ORIGINAL PAPER

Multilevel Innovation in Remote Networked Schools

**Sandrine Turcotte · Thérèse Laferrière ·
Christine Hamel · Alain Breuleux**

Abstract Small remote rural schools in Quebec face an ongoing challenge to provide similar quality educational services than bigger schools. Since 2002, the Remote Network Schools (RNS) initiative afforded schools the opportunity to reinvent their practice by using online tools to experience collaborative learning activities with other remote schools. Teachers and students experienced quality learning and demonstrated agency by implementing the RNS in their context. Measures include: diversity of learning activities, quality of online classroom interactions, changes in teacher beliefs, and shifts in teacher and student roles. Our results show that it is a viable operating method for such schools and that other schools could contemplate implementing such innovative practices.

Keywords Systemic innovation · Collaborative learning · Classroom interaction · Rural schools

Introduction

A new perspective on small rural communities has emerged in Quebec, Canada. The local development perspective emphasizes the communities' endogenous ability to develop (MELS 2006; Prévost et al. 2003; Prévost et al. 2007). Such development does not depend, as it has all too often been thought, on external aid but, first and foremost, on their ability to generate their own objectives and to define themselves in relation to external frameworks and interveners. To the extent that the community's vitality depends on the school's vitality, the perception that the local community has of its school is very important. When

S. Turcotte (✉)
Université du Québec en Outaouais, Gatineau, QC, Canada
e-mail: Sandrine.Turcotte@uqo.ca

T. Laferrière · C. Hamel
Université Laval, Quebec City, QC, Canada

A. Breuleux
McGill University, Montreal, QC, Canada

asked how information technology could contribute, researchers put forward the idea of the remote networked school.

The *Remote Networked Schools* (RNS) is an initiative of the Quebec Ministry of Education, Leisure and Sports, a knowledge transfer agency (CEFRIO) and university researchers aimed primarily at examining the potential of information and communication technologies to enhance the educational environment in small rural schools. The initial phase of this project was carried out between June 2002 and September 2003 at three sites, and primarily in three schools, operated by three different school districts. Still ongoing, the purpose of this paper is to present and discuss the first results of the RNS project (Phase 1) which led to further funding and research into this major educational innovation.

Perspectives and Theoretical Framework

Building on a review of relevant efforts to achieve equality of opportunity through the use of digital technologies in countries such as Norway, the United Kingdom, Australia and Canada (see Laferrière and Breuleux 2002), we oriented the design of this initiative around the use of network technologies to support collaborative learning communities rather than information broadcasting and distance education.

The whole project was inspired by school success, educational reform, and innovation literature. Given the nature of the project, the systemic approach of Banathy (1991) appeared to be most relevant, especially his framework for thinking about new educational images and exploring and creating options for the design of learning environments. Banathy's framework is based on the following three dimensions: (a) focus of the inquiry (governance, administration, instruction, learning), (b) scope of inquiry (class, school, school district, environment, community, society), and (c) patterns of interaction (information exchange, cooperation, coordination, integration).

According to Banathy, the first dimension is attended to by asking which system level(s) is (are) the focus(i) of the change effort: the learning experience, instruction, administration, or governance?

The second dimension, the scope of inquiry, presents four options regarding the boundaries and the scope of the design inquiry: (a) the limiting boundaries of the existing system, (b) the broadening of the boundaries of the existing system in order to consider certain issues in the environment, (c) the extension of the boundaries of the existing system to include the entire community as the domain of design, and (d) the larger society as the space of design.

The third dimension, patterns of interaction, concerns the relationships between educational systems and other organizations and agencies. They may illustrate processes of (a) information exchange, (b) cooperation, (c) coordination and linkage, or (d) integration. According to Banathy (1991), this framework enables us to:

(a) portray the image of the existing system as a base-line against which the design from which to depart, (b) map the overall context within which to explore and create new images of education, (c) consider and create various alternatives to the existing image of education, by creating alternative images, (d) formulate criteria by which to select from alternatives, and (e) select from the various alternatives the most promising alternative and describe it as the new image. (p. 50)

In the present study, Banathy's model was adapted (see Fig. 1) to portray the multi-dimensional aspects involved in the RNS initiative. This approach will therefore frame the

**Fig. 1** Adaptation of Banathy's Model (1991)
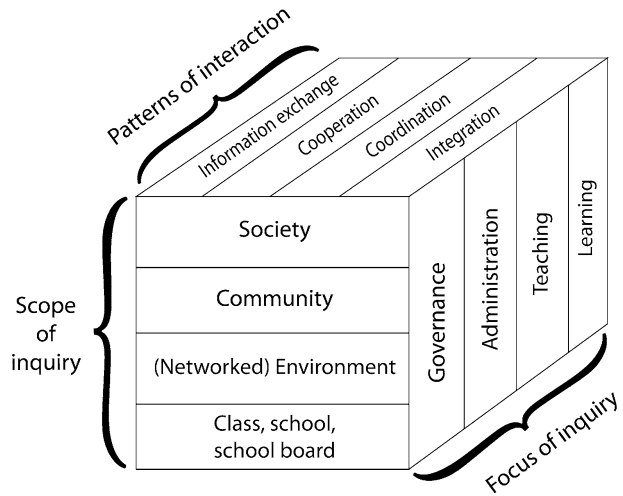
presentation and discussion of those results. Some of the results reported here relate more specifically to the innovative nature of the project. In these cases, Seidel and Perez's model (1994) will help us define them.

Building on a vast public consultation that has led to an important educational reform since 2001 (Ministère de l'Éducation 1996), it was clear that Quebec rural schools lacked social interaction as well as needed better equality of chances for their students. The Ministry provided the infrastructure (high speed Internet access and computers, human resources, etc.) but the classroom applications were the result of university/local actors participatory research design. In the classroom, the networked activities proposed to students were to emphasize the need for active participation and collaboration with their peers. This approach was based on constructivist and socioconstructivist learning theories that highlight one essential trait of successful learning, i.e., the active process in which the learner is involved (Bransford et al. 2000; Brown 1997; Brown and Campione 1994; Sawyer 2005; Vygotsky 1978). To ensure understanding, the learner must actively establish the conceptual links between what he must learn and prior knowledge. In this construction process that allows for understanding, social interaction (with teachers and peers) centered on communication, sharing, cooperation and collaboration plays an important role.

For teachers, it meant the integration of ICTs to teaching and learning in ways that were either incremental or transformative. For this reason, Seidel and Perez's (1994) model for understanding innovations with technology in education was chosen. Consistent with Banathy's perspective, this process model allows the consideration of multiple levels of target users of a technology (student, classroom, school, community), different stages of use (adoption, implementation, institutionalization), and two types of processes that can characterize the use of technology (assimilation, whereby the innovation is absorbed into pre-existing modes of operation, or accommodation, whereby new ways of working are developed in an effort to utilize an innovation fully). Seidel and Perez's model (see Fig. 2) will help us analyze more closely the innovation- related results of our study.

Fig. 2 Seidel and Perez Model
(1994)
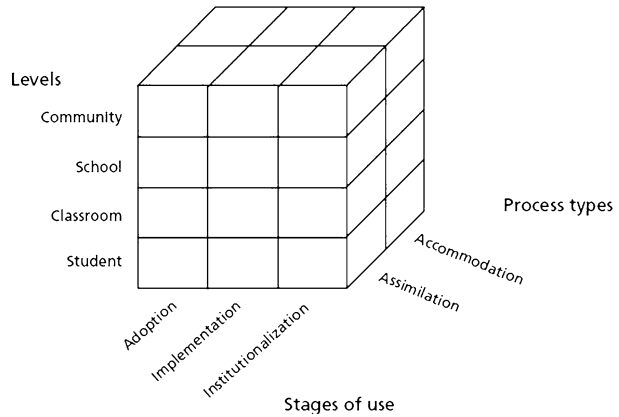
Method

In this study, the unit of study was the school, but the school as it connects to other schools
in a variety of ways: teacher to teacher, classroom to classroom, school staff to school staff
and across.

A participative design research approach was taken (Brown 1992; Collins 1999; Silva
and Breuleux 1994, Design-Based Research Collective 2003). This approach allows for an
intensive concentration of interaction between the interveners both with respect to the
project's realization and to its analysis. In this research approach, researchers are not
simple external observers but support the project's teams (teachers, professionals, school
management) and participate with them in formulating policy directions and implementing
activities. For example, the research team (1) supported the innovation design at each local
site according to each level of Banathy's scope of change, (2) documented the new pro-
cesses as they were implemented (short feedback loop), (3) encouraged decision-makers to
identify adequate actions, including the development of policies, for facilitating the
innovation process at the local level (e.g., slow down personnel turnover, keep personnel,
attract the best resources, sharpen school management role and exercise leadership), and
(4) assessed the conditions of innovation in place (Turcotte and Hamel 2008).

Reciprocally, the stakeholders participated in the researchers' analyses. For example,
they validated the collected data, they added categories to observation grids for innovation
and learning processes and they critiqued research results as well as their usefulness. They
also imagined new forms of professional development. We were not seeking, as is the case
in experimentation research, to isolate a variable in order to ascertain its effects but rather
by means of cross-sectional observations and analyses attempt to pinpoint the variables
that affect the results. Such examinations were conducted periodically and, at the con-
clusion of each iterative process, the findings were incorporated into the subsequent iter-
ation activities to ensure that the level of achievement would keep rising. Four times
throughout the duration of the project, researchers offered targeted evidence-based feed-
back to participants (local project steering committees, school principals, and teachers).
Research iterations were revised according to the actors' understanding of the results. New
observations were made following the actors' comments either because the researchers did
not think of them before or because they did not have access to them prior to their
discussions with the local actors. Suggestions were taken into consideration in the future

iterative design, for example a new dimension to the measurement of motivation was added to take into account project-based learning. Ely's (1990, 1999) conditions for innovation framed the first and, partly, the third feedback iteration to local participants in Phase 1. The adaptation of Ely's conditions of innovation to the specific RNS context was also done conjointly with the stakeholders. Interaction analysis results were offered as early as the second iteration. The fourth iteration presented learning outcomes. Teachers' belief changes were the main outcome regarding teacher learning, and it was found highly relevant because the scientific literature points to them as being critical. Ajzen and Fishbein's model (1980) was used to this end.

Schön's reflective practitioner model (1983) was also adopted. A *reflective practitioner* is someone who, while he or she focuses on his or her action, attempts to understand it through self-observation and cross-sectional observation, then to explain it by means of theoretical models. Through cycles of analysis and action, effectiveness is achieved when results meet the practitioner's goal. Since some individuals' knowledge could broaden that of other individuals, the participants were constantly encouraged to reflect critically on their action and to share with others the knowledge acquired during the innovation phase. As well as with regard to their ongoing participation in the research design, the RNS actors were convened to share their best practices with each other as well as with the decision-makers at all levels of the system.

Participants

The Ministry of Education was responsible for the choice of the school districts participating in the RNS initiative. First, after having consulted with their local actors, interested school districts submitted their candidacy to the Ministry. Their participation was thus voluntary. The research and intervention team was to adapt to each local context. Everything was new to everyone involved. The research team members brought their theoretical and practical knowledge to the table. The context of a new curriculum, based on the development of competencies, greatly facilitated its acceptance at the local level.

In Phase 1, three village schools were placed in a position to innovate along with other units of their respective school district. At the outset, researchers met with parents, political authorities and leaders. The school and the future of the children attending it were the focal point of the residents' concerns. There was widespread fear regarding the school's survival but the conviction that it must change its practices to enhance its vitality was not, generally speaking, apparent. However, the project was accepted, the innovative aspect of the technology used appearing useful to bolster the children's feeling of belonging to and pride in their school and village (see Laferrière et al. 2004).

Initially, three school principals and nine teachers accepted to carry out, as they saw fit, networked learning activities with at least one other school or other facilities. Knowledge Forum (electronic forum) was used to support asynchronous online progressive written discourse, and iVisit (desktop videoconferencing system) was used for synchronous oral communication. Participants sought to examine actual possibilities of networking learning activities in and between remote schools. Decisions were made with equal participation of the school teams, school district resources and the research team. It allowed for an intensive concentration of interaction between the interveners and researchers with respect to the conduct of the initiative and its analysis.

The research and intervention team provided information and data to school principals as regards the redefinition of their roles, and those of support staff. They also provided information and data to teachers as they designed activities relevant to the work of the

networked classrooms. The researchers presented the results in light of several theoretical models and we discussed with the actors what they believed was most useful to their practice and to the innovation process. Being from remote regions, thus far from any university, these schools had almost never participated in research projects before, and it meant that a university/school relationship was to be established. It was difficult for them to identify the kinds of measures and analyses they wanted to see occurring but, with the help of the researchers, the local actors (teachers, school principals, support staff) became more and more involved in the collaborative inquiry. They sought to examine how effective networking could occur, i.e., the conditions of innovation required, the activities afforded, the remedial measures adopted in the wake of initial observations, and the results achieved.

Data Collection

The research objectives and the different levels and foci of the inquiry required varied tools and techniques: ethnographic observation (captation of images of activities, participant observation, distribution of time spent on each type of intervention), individual and group interviews, administration of tests, questionnaires and evaluation grids (see Laferrière et al. 2004). Interactions that occurred between the pilot schools and their partner schools from the same school district and with university interveners and researchers were preserved in databases and several videoconferencing sessions were recorded. Support software for online ethnographic methods included email, the videoconferencing system, the electronic forum, instant messaging (chat), and a web-enabled database of observation reports and gathered digital artifacts (pictures, drawings, videos).

Quantitative measures of online activity and interaction were obtained through systematic observation. An ethnographic breakdown of the hundreds of hours of networked activities revealed various uses of the Internet for carrying out educational activities, the nature and quality of the social interactions supported on the network, and the resulting changes in teaching practice. Data was collected and analyzed periodically and, at the end of each of the four iterations, findings were incorporated into the subsequent iteration's activities for the level of achievement to increase.

Moreover, it was necessary to ensure that the innovation would not hamper student success by virtue of unfolding new practices. To this end, students' academic results were compared with their results from preceding years, and four distinct result profiles (higher results, similar results, lightly lower and lower results) were created to this end.

Data Analysis

The researchers engaged in an analytical induction exercise (Taylor and Bogdan 1998)—findings are formulated as assertions that must be confirmed by the data collected and not be invalidated by other data—and referred to models or grids to interpret them. To understand teacher learning, theory of reasoned action (Ajzen and Fishbein 1980) was referred to, and similarities and differences in pre- and post- teacher beliefs identified. Ajzen and Fishbein (1980) theory stresses that a person's intent as he or she does something is a major determinant of his or her behavior. The person's intent is itself determined by two factors: (a) the attitude of the person toward the behavior to be adopted, which is the result of his or her beliefs regarding the advantages and disadvantages that will result of the action to be taken, (b) the person's perception of the social pressure that he or she feels regarding taking the desired action. These results will be discussed in a future paper.

At the behavioral level, classroom processes were studied applying cultural historical activity theory (Engeström 1987; Vygotsky 1978) to the ethnographic data. We focused on the basic elements of the activity system, distinguishing and characterizing subjects (the person who acts), objects (intended results), techniques (the tools used), their community (classroom, school, school district, village) and the division of labor (apportioned and newly established functions and roles), and emerging rules (norms and conventions). These results were discussed in a different paper (Allaire et al. 2006).

The following section presents the results obtained and interpreted within Banathy's framework for designing learning environments.

Results

Focus of the Inquiry

The focus of the inquiry, which is the most salient dimension of Banathy's (1991) framework as it is the primary focus for the change efforts, was the learning experience. Indeed, learning was the primary level around which the entire project was built but the other levels (or constituents of the focus of the inquiry dimension) were also involved (instruction, administration and governance), each within their own systems. They too were subject to transformation and change during the first phase of the RNS initiative.

The study revealed that participants from every level (learning, instruction, administration and governance) had a new awareness of the issues that usually concerned the other levels. From iteration to iteration, the different levels were involved in resolving those issues and became increasingly aware of each other's issues. For example, teachers had a word to say regarding resources such as bandwidth and computer labs while school principals became more conscious of pedagogical issues specific to the RNS. Consequently, the four systems became involved.

Also, informal professional development, anchored in instructional practice, revealed to be most engaging and satisfying for teachers. Support and professional development was directly related to day-to-day instructional practices and closely related to the teachers' needs. For example, online discussions with members of the research-intervention team and other teachers regarding specific facets of the asynchronous communication tool provided just-in-time support adapted to the teachers' needs in the classroom (Hamel et al. 2009).

Teacher Learning

In order to improve student learning, the assumption was that teacher learning needed to be first addressed. More specifically, student learning was thought improvable as a result of teachers' learning and transformation of their own learning process as the RNS was being implemented. Through a reflective process, teachers developed an understanding of the RNS and engaged in new practices. Teacher learning was manifest as their beliefs evolved toward a better image of the learner, one in which the learner can be active, trustworthy, and responsible when using online tools. They developed higher expectations regarding what to expect from elementary and secondary school students. We consider these shifts in their beliefs and expectations, and the processes that led to those changes, as part of teacher learning. Moreover, the collaborative nature of the research made it possible to identify, based on the results obtained, new practical knowledge on innovation as well as new ways

to learn using the network. As such, both new practical knowledge and existing research knowledge led to the generation of new knowledge that is now available to all teachers.

As regards changes at the different levels of the system (classroom, administration and school district), we observed the broadening of the learning situations offered to students. On the whole, we observed 17 different types of activities that illustrate the wide range of situations that the videoconferencing tool alone could accommodate. Some of these activities were linked to the planning and conduct of learning activities (e.g., training in the use of software tools, encouragement and support to teachers, students' expertise put to use, pairing of strong and weak students, delocalized teamwork, delocalized team teaching, mentoring, lessons in expanded classrooms). Some of the emerging practices are intersecting the three dimensions; for instance, "lessons in expanded classrooms" are within the learning focus, present a transformation of the current system, and involve a pattern of connection between classrooms. Other activities were related to pedagogical and technological solutions (participants networking with other participants, just-in time troubleshooting, etc.) (see Laferrière et al. 2004).

The transformation of classroom activities is what Seidel and Perez (1994) called, referring to Piaget's work (1936, 1963), accommodation to the innovation. This means that the actors not only include the innovation as part of their common practice but that their practice is actually transformed by the innovation. In other words, the actors are no longer adjusting the innovation to their practice but are instead reinventing their practice as a result of the innovation. In the present case, the network enabled new practices to meet teachers' and students' needs in a way that would not have been possible without it. The resulting transformations are presented next.

First, different activities began to occur synchronously between remote classrooms: students engaged in videoconferencing with their peers from another classroom while their teacher interacted with the other students of their own classroom; a group of students from one classroom engaged in individual work while one student from another classroom helped them one at a time. Relating this to the scope of inquiry dimension, some transformations within a system do not necessarily involve crossing into the next level. In this case, the transformation is happening in the existing classroom system without involving the next level.

Second, remote exchanges of expertise occurred: students in one classroom received content adapted to their level, e.g., in mathematics, science or French, from the teacher of a partner classroom, and vice versa. Schools' schedules were adapted in those instances. Such interactions were rather collaborative in nature as teachers worked from different locations on a common topic or problem rather than one person teaching another at a distance.

Third, many activities were proposed to the students engaged in as inquiry-oriented projects to be carried out among themselves and/or remotely. Their collaborative inquiries were conducted in coherence with the knowledge building principles, for example, real ideas/authentic problems, idea improvement (Scardamalia 2004). Various school subjects were gradually integrated: science, technology, geography, history, ecology, mathematics, French, English, and citizenship education.

Fourth, in the multigrade (multiage) classrooms of the remote schools, the differentiation of teaching and learning activities is part of the teacher's daily life, if only by necessity given the fact that more than one curriculum is concerned. The possibilities offered by networking bolstered and enriched this practice. Indeed, we noted a broadening of the learning situations proposed to students: a greater variety of the teaching/learning objectives, pedagogical intentions/strategies and means were associated with the onsite/

online learning context. We also observed an increase of learning situations requiring student interaction or interaction with other individuals (e.g., special educators/counselors, invited guests other than teachers).

Keeping with teacher learning, new pedagogical beliefs surfaced as teachers discovered (1) the importance of collaboration for remote school teachers through networking and its derived benefits; (2) the abilities of students thought not to be autonomous and motivated enough to work in a network–as they got involved and made decisions; and (3) the new facets and bolstering of an essential belief of theirs, i.e., that students learn actively and that they are able to take responsibility in learning processes. These beliefs not only influenced instruction (the second of Banathy's foci of inquiry), but also the patterns of interaction between classrooms, and also schools and their local communities.

As mentioned earlier, learning as the focus of the inquiry concerns new knowledge and practices but also the processes that led to those changes. In terms of Seidel and Perez's (1994) model, we observed teachers' and learners' impressive capacity to embark on a multi-level process of adopting an innovation at the classroom level and beyond, and with a mixture of assimilation- and accommodation- related behaviors.

Meanwhile, we were noticing a lack of anticipation and preparation for innovation at the participating schools' and school districts' level–decision makers had tended to underestimate the scope of the change process likely to occur and also to underestimate the corresponding requirements for intellectual capital and professional development. As a result, participants operated under the assumption that they already had the knowledge required to achieve the project's goals–this in turn gave way to a heightened awareness of the systemic nature of the project. Also, there were participants at all levels of the educational system (classroom, school, school district, Ministry of Education) that had a tendency to practice reductive assimilation, i.e., to make the innovation accessible by reducing its scope, thus absorbing the project into previously known practices. This became less noticeable as plans for Phase 2 unfolded. In our understanding, this shift was a clear sign of transition from an assimilation process to an accommodation process (Seidel and Perez 1994).

Moreover, as evidenced by many interview excerpts, teachers developed a better sense of self as professional teachers as they became aware that their expertise in a networked school could be of value to others, and began to envision "teaching" other teachers. Relating this to Seidel and Perez's model, the larger professional community (within and beyond the initial school districts) was at the adoption stage of use (assimilation/accommodation processes). Word was spreading that positive outcomes for teachers and students were coming out of remote networked schools.

Student Learning

Student-related outcomes were the following:

1. Student motivation regarding educational activities increased.
2. Students progressed in the acquisition of social and communications skills.
3. Students acquired computer/network skills (technology literacy).
4. Students displayed shortcomings in writing and reading.
5. Students' academic results were equal to or better than those of previous years. In some cases, students had greater success on standardized examinations. In no case was lower achievement observed (see Laferrière et al. 2008a).

Some of the beneficial effects regarding student-related outcomes were perhaps nothing more than a manifestation of the Hawthorne Effect. On the other hand, the subsequent RNS

reports indicate either the persistence or an increase of those results, and that even if the university-based teams almost never went onsite but continued to offer professional development online and provide research results (Allaire et al. 2006; Laferrière et al. 2008b).

Also noteworthy, the observation of videoconferencing interactions (Fig. 3) revealed that student talk/teacher talk time differed from usual face-to-face interaction, which is largely dominated by teacher talk (Cazden 1988).

Moreover, we observed the emergence of new role configurations during videoconferencing interactions. Some teachers planned and carried out projects together that other teachers, in turn, carried out with their own students. In other projects, some teachers worked with another teacher's students from a different school. Some students acted as experts with students of another school, and so on.

Administration and Governance

Other learning results concern the administration and governance levels of the project. Namely, school administrators became more aware of Ely's innovation conditions (1990, 1999): dissatisfaction with the status quo, adequate time, resources, knowledge and skills, rewards and incentives, participation of the stakeholders, commitment of the upper level leaders or powerbrokers, and leadership. Also, the school principals' environment was broadened and their roles diversified: planning, coordination of activities with interveners outside the school (municipalities, partner schools, school boards), communication with parents, the media, and steadier educational leadership.

Educational advisers were involved in the planning and conduct of learning activities/ projects for remote networked schools. They had to adapt their roles to their networked school(s), shifting from the role of "supplying traditional advice and resources" to teachers to satisfying emerging teachers' needs. This meant that they had to adjust their initial needs assessment to the teachers' genuine needs for support and assistance. Indeed, the need for support in changes related to actual educational practices proved to be more decisive than needs for ICT-related learning.

Fig. 3 Distribution of videoconferencing activities by RNS stakeholders
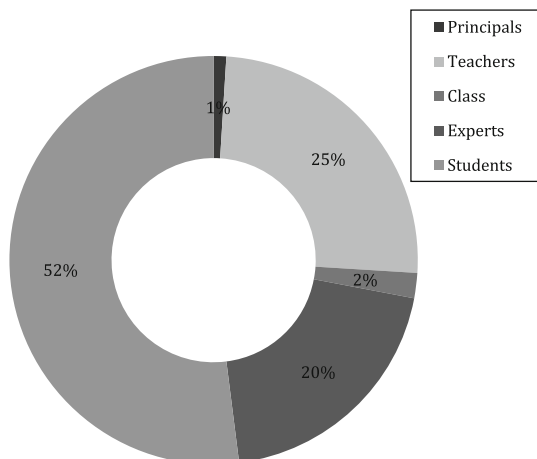
Participants' professional roles (adviser, principal, teacher, IT technician) were correlated with different perspectives on technology, going from a limited view of software applications to an ecological view of technology as a system of tools and people. For instance, IT technicians, who played a crucial role in the networking operations, were on new "professional" territory. Discrepancies in relation to the expected standard of conduct occasionally engendered tensions here and there because, according to activity theory, new norms were emerging but were not yet been established and accepted.

Scope of Inquiry

Change happened on the existing boundaries of the systems as subtle movements were observed at one level or another. Schools worked with other schools but, in most cases, modifications to school schedules to accommodate collaboration ventures were difficult to make. School districts, which usually work quite independently from one another, were found to collaborate to (1) resolve common technology-related security issues such as opening ports and firewalls so that teachers and students could communicate online between school districts, and (2) share exemplars of school principals' and teachers' innovative practices.

Visionary leadership, that is, having a global vision of the innovation and using one's leadership to ensure the innovation's success, was localized differently at different sites. It could be observed either at the school district or at the community level, resulting in different emphases (mostly academic performance in the former case, and mostly survival and maintenance of the village in the latter), and tended to expand to new areas.

According to Banathy (1991), if the scope of inquiry is limited to the existing system of education (schools, school districts, Ministry of Education), the inquiry stays within the boundaries of the system as it explores issues surrounding management, organizational communication, instructional effectiveness, professional development, etc. While such a scope is typical of current educational reforms, the RNS initiative broadened the scope of inquiry to include issues in the environment such as the development of a unique relationship between the school and its local community, thus making changes at the margin of the existing system. One must know that in Quebec, the school and the municipality are two separate entities, with different lines of administration and governance.

In some instances, views of technology supported an opening of the educational system to the larger community. For example, elders of one local community participated onsite and online to the students' understanding of the evolution of the way of life in Quebec over the last century. From one participating elementary school, the community had access to English courses adapted to their ability level, when they usually had to drive more than 45 km to attend those courses.

Patterns of Interaction

With respect to the patterns of interaction, RNS aimed at moving from information exchange between the school and the community, to cooperation and, eventually, coordination. Coordination implies inter-organizational linkage and shared ownership of an educational enterprise that is mutually beneficial to the participants (Banathy 1991). Here too, the most important changes in the patterns of interaction were seen in the existing system but between levels that were usually not interacting much with one another.

During the first phase of the project, coordination became the main pattern of interaction that connected systems (classroom, school, local community, and school district). For one,

we observed patterns reflecting the acquisition of new knowledge in pedagogical practice and technology, e.g., teachers from different schools engaged in newly developed collaborative partnerships allowing them to learn new technology during out-of-class release time and then to integrate the new tools into actual classroom activities with students. Some teachers exercised strong professional ownership of their collaborative space. For instance, although educational advisers and researchers were considered as active collaborators, teachers remained in charge of their actual agenda.

Other patterns observed indicate that new knowledge was required at all levels of the system, including at the researchers' level. In some instances, such knowledge could not have developed and shared using only traditional means, and required innovative forms of coaching and mentoring, including online collaborative tools. In other instances, face-to-face interaction prevailed as in the case of a school that hired an "information agent" to maintain liaison between the school and the community; this person organized meetings and published a series of newsletters about the school transforming into a networked school.

Discussion

Networking school activities is an innovative operation, one that engenders changes in the predominant practice model of an education system. Emancipatory approaches to teacher professional development and assessment were adopted. It was essential for this project to involve not only front-line interveners, i.e., students and teachers, but also interveners throughout the system. And participants rose up to the expectation of designing the RNS for student success and for the benefit of their local community. They engaged in a collaborative knowledge building process (Bereiter and Scardamalia 2003) regarding what a remote networked school could be, and kept improving their ideas with supportive evidence. As the range of possibilities offered by connectivity improved, the array of activities widened and the opportunities for remote collaboration increased.

However, in Phase 1, the idea of the remote networked school itself was still rather new for participants. The above early results (changes in teacher beliefs, emerging roles and practices) pointed to the broadening and enrichment of students' learning experience. While teachers transformed classroom processes in designing the remote networked school, student academic results remained the same or increased, and this was considered satisfying for the time being. Exemplary collaborative knowledge building was achieved, and made participants proud of what could be accomplished: for example, two grade eight classrooms that were over 500 miles apart engaged in knowledge building by inquiring into the conflict between Israel and Palestine and submitted recommendations to the United Nations.

Electronic connectivity was important, but so was social connectivity. The latter refers to having other teachers with whom to collaborate. Coordination is required between schools or between school districts (e.g., school scheduling, management of firewalls) in order to fully support such collaboration. Moreover, collaboration between classrooms has to be rewarding for participants.

Throughout Phase 1, the iterative results submitted and discussed with the participants led to a deeper understanding of what a remote networked school could be. We must stress that it is our understanding that an accelerated process took place, one propelled by the fact that all system levels were engaged in the innovation. We also understand that the

innovation requiring every level of the system to focus on learning, it accelerated the adoption of the innovation. It may not have been the case in different circumstances.

As time went by, many participants and observers became persuaded that RNS is a good idea, one on which to build for the sustainability and development of the Quebec education system. One of the main results of Phase 1 was the local demand for further research and funding because they saw a direct impact of RNS on their students' motivation and learning and also because they had finally found a solution to their professional isolation. Moreover, policy makers were well aware that, in order to maintain the innovation, the initiative had to be pursued and validated in a greater number of contexts. Indeed, during the first two years, other school districts had put a lot of pressure on the Ministry in order to have access to RNS resources and expertise. In sum, the results were convincing but more than that, the local actors were ardently interested in pursuing this line of collaborative action research.

As a result, the main outcome of Phase 1 was that policy makers were impressed with the outcomes and granted funding not only for participants to inquire further into the remote networked school idea, but also to scale up the initiative: ten more school districts joined the initiative for its Phase 2 (2004–2006) and later, ten other joined (Phase 3, 2006–2008) which led to a total of 23 school districts all over the province (30% of all school districts), reaching more than 200 schools, over two thousand students and as much as 10% of all rural schools in Quebec. A fourth and final Phase was launched in 2008, which aims, among other things, at the institutionalization of the RNS model at every level of the system. The results of each of these research phases focused on different aspects of the RNS initiative such as: transformation of the stakeholders' practice (Engeström 1987) using the network (see Allaire et al. 2006), student learning and motivation, and teacher professional development (see Laferrière et al. 2008a, b). These later results build directly on the observations reported in this paper and as we look back on them, we firmly believe that Banathy's (1991) and Seidel and Perez's (1994) frameworks were most insightful in helping us identify, document, and reflect on the subtle and profound changes that led to the positive development of RNS.

Conclusion

Not only has Banathy's model (1991) shown to be effective in analyzing and understanding the complexity of this multi-dimensional research context, it also allowed us to organize and conceptualize how events, observations, and exchanges with stakeholders at the local level could impact other dimensions involved in the RNS initiative. What began as a relatively small educational initiative soon became incredibly complex and intertwined with personal, organizational and societal issues and interests as is the case with any important organizational change. Our research results from the first phase of the RNS initiative enabled us to identify some of the levers necessary to facilitate the implementation of RNS in other school districts. For example, it was decided that new school teams would meet with the research team as early as possible in order for them to gain a better sense of what was the nature of the initiative and what their role could be. Furthermore, the daily access to the research and intervention team via desktop conferencing was quickly identified as a key element in RNS and it still is as we undertake our last year of implementation (Hamel et al. 2009). As the RNS knowledge base expanded, online structured sessions of professional development began to occur on a regular basis. First led by the research team, they are gradually being led by experienced RNS teachers who are confident

enough to share their expertise with their peers as RNS is now embedded in their everyday practices. We believe this is a most telling sign of the institutionalization of the initiative in the school culture, and as previously demonstrated by Blumenfeld et al. (2000) and Miles et al. (1987).

Our conclusion is that all system levels must engage in redesigning practice and technology when innovation is concerned. This may seem an obvious conclusion but it is, nevertheless, a crucial one. Future research will document the circumstances that sustain moves towards extensive institutionalization of the innovation–for both the success of individual students and the school's and community's success, and taking full advantage of the renewal opportunities of the technical infrastructure. Research on the decision-making process is currently underway and should provide unique insight on this critical innovation process.

Important challenges remain. Continued resources and tools, and constant support must be provided at all the levels of the system for the innovation to reach the institutionalization level (Seidel and Perez 1994). Without it, the entire process is hindered and it may even lead to starting all over again. In Banathy's terms, this means that patterns of interaction are of the integration type as the relationships between sub-systems should never be taken for granted. As we undertake the final year of this research program, and remain aware of sustainability and scalability issues facing innovation in educational contexts, we firmly believe that because its initial design was based on Banathy's model, RNS was successfully anchored in the school culture.

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