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# E-science, E-research and E-learning: New Perspectives for Graduate Studies

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**Abstract:** The quality of education for doctoral students is closely linked to the quality of the research they undertake. Benefiting from technological advances, new distributed and collaborative research practices can be witnessed. The concept of *e-science* has emerged and evolved to the concept of *e-research*. These concepts bring about a new research philosophy and the notion of *collaboratory*. Our research project aims to develop a renewed doctoral training approach and to facilitate researchers' adoption of new research practices which will then be reinvested in the training of future researchers. Three general objectives have been defined: the rethinking of instructional model and objectives of doctoral training, the development of new technology-enhanced research practices and their reinvestment in graduate studies, and the development of approaches and methodological tools to support the preceding objectives. This paper presents the results of the first of a three year project.

## Context

Most current research agrees on the pedagogical factors responsible for student loss and the excessively long duration of doctoral studies. Studies which investigate students' opinions indicate that the academic experience has a significant influence on their decision to abandon their studies (Gemme & Gingras 2006; Golde & Dore 2001). The two most common factors linked to students dropping out of school are the inadequate design of programs and the lack of constructive supervision of students. In this context, an international consensus seems to emerge as to the necessity to undertake and rethink the instructional models and the objectives of doctoral training. This approach invites researchers to emphasise the process (training a researcher) rather than the product (the thesis.) They are also encouraged to assess students' competencies and development rather than the mastery of the subject matter (Enders 2004; Park 2005; Park 2007). Moreover, there is a need to balance doctoral training objectives in order to adapt them to the increasing diversity of careers, greater interdisciplinary collaboration and the internationalization of research. In order to do so, it is recommended to go beyond the traditional model of doctoral training that is centered on the master-apprentice relationship in a disciplinary context. As (Chubb 2000, p.18) states, "The old

apprenticeship model is a reflection of a less costly, less complex, less competitive and better resourced time [...] There are skills that are required of today's graduates that are different from ours and these are skills that will be best developed in an environment that is more structured and more coherent than the one we saw."

Improving the quality and accessibility of doctoral training also implies considering the diversity of the student population. Numerous doctoral students register in a PhD program while working and supporting their families as well as themselves (Park 2007; Butcher & Sieminski 2006). The challenge consists of designing high quality doctoral programs that offer training that is similar for all students, whether they are on campus or online, studying full-time or part-time. Such training would include *e-learning* strategies to increase accessibility and allow all students to become active in the research community of practice, while favouring the self-management of the learning process.

Doctoral students' quality of education cannot be seen as separate from quality of research in general. Benefiting from technological advances, new distributed and collaborative research practices can be witnessed. The concept of *e-science*, where an array of heterogeneous and geographically distributed human and technological resources is called upon, has emerged and evolved toward the concept of *e-research* in order to encompass social sciences and humanities. These concepts bring about a new research philosophy and the notion of *collaboratory*, based on knowledge sharing, transformation of research techniques and new security and ethical constraints. Although technologies can facilitate communication and knowledge sharing between networked research teams, they are not the only required condition to implement new e-science and e-research practices. Researchers often experience an uneasy phase of appropriation of these technologies. The appropriation happens both at the individual level, through a process of instrumental genesis (Rabardel 1995), and at the collective level, through a social negotiation of these technologies' use (Blandin 1997). This learning process brings a research community to develop a new framework for the use of technologies.

## Purpose of Research

Our research project aims to develop a renewed approach to improve the quality doctoral training, to enlarge its accessibility and to facilitate researchers' adoption of new research practices which will then be reinvested in the training of future researchers through the supervision of graduate students. Four general objectives have been defined:

1. Rethink instructional models and objectives of doctoral training according to a competence-based approach and adapt or re-design graduate studies programs so that they can be delivered in a distance or mixed mode;
2. Develop new technology-enhanced research practices and reinvest them in graduate training and research supervision;
3. Develop administrative and management models adapted to the delivery of international distance or mixed mode graduate studies programs;
4. Develop approaches, intervention models and methodological tools to support the preceding objectives.

## Problem Situation

Four academic graduate programs are involved in this project: the PhD in Cognitive Informatics, a joint program offered by the University of Québec in Montréal (UQAM) and the Télé-université (TÉLUQ), the training program for research graduates MENTOR in which the École de Technologie Supérieure (ÉTS) takes part, and two program projects at the School of Management Sciences at UQAM, the international Master and PhD in Tourism. These four programs share three main needs: 1) the appropriation of technologies for the development of new research and pedagogical supervision practices stemming from e-science, e-research and e-learning approaches; 2) the pedagogical adaptation of academic programs to the demands of these approaches; 3) the administrative adaptation of these programs to a distance and international clientele and the further development of international research and teaching collaborations.

The use of technologies as learning tools to develop future researchers' competencies or their use as working tools for researchers is surprisingly not widespread. Technologies for synchronous display of information across sites, distance research experimentation or virtual laboratories are usually not inscribed in researchers' practices. E-science and e-research are seen by the project's partners as a competitive advantage able to reinforce their research capacities and increase the quality of future researchers' training. They thus wish to develop a

framework for the development of leading-edge research practices that can then become models for graduate students.

To reach this goal, three levels of practices are being analyzed and modeled within three sub-projects: pedagogical, technological and administrative. At the pedagogical level, the modeling of an e-learning doctoral training approach based on competency development and students' research immersion in the scientific community has been undertaken. At the technological level, a model for the appropriation of technologies by a research community to conduct their research activity and to supervise graduate students will be proposed at the end of the three-year project. At the administrative level, traditional and distance graduate studies programs will be analyzed in order to develop a model for the management of international distance or mixed mode graduate studies programs. Interventions on all levels are thus proposed in an integrated manner to support e-science, e-research and e-learning.

## **Preliminary Results**

### **Pedagogical Modeling of an E-Learning Doctoral Program Based on Competency Development**

This sub-project aims to develop a new pedagogical approach for doctoral training and to create a model for renewed studies program and supervision practices. The PhD in Cognitive Informatics (PhD in CI) has been chosen as a trial program to develop this new approach. The work of this sub-project proceeds in four major stages:

1. Establish a consensus on the orientations that should guide the elaboration of the renewed program;
2. Create a model of the current program in order to explicitly state and formalize all its components;
3. Create a competence-oriented model of the renewed program which uses e-science, e-research and e-learning approaches;
4. Validate the renewed program with the program community and set a transition strategy.

At this point, the first two stages have been completed and the third is in progress.

During the first stage, discussions among the research group members lead to a consensus based on the following three key ideas for the elaboration of the renewed program: 1) offer a student-centered and competence-oriented program, 2) design modular teaching approaches which give more flexibility to the program and allow its adaptation to the needs of the students, 3) ensure students' immersion in a scientific community in order to facilitate the learning of the research field and new practices of distributed research. In order for the PhD in CI community to voice their opinion about these orientations and eventually adopt them, a meeting where the majority of active professors in the program participated allowed a debate and rallied the support of the greater part of the community.

The second stage aimed to offer a thorough description of the current doctoral program in CI as it is described and experienced. The modeling process made explicit the main aspects of the program, mainly the admission procedure, the competences that the program aims to develop, the knowledge being transmitted, the pedagogical principles that govern the program, the evaluation principles and the rules for students' progression in the program. This study brought to light certain deficiencies in the program, such as inconsistencies between learning objectives, knowledge taught and evaluation principles, particularly regarding the thesis. Whereas research today is almost always practiced within a group, the realization of the thesis is an individual activity where the ability to collaborate is not assessed although it is an essential competence for a researcher. There is a lack of instructions or definition of the joint supervision process and the concept of interdisciplinarity, two characteristics of the program. Some courses are unclear about several aspects: goal competences are not defined, evaluation guidelines are not formalized, and pedagogical principles are not explicitly stated. Apart from the supervision and joint supervision of the thesis, little connection is made between the different program activities and their contribution to the students' project. The process of modeling the courses shows that the pedagogical strategies used for on-campus courses are not appropriate for a distance learning context or e-learning. This is mainly because they are based on a transmissive teaching approach. In an e-learning perspective, training must be guided by a learning paradigm instead of a teaching approach, and pedagogical design must be tackled in terms of the activities to be accomplished by the students.

The third stage has been undertaken. It aims to design a new model for the PhD in CI which is based on the three key ideas on which a consensus was reached during the first stage and are confirmed by observations stemming from the PhD in CI modeling process of the second stage. At this point, the research team has identified four high-level principles that will guide the modeling process of the renewed program.

1. The program should be elaborated from a central repository of competences in which the generic competencies of a researcher are defined. It should also include competences needed in the cognitive-science domain identified by the professors of the program and agreed upon in the PhD CI community.

2. The student should be able to act in an autonomous manner, assess his own progress in the program and reach a clear understanding about the activities of the program, the competencies to be acquired and the research project he is carrying out.
3. The program must explicitly states and guides the joint research supervision conditions offered to support interdisciplinary research project.
4. The program must plan steady authentic research activities enabling the integration of students in the scientific community and the development of e-science, e-research and distributed research practices.

Taking into account these principles, the new program must now be modeled with a pedagogical engineering approach taking its origin in the constructivist paradigm.

The fourth stage will be the most important for the project. Its objective is to validate the renewed program and to propose a transition strategy for the adoption of the new pedagogical culture previously described as student-centered, promoting learner's autonomy and being supported by technologies. This stage should gain the professors agreement and participation in the development of the program according to the new model as well as a strong institutional support. It also assumes the broadening of the research community so as to integrate new international distance students.

### **Appropriation of Technologies by the Research Community**

The objective of this sub-project is to elaborate an intervention process and develop methodological tools able to facilitate researchers' appropriation of new technological instruments, and accompany them with the development of new e-science, e-research and research supervision practices. More specifically, the types of technologies needed by researchers to collaborate in scientific projects and supervise distance research projects were defined with the participation of researchers. In this sub-project, the research field is offered by MENTOR, a complementary graduate training program in the domain of mobility and posture disorders. The sub-project proceeds in four stages.

1. Identify desired uses of collaborative technologies and elaborate a solution adapted to researchers' needs with the help of a survey among the MENTOR researchers.
2. Assess the proposed solution during pilot-sessions.
3. Elaborate a conceptual framework and a methodology aimed at understanding the organization and the dynamics of small group work and research supervision sessions.
4. Plan of test bed for the obtained solution.

A survey was first carried out with MENTOR researchers. It aimed to identify which computer applications they wish to use in order to work in a distributed manner and which collaborative tools are needed to share these applications and supervise their students from a distance. It appears that researchers wish to use portable and easily accessible collaborative technologies allowing for synchronous communication and proximity. They reject complex technologies which require technical assistance, advanced planning of work meetings and the reservation of dedicated rooms. They wish to have access to flexible tools which let them communicate with their colleagues as easily as they do by phone.

In the second stage of the sub-project, a technological solution using commercial applications and tools was developed: peer-to-peer collaborative software with application sharing functions and videoconferencing, 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. The relevance and ergonomics of this solution was evaluated during pilot-sessions. The evaluation showed that the collaborative environment must possess some characteristics if researchers are to integrate it in their practice: absence of latency for images and sounds transmission and for interactive actions, high quality of images and sounds, good support of document management.

The third stage leads to the development of a conceptual framework and a methodology aimed at understanding the organization and the functioning of small group work and research supervision sessions. Following this methodology, collaborative work sessions will be observed to depict the activity pattern of researchers before the introduction of new technology (Cerrato Pargman 2005; Béguin & Rabardel 2001). The resulting model of activity (Engestrom et al. 1999) and scenarios proposing new practices of distributed collaborative research activity will be validated through a process of negotiation with the researchers as a first step in the appropriation of the proposed technological system.

In the fourth stage, a test bed of the negotiated solution will be conducted with the participation of researchers, thesis supervisors and doctoral students. This experiment will allow the exploration of scenarios where these technologies are used with respect to current work patterns and facilitate collaboration and distance thesis

supervision. In this sub-project, one of the main drawbacks is the long-range institutional planning and logistics required. As a consequence, the choice of technologies must often be done before knowing how they will be used and doesn't permit sufficiently long trial periods to better assess the adequacy of the technologies. Another difficulty lies in offering collaborative applications performing at an acceptable level to answer the very demanding needs of research and training programs in sciences in terms of data transmission.

### **Administrative Adaptation of E-learning Doctoral Programs**

This sub-project is concerned with the administrative and management of international distance education doctoral and master programs. Organizational changes to be implemented in traditional institutions are being identified, and inter-institutional partnership models are being studied. Using the concept of "stakeholder" (Freeman, 1984), the sub-project team is trying to understand the organization to be set up. According to this theory, an organization is a set of relations and transactions between the actors who develop «stakes» for the organization. «Stakeholders» are both within the organization (professor, student, tutor, coordinator) and external to it (international partners). Participants or stakeholders of different graduate programs in international partnership are identified. Understanding how these programs operate will enable the elaboration of proposals for distance training organizational models.

This sub-project is driven by the following four objectives:

1. Identify and describe the appropriate structures and procedures for international graduate training programs offered entirely at distance or in a mixed mode.
2. Design a model for distance program management within an institutional partnership.
3. Prepare an academic management guide for training programs offered entirely at distance or in a mixed mode.
4. Propose a model for an international master program in tourism delivered in a mixed mode.

In connection with the first objective, two case studies were realized. The first studies a short graduate program in Education related to the Environment (Research chair in Education related to the environment at the University of Quebec in Montreal- UQAM) and the second studies an international doctoral program in Education Sciences (University of Montreal and Agence Universitaire de la Francophonie)

Regarding the organizational level, these two case studies allow the following observations. There exists an academic management structure parallel to the institutional structure integrated in the Research Chair which does not have the mandate to develop distance training programs and manage them. This situation shows that traditional administrative structures are being bypassed and cannot rapidly adapt themselves to the reality of distance training programs. This situation implies that handling the regulation of the administrative functioning engulfs 50% of the average time devoted to the total coordination of the short graduate program (management and direction). The pedagogical team involved in the distance training doctoral program appears very committed to the success of the program and have improved its functioning on the basis of an analysis of distance training practices since 1998.

According to the participating professors, these programs also offer better supervision than that of a traditional doctoral program. In both case studies, a small group of professors, teaching assistants, tutors and a secretary ensure the program's functioning. The tutor does not hold the same functions in each program, but his role in pedagogical support is questioned in both cases. In the doctoral program, the pedagogical support of students is ensured directly by professors, whereas the tutor provides help to the student, whether technical or cultural for communication with foreign students (Africans) regarding their cultural code. The role of "filter" played by the tutor in the relationship professor-tutor-students is rejected. In the master's program, the tutor is always present; however, the professors and tutors communicate closely in order to better regulate the progression of students. Nevertheless, it is felt necessary to re-examine the role of the tutor and favour a direct relationship with the student, dismissing the tutor model generally offered in the undergraduate distant programs.

The structural and organizational innovation in distance training also involves changes of the organizational culture. Although some misunderstandings between the administrative world and the pedagogical world can be observed (Loisier & Marachand 2001), in both cases much importance is given to relationships of collaboration and negotiation between the two structures. Also, in both case studies, the distance training program is created, developed and maintained within structures that are not dedicated to training, but rather to an action-research oriented activity. Nevertheless, these structures are predisposed to tackle problems related to the integration of technologies in graduate training. They possess characteristics such as a flexible structure, a small number of staff, they are constantly in a mode of negotiation, they develop innovations and experimentations, and they reflect about practices able to improve how graduate training programs function.

## Conclusion

The work started in the first year of this three-year project indicates that there is still a long road to cover in order to shape the pedagogical, technological and administrative transformations that arise from our vision of doctoral training. It calls for a renovation of university practices and culture that cannot be imposed. In fact, our research project is concerned in the first place by the social and practical acceptability of the changes induced by the new approach we promote. Social acceptability is namely related to the transformation of the activity and the modification of practices and refers to whether new ways of thinking and of doing things are applied effectively. Practical acceptability includes usability, reliability, compatibility, and utility of structures, procedures and technologies that will materialize the changes.

Our goal is not to provide a predetermined answer to improve the quality of doctoral training, but rather to establish the inherent issues linked to it and to negotiation of an acceptable solution. Our work constitute a "border" or "intermediary" object that should spark discussions amongst stakeholders. We believe that dialogue and collaboration, the recognition of the different parties' various interests, as well as a solid institutional support are mandatory for the renewal of graduate training programs.

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