Impact of individual laptop use on middle school mathematics teaching and learning: implementation of problem based learning scenarios

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Abstract

Our paper presents partial results of a two year study of laptop use by New Brunswick (Canada) 7-8 grade francophone schoolchildren and its impact on mathematics teaching and learning. This study has been conducted within New Brunswick's Notebook Computer Project which provided 7-8 grade students of six public schools with individual laptop computers. In order to better understand the impact of laptops on teaching and learning, we developed two problem based learning interdisciplinary scenarios (math, science, language art) that were realized during the 2005-2006 school year in 8 experimental classes. Using a problem based learning model (PBL), we aim to better understand the reasons of such improvements while looking more closely at various abilities to solve problem situations, to communicate, to reason mathematically, and to make links. In our paper, we are going to analyse and discuss in more detail some initial findings and make some preliminary conclusions. Further research perspectives will also be discussed.

Introduction

The development of a knowledge based society challenges traditional teaching and learning methods suggesting the use of more complex non-routine problem solving which would enable learners to develop a broader spectrum of abilities that go beyond disciplinary knowledge and skills including *learning how to learn*, to *communicate*, to *think critically*, to develop a variety of *organizational strategies*, and to be *technologically competent* (MENB, 2003). Under this point of view, learning is seen as a culture of a hard intellectual work supported by a rich social and affective environment.

The results obtained by 15 year old New Brunswick Canadians in the international PISA study show that this culture is yet to be developed and the school system can and actually must contribute to this development (PISA, 2000, 2003). The local government is looking at ways to provoke and support these changes with several educational initiatives that fit into the priority government learning agendas (GNB, 2002, 2007). One such initiative called New Brunswick Laptop Initiative has been implemented in the form of an action research project in six provincial schools, three in each Anglophone and Francophone sectors. Grade 7 and 8 students and their teachers benefited from having a 1 to 1 access to the laptops during the 2004–2005 and the 2005–2006 school years. Two research teams from Mount Alison University (for the English sector) and from the Université de Moncton (for the French sector) were mandated by the provincial ministry of Education to study the impact of the project on teaching and learning.

The preliminary reports were submitted in October, 2005 and prompted the government to pursue the project extending to the Grade 9 (for those students who have been involved in the project) and expanding to new schools (one in each school District). Although the final report is yet to be made public, the discussion about the educational impact of the laptops and possible continuation already makes frontlines of local media (Acadie Nouvelle, 2007).

Next, we will briefly present the context of our study being the theoretical and methodological decisions made by the francophone research team and make some partial reflective comments on what happened in the classroom regarding to mathematics in connection to other subjects in a 1 to 1 laptop access environment.

Theoretical framework

Our article features only a part of a much larger study that also measured motivation, attitudes and beliefs, computer skills and competencies, classroom management, teaching practices, school leadership and administration as well as project implementation using a pragmatic research paradigm along with mixed (quantitative and qualitative) methods of data collection and analysis (Fournier, et al., 2006).

While several studies provided data on the impact of laptops on motivation, attitudes and beliefs, computer skills, and leadership, less was done to track teaching and learning that occurs with laptops. While few available studies report improvement of learning outcomes in the majority of participating students, there are very few details on how reliable these results are and in what degree they can be attributed to the 1 to 1 access to computers. Many of these studies seem to measure the outcomes using special or standard tests or comparing marks from the report cards based on well defined knowledge and skills although there are indications that ICT, in general, and individual laptops, in particular can generate innovative learning and teaching approaches. Therefore, looking into the process of learning may provide us with more substantial insights.

According to recent research results, ICT can give a new dimension to teaching and learning, allowing students to solve more complex tasks and use powerful computer tools to get more information, represent it in many different ways, analyse it more efficiently, use dynamic tools, and finally produce new and often unexpected knowledge. Kennewell (2004) mentions a particular role ICT can play as a catalyst of intellectual challenges because it allows teachers to propose tasks to students within their zone of proximal development (in Vygotskian sense) and to give students feed-back. Klotz (2003) points at interactivity as a motivating factor for students, bringing them the pleasure of taking risks, to explore, to conjecture, and to test their hypotheses while learning from trial-and-error efforts, thus helping to develop such qualities as perseverance and the willingness to surpass themselves and to fully appreciate the fruits of their intellectual efforts.

In mathematics, an easy and equitable access to powerful technological tools and endless Internet based resources may enlarge traditional pedagogical spaces and create occasions for all students to participate in new types of genuine mathematical learning experiences. Such experiences are often based on the authentic problem solving situations that emphasize a broader view of school mathematics as a tool for everyday life experiences (NCTM, 2000).

Recent New Brunswick mathematics curriculum sees contextual problem solving as an important tool for the development of mathematical reasoning, communication and the ability to make links that provide learners with better understanding of purely mathematical domains, such as numbers and operations, space, algebra, probabilities and statistics (MENB, 2003).

Referring to recent learning theories according to which problem solving is a heart and a nature of every mathematical activity, Poirier (2001) stresses a need for creating a rich and stimulating learning environment to enhance a better understanding in all students.

These theoretical considerations explain our choice of PBL scenarios to evaluate the learning process that occurs in the 1 to 1 laptop access classroom environment. In fact, in our approach, we consider the influence of both variables, 1 to 1 access to the laptop and problem-based environment as catalysts of meaningful learning from technological and pedagogical points of view.

Methodology: The problem-based learning scenarios

Working within the three spaces of the PBL model (Guilbert, L. & Ouellet, L., 1999): *problem space* (exploration, definition, and planning); *solution space* (search for information and

analysis of information); *reflection space* (synthesis and reflection) allowed us to elaborate and to implement two learning scenarios during the 2005-2006 school year with students from all 7th and 8th grade participating classes.

The first set of scenarios implemented in the beginning of the year has been developed by the research team drawing on learning outcomes and topics required by the provincial science curriculum. Both scenarios prompted student's driven research activities whose goal was to study in small groups of 3-4- students one aspect of each issue (learning task) in order to make people aware of those issues.

In relation to mathematics, the first set of scenarios required the students to create and conduct a statistical survey following standard statistical procedures: preparing a questionnaire, collecting data, representing data, and analysing data. The scenarios set up certain criteria of what to expect as final products of the students' work but never specified what tools to be used to collect or represent data and how to analyze them in their final report. Our approach left students a lot of room to ask questions, making their own choices, discussing them in small groups and developing their own problem solving strategies.

Using a qualitative research-development collaborative model (Van der Maren, 1999), we built our research instruments in collaboration with teachers drawing on their observations and concerns and taking into account their needs and beliefs. During one school year, two complete cycles of research have been realized including four stages each time: needs analysis, planning, action, and evaluation-reflection. Data collected during our study came from different sources: interviews with participating students and teachers, video and in-classroom observations, samples of students' work, and reflective journals.

Partial results: How students develop and conduct statistical survey?

The task:

Seven tasks have been given to all students (n=160) in each of 7th and 8th grade experimental classes. For grade 7, they were focused on environmental issues like the *Kyoto protocol*, endangered species. With grade 8, students worked on health issues like drugs, stress, and others. Each team consisting of 3-4 students thus had one learning task that involved the preparation of a survey. Here is an example of such task (*Task#3*):

Task #3

> The Recovery of Nationally Endangered Wildlife Program (RENEW)*, is a nation wide initiative to save endangered species in Canada. You should choose two endangered species and study the problem in depth in order to convince people to support the initiative*
> - o **Some questions to explore**: *What are their characteristics (habitat, food, predators, reproduction)? Why are they in danger? How would it affect our ecosystems?*
> - o *Your **survey** can be done to learn what people know about endangered species.*

Internet site to visit: http://www.ns.ec.gc.ca/wildlife/index_f.html

The task of doing a survey is familiar to the students, while they were often asked to collect data about other people's favourite food, hobbies, animals, etc. They are also used to represent data by means of graphs and diagrams. Typical tasks from their textbooks already contain all information needed and all questions to be answered using graphs. The type of graph needed is also given. Our scenario required a different type of work since the survey was a part of a problem solving process in which students had to decide by themselves what information they needed to collect and how. They also had to decide what kind of graph would represent their data better and how it can be used further in their research. This kind of activities was new to the students and they had to develop their own strategies, implement and validate them. The work has been done in small groups. While the whole project required in average a month of work, the preparation and realisation of the survey took about the third of this time.

Data collected and data analysis:

Each team has produced a written report and an oral presentation that has been presented using PowerPoint or other software. In their written report, we expected students to incorporate their survey questions, collected data, graphs and diagrams representing data, and the analysis of results. All written reports have been analysed using special forms and criteria like presence of important elements (ex: titles, labels) and their appropriateness. We also collected statistics of types of questions and types of graphs used by students. We completed our analysis with additional information from PowerPoint presentations and videotapes. Finally, data from post-project interviews with participating teachers and students were used to complete the triangulation of our findings.

Findings:

During the observation period, we were asking students to explain what they were doing and why. One student said that they were going to calculate mean, median and mode, putting all these data from the first question of their survey and adding them up which would enable them to organize data and build up a graph showing how it looks like and what people think about their question. The same student said that he is not sure what problem they were going to solve using the graph but it is about "stress". He thinks their data will show if people experience stressful situations in their life and if yes, when, where, and how much stress are they experiencing. After the data analysis, the students will think how to diminish stress.

This conversation shows that while student didn't seem to be considering his final goals at this level of the problem solving process, he was able to articulate them as well as his expectations to use the graph in order to find a solution.

We also observed a group of students discussing the choice of the particular type of a circular diagram using the computer program Excel®. One student was going back and forth through different computer options each time choosing a different type of graph. His peer was arguing that these choices were inappropriate. Finally, both students agreed on a 3-dimensional graph with the explanation that the 3rd dimension makes the diagram bigger and easier to understand. This discussion shows that the problem has initiated the interactions between students allowing them to express, argue and validate their choices within their group of peers. This particular moment, according to Poirier (1997), is crucial for the process of construction of new knowledge.

The frame of this article makes it difficult to go deeper into the details of our analysis. We will mention briefly the most interesting findings. Firstly, statistical procedure is seen more as collecting and compiling data than a source for reflective problem solving. In fact, students in the study produced a lot of graphs by means of technology but we didn't find many artefacts of their reflections in their final reports. Making up their survey questions, students were asking more frequently about knowledge (*Do you know that...?)* or facts (*What do people ...?*) and less frequently opinion questions (*Do you think it is good to ...?).* Most of their questions allowed simple '*yes-no'* answers. Few groups used more complex scales.

While many groups were using paper and pencil techniques for their questionnaire, some of them created electronic forms (website) to collect their data. While making their graphs, almost all groups chose to make a separate graph for each question. Grade 8 students used a larger variety of types of graphs comparatively to their 7 Grade peers. It was no surprise to state that computers help students to make their graphs and in most of the reports they did it correctly.

In a few cases, we observed incoherent data representation due to an inappropriate choice of variables or scales. The technology did allow for quickly making nice representations but it seems that a higher level of critical thinking was rarely applied in order to validate the obtained

results. Finally, only half of the reports contained some elements of quantities interpretation of results to support scientific conclusions about the original problem.

In the post-study interviews, participating teachers and students shared their opinions on what impact direct access to laptop computers has on mathematics teaching and learning within a real-world contextual problem solving environment. In the coming paragraphs, we will briefly present key findings from these interviews.

In the interviews, students said that the arrival of laptop computers has changed the way they learn. They find that a computer is a useful tool helping to better understand mathematics because it simplifies the task of constructing graphs which happens automatically once the data has been entered. The obtained graph can be better understood when it is made at a computer rather than using paper and pencil. According to the students we interviewed, Excel® is the most frequently used software program for making diagrams. Students like this kind of work and find that it has a better quality. Some students expressed that when the graph is more complex, its construction becomes more difficult. Also, some said that they may become dependent on computers therefore it might be difficult for them to do the work when the computer is not available.

Teachers find that the 1 to 1 access reinforces students' abilities to communicate mathematically, especially, when it concerns those who do not like writing long texts. When these students were given an opportunity to type their text on the computer, they started to give more detailed explanations of their mathematical solutions. While teachers confirm the advantage of having individual access to computers for the rapidity and quality of students' work, they feel that students need to develop better trans-disciplinary abilities in communication, critical thinking, creativity, reasoning, and in methods of work in order for them to better evaluate their pupils learning

Teachers also mention that the use of spreadsheets in mathematics allows students to make links with real life, applying mathematical methods learnt in class because of the rapidity of calculations and a better access to multiple sources of information available online, thus providing them with concrete examples of mathematics use in everyday situations. Teachers underline that a problem-based learning environment seems to help students see more interdisciplinary links between mathematics and other subjects as well as its utility.

In their interviews, teachers reveal that a number of students improving their mathematical learning is increasing during the use of laptops, especially concerning their problem solving abilities. They also noted that students' marks are also increasing. One teacher explained it by the fact that students put more time to analyse graphs and diagrams than before when most of their time and energy was spent on drawing them manually. The same teacher adds that by doing their work on the computer, students can make better quality presentations with fewer errors.

Conclusions

According to Putnam (2003), the increasing expectations from technology are based on their potential as powerful learning tools because of the new possibilities to represent abstract mathematical ideas, richness of virtual real data that could enhance problem solving ability, and the communication tools, all this helps students to focus on higher level aspects of the problems they are trying to solve. Also, the use of ICT opens doors to new mathematical content and new methods of managing this content, and finally can create opportunities to fundamental changes in teaching and learning practices. In fact, during the interviews, our participants mentioned that a 1 to 1 access to the laptop computer changes ways to teach and to learn, increasing productivity and quality of mathematical work, and helps to visualize abstract mathematical concepts.

Other data collected during our projects suggests several positive impacts of our scenarios on students' learning: positive attitude towards the task, more autonomy, larger variety of strategies used, good mastery of computer tools, constant discovery of new methods to use, and the use of rich and coherent vocabulary. At the same time, our data shows limited capacities to analyse problem context, lack of critical evaluation of computer produced results, lack of details in mathematical representations (titles, legends, labels, units), and limited meta-cognitive links between different parts of the problem solving process.

Returning to the goals of our study, we will quote Saljo (1999, p. 159) who affirms: « What the technology does is that it increases the range and nature of experiences that can be provided for the learning of subject matters that are complex and abstract. The interactive character of modern technology can support reasoning by amplifying the nature and boundaries of scientific models of objects and events. But the full realisation of the potentials of such experiences will still rely on students' access to conversation partners who carry on discussions in which these models and concepts are validated. Technology should not be seen as replacing such communication but rather as providing a resource for supporting it ».

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