research practices of this scientific community, to propose scenarios for the use of these technologies, and to prepare a test-bed for the resulting solution.

Problem situation

The boundary between learning about research and doing research is fluid in the MENTOR community. Both processes are inextricably linked and must be jointly supported. Because of this, learning done through laboratory research activities is more akin to social learning than to traditional academic learning (Gibbons & al. 1994). By participating in common activities, students and researchers develop a shared research practice.

Within MENTOR, learning and research work are guided by a multidisciplinary research approach, which necessarily involves collaboration between researchers and students of the community. This scientific collaboration can be found in many forms within MENTOR. Researchers of complementary expertise collaborate in varied research projects and participate in joint supervision of graduate students' research projects. Bursary students of different disciplines engage in joint research work, share data and exchange knowledge.

The multidisciplinary nature of this collaboration process brings together researchers and students from different laboratories and institutions. Collaborators are thus often distributed across geographical sites. Although the community uses traditional ICTs such as email, fax and telephone to communicate and lead some actions at a distance, researchers and students do not have access to technologies specifically designed to support a distributed scientific activity. This is particularly true for students who do not benefit from some of the institutional services that are available to researchers, such as an audioconferencing system, because of their high cost. The resulting frequent need to travel for researchers and students is an obstacle to the community's development and to greater collaboration between its members.

An appropriate technological environment integrating new and existing technologies should thus be made available in order to support the distance learning and collaboration process between researchers and students of the MENTOR scientific community. In order for this environment to become part of researchers and students' daily practice, it needs to be accompanied by an intervention process and methodological tools guiding the appropriation phase as well as the development of new distributed research practices.

Proposed Solution and Methodological Approach

Although communication between researchers is an important part of scientific collaboration, technologies solely enabling oral or written communication are not sufficient to support the entire process of distributed scientific collaboration. Technological environments designed for collaboration between distant researchers must instead support the different types of relationships that can be found between collaborating researchers, such as exchange knowledge, joint research, learning and socialization (Haythornthwaite 2006).

Collaboratories, or virtual laboratories where scientific equipment can be accessed from a distance and shared between distributed researchers, appear to offer such a support. Although existing collaboratories do not offer the same functions, they possess common characteristics. Successful examples let researchers communicate, exchange information, co-produce and access data, and offer tools for the coordination of research tasks (Teasley 2001; Chin & Lansing 2004).

But such technologies cannot be imposed. They must be accepted by the researchers and students if they are to be integrated into their daily practice. Moreover, researchers and students must be active participants during the design process and the necessary phase of appropriation of these technologies. Indeed, the introduction of new technology challenges and modifies current practices at the same time as technologies themselves are being shaped by a specific use (Rabardel & Bourmaud 2003).

In order to successfully support scientific collaboration and learning within MENTOR, we propose a solution that encompasses the design of a collaborative environment and the development of scenarios for its use. In our vision, “design” does not designate a delimited step taking place before the implementation of the solution, as is the case in most engineering-oriented approaches. Instead, we consider design to be an ongoing process where technologies are shaped and modified as individual or collective users are operating them.

The development of scenarios for the use of the technological environment is thus an important step of our methodological approach. It allows us to formalize in a very concrete manner our proposals of new practices of distributed collaborative research activity. These scenarios also show themselves to be efficient means of communication between our research team and the scientific community. Throughout the design process, they are used as boundary or intermediate objects to spark discussions and identify what the scientific community considers to be an acceptable solution. To develop these scenarios, collaborative working sessions, an important part of the scientific community’s activity, can be observed and modeled in order to identify their pattern (Cerrato Pargman 2005; Béguin & Rabardel 2001).

The resulting model of activity (Engestrom & al. 1999) is a first step in the appropriation of the proposed solution. It identifies actions and operations which should be supported by technologies in order for these sessions to be led at a distance. To further guide the appropriation of the collaborative technological environment by the researchers and students, the instrumental genesis approach of (Rabardel & Bourmaud 2003) is being used. On one hand, the instrumentalization process leads to the modification of the proposed environment to fit the researchers’ activity, and on the other hand the instrumentation process leads to the modification of their practice in order to incorporate the new system.

Five key steps account for the development of our solution:

1. Identify, with the advice of the scientific community, which interactions need to be supported by technologies in order to facilitate distributed collaborative research and learning within MENTOR.
2. Identify the conditions at which MENTOR researchers and students will integrate a collaborative technological environment into their daily practice in order to guide the development of the solution.
3. Make preliminary technological choices and assess their relevance and ergonomics during pilot-sessions and discussions with participating researchers and students.
4. Analyze the organization and the dynamics of small group collaborative working sessions and supervision sessions in order to develop a model of the co-located activity to be validated with the scientific community.
5. Propose and discuss with the scientific community scenarios for the use of a collaborative technological environment which are adapted to current practices, and plan a test bed for the proposed solution.

Analysis and Preliminary Results

The first step of our project aimed at identifying the type of interactions that need to be supported within MENTOR in order for distributed collaborative research and learning to be led at a distance. Small group collaborative working sessions and supervision sessions were identified as important moments of collaborative work within MENTOR. Scenarios of typical sessions were identified, described and validated with MENTOR researchers in order to gain a first understanding of the activity. Common characteristics for these varied collaborative working sessions and supervision sessions were found: two to eight researchers, students and research staff participate, meetings are opportunistic or planned shortly ahead of time, interactions between participants are organized around documents or research data such as medical images or gait laboratory data, and participants usually travel to one of the researcher’s office or laboratory where the session lasts for a few minutes to an hour.

Technologies used for these sessions can be grouped according to the type of tasks they enable. Typical office applications combined with infrastructures enabling communication such as Internet and private networks are used for planning the sessions and exchanging information and documents after it, and leading-edge research technologies used in the domain of posture and mobility disorders (e.g. Matlab, Visual C++, Anybody) are used in order to analyze and discuss data. Its main drawback, according to MENTOR researchers, is the time needed to travel between laboratories, considered to limit the frequency of such meetings. Moreover, researchers find it difficult to keep track of the sessions’ discussions and decisions. Indeed, the document or data sets around which the sessions are organized are annotated by hand on a printed version and parts of the discussion are illustrated on a traditional white-board or with hand-drawn notes and graphs. Documents and data sets must thus be modified after the session by a designated participant and sent to all participants for approval, resulting in cumbersome follow-up work.

The scenarios of co-located research work and supervision sessions give a first understanding of the context in which the solution will be used: sessions take place with few researchers and students who meet when they feel the need to exchange about, supervise, or engage in research work.

In the second step of our project, the conditions in which researchers will accept to integrate a collaborative technological environment into their daily practice were identified.

Firstly, discussions with MENTOR researchers highlighted three requirements with which the proposed solution should comply: both typical office applications and leading-edge research technologies must be accessible, informal communication and contact must be facilitated and decisions, modifications and discussion should be inscribed and accessible at a later time. As well, three main guiding principles for the development of the solution emerged. The technological environment and scenarios for its use should 1) integrate themselves in the existing laboratory settings, 2) let distance team work go on as if around a table or desk, and 3) be easy to use and access.

Secondly, a possible model of collaboratory supporting the MENTOR community's collaborative research and supervision practice was presented to core members of the community as a basis for a discussion on how technologies can be used to enrich their activity. The resulting discussion brought to light these researchers and students' priorities, additional requirements, learning needs and perceived obstacles. Four activities researchers and students wish to perform in priority were identified: lead distributed sessions for the supervision of students' research projects, access detailed information about researchers' scientific activity, exchange knowledge, and share, annotate and archive documents and data. Researchers and students also expressed two critical requirements when using a technological environment: there must be a complete absence of latency during interactive actions such as co-manipulating 3D images, and the security of data and documents must be guaranteed. The ability for external collaborators to access the environment was found to be a non-critical requirement. Participating researchers and students also expressed many concerns about the efforts needed to learn how to use such an environment; PhD students, in particular, do not wish to add to an already heavy workload. To ease the learning process, students wish to have access to documentation about the environment as well as to personalized training sessions available on-demand. Perceived obstacles to the use of a collaborative technological environment are the technical and financial resources needed for its set-up and maintenance; as is commonly the case in research communities, these resources are scarce within MENTOR.

In the third step of our project, a survey among MENTOR researchers identified which research applications they wished to share in order to do their collaborative work in a distributed manner. Based on the guiding principles, priorities, requirements, learning needs and obstacles that were identified, a collaborative technological environment was designed using commercial tools. Its consists of a peer-to-peer collaborative software with application sharing and videoconferencing functions, portable electronic blackboards enabling graphical annotations of shared files and the display of high-resolution images, powerful laptop computers with audio and video peripheral devices and an Internet network. This relatively low-cost environment requires little technical support and can easily be set-up in a number of laboratories, letting researchers as well as students access and use it at all times. With the use of the videoconferencing functions and individual headsets combined with application sharing, researchers and students can hold small group collaborative working sessions and supervision sessions in a manner resembling co-located meetings. Moreover, the environment can be used without reservations. It provides instruction manuals to guide inexperienced users or can be learned by exploration for users at ease with typical computer use.

The relevance and ergonomics of this solution was assessed during pilot sessions with six MENTOR researchers, students and research staff. Some technical problems were found and need to be addressed. Namely, latency during interactive actions, sound quality problems and inadequate support for the management of documents after the sessions were pointed out. Nevertheless, participants found the solution useful for presenting, discussing and co-modifying documents and data. They felt that such a solution would successfully enable them to pursue collaborative research in a distributed manner in many situations. Nevertheless, regular co-located meetings were still seen as necessary in order to maintain quality personal contacts. It was thus felt by the researchers that the proposed technological solution, with necessary modifications, was apt to support their activity.

In order to accompany the community's appropriation of the chosen technological environment by providing scenarios for its use, it is necessary to understand the current work pattern of small group collaborative working sessions and supervision sessions. For this, collaborative working sessions were being observed and modeled during the fourth step of our project. The subsequent model of activity for small group collaborative working sessions and supervision sessions obtained at this point is divided into two main parts: a sequential structure and unplanned interventions (see Table 1). The sequential part of the model shows an iterative structure where discussions are aimed at modifying the object around which the session is organized (document, data, idea not yet formalized). In the unplanned interventions, which take place anytime during the sequential structure, participants

step away from the process of modification of the object and reflect on the organization of their work, the approach they are using, knowledge they should acquire, differing points of view or facilitating their interactions. Key aspects of this model are facilitating participants' interactions and modifying the object of the meeting. The further observation of small group collaborative working sessions and supervision sessions will validate and refine this preliminary model of the community's current activity. This will lead to the development of scenarios where the collaborative technological environment enables both key and secondary aspects of the model. These scenarios, which will propose new practices of research and supervision work, will then be validated through a process of negotiation with community members as a first step in the appropriation of the collaborative technological environment.

	Sequential structure
1	Making contact
2	Session organization
3	Initiation of discussion on a subject
4	Individual and collective information seeking on a subject
5	Negotiation and decision making concerning the modification of the session's object
6	Confirmation of the modification to be made to the session's object
7	Request of approval to pass on to the next subject
	Unplanned interventions
	Organization of latter work
	Reflections on the approach used during the work / knowledge to be acquired
	Expression of expert status
	Impromptu training
	Expression of a new point of view on the session's object
	Expression of a new point of view on participants' role in the work to be done
	Facilitation of interactions

Table 1: model of activity for small group collaborative working sessions and supervision sessions

The validated solution will then form the basis of the planned test bed where distributed small group research and supervision activity will be analyzed and modeled in order to ensure that the chosen solution supports all levels of MENTOR's co-located model of activity for small group work sessions. The test bed will also reveal if modifications made to the collaborative technological environment will suffice to efficiently overcome the latency, sound and document management problems revealed in the first pilot sessions. This two-year period should bring modifications both to the technological environment and to scenarios adapted for its use within the research community.

Conclusions

We have found that technologies able to support new distributed research practices of the MENTOR scientific community must be accessible to both researchers and students in their current laboratory settings, facilitate participants' interactions and direct modification of documents and data, and require little or no technical support and learning. A collaborative technological environment designed with commercially available components seems to offer such a support, although further evaluation is needed to confirm that all requirements are adequately met, especially the absence of latency and the security of data and documents.

Scenarios proposing new practices of research and supervision using the collaborative technological environment are being developed. They need to enable all aspects of MENTOR's model of activity for small group collaborative working sessions and supervision sessions, concerning both sequential interventions aimed at the modification of the session's object and unplanned interventions concerning reflections, learning and interactions.

A test bed for the evaluation of the solution is to be conducted in the coming two years, leading to an evaluation of the use and appropriation of the technologies rather than restricting the evaluation to the environment's performance. During this period, both the technological environment and the scenarios for its use will be shaped by the renewed practices of research and supervision developed by the MENTOR research community.

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