One mathematical formula in the science textbook: looking into innovative potential of interdisciplinary mathematics teaching

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Abstract

Our paper presents some preliminary observations from a collaborative exploratory study linking mathematics, science and reading within a technology enhanced problem-based learning scenario conducted at one French Canadian Elementary and Middle School. Presented in a form of dialogue between teacher and researcher, our findings give some meaningful insight in how an innovative mathematics teaching can be developed and implemented using a real-world problem solving. Instead of a traditional presentation of material about lighting up homes, participating mathematics, science and French teachers were working collaboratively with the ICT integration mentor and two university professors helping students investigate a problem from various perspectives using a variety of cognitive and metacognitive strategies, discussing and sharing the finding with peers and presenting them to a larger audience using media tools. Our preliminary results may prompt further investigation of how innovation in teaching and learning can help students become better critical thinkers and scientifically empowered citizens.

The project we are going to describe in this paper is a collaborative initiative of teachers, school leadership and researchers to explore innovative ways to teach students to become a real-life connected, problem-oriented and technology empowered learners of the 21st century. Following Lesh (2007), we ask what would be learning needed for successful citizen living in the world with the increasing use of mathematics, science and technology and how the traditional conceptions of reading, writing and arithmetic could be extended or reconceived to prepare students for such success.

Aldous (2007) is mentioning six key ideas that characterize engaging pedagogies in mathematics and science education: equity, service to humanity, literacy, knowledge dimensions and their changing emphases, affective as well as cognitive responses to mathematics and science, and connections to technology. The author mentions the need to identify and explicate the strategies of investigating and explicating the creative processes involved in solving novel real world problems and pointing to a way in which the content/processes/context and affective connections intrinsic to mathematics and science learning and teaching can be found. Our paper describes some preliminary observations on how innovative teaching, collaboration between teachers and researchers, and use of technology can change the way mathematics is taught and learnt.

While many researchers, practitioners, and government authorities call for the search of innovative approaches in teaching and learning, little is known of how innovation can be developed, implemented, and assessed in our classroom.

At the macro-level, its origins may be referred to the vision of today’s society as ‘knowledge society’ one, based on innovation and ingenuity. Hargreaves (2003, p.2) argues that we can (and should) ‘promote a high-investment, high-capacity educational system in which highly skilled teachers are able to generate creativity and ingenuity among their students by experiencing creativity and flexibility themselves in how they are treated and developed as knowledge-based professionals’. In this way, it is the changing society that forces governments to put pressure on educational systems to look for new and more effective methods preparing young generation to deal with the complexity of the modern world.

An analysis made of PISA data by Canadian New Brunswick’s provincial government, showed in early 2000s that the educational system failed to adapt to new requirements, so the improvement is necessary (Freiman, Lirette-Pitre, 2007). Concrete steps have been taken since
2002 to improve mathematical, scientific and reading culture in our schools with the Quality Learning Agenda (GNB, 2003). The document introduced individual laptops in six middle schools (three French and three English) promoting an innovative use of technology to improve learning in mathematics, science and literacy.

At the micro-level, there are always devoted and enthusiastic teachers that are open-minded and critical to what they do trying to find better ways to reach every student in their classroom. In order to plan and implement new methods, they would turn to the research looking for ideas and innovative strategies. This is about how a sustainable collaboration between innovative teachers working in innovative schools and researchers who look into practical outcome of research may arise.

Freiman et al. (2007) examined an impact of individual laptop use on the middle school mathematics teaching and learning within the New Brunswick Individual Laptop Initiative. Research team of specialists in French, science and mathematics didactics has realized several interdisciplinary problem-based learning scenarios with Grade 7-8 (13-14 years old) middle school students that to worked on complex non-routine real life connected problems. Our major findings showed positive attitude towards the task, more autonomy, larger variety of strategies used, and good mastery of computer tools, constant discovery of new methods to use the Internet and different software, and the use of the rich and coherent mathematical vocabulary. At the same time, we found limited capacities to analyze problem context, lack of critical evaluation of computer produced results, lack of details in mathematical representations, and limited meta-cognitive links between different parts of the problem solving process that prompted us look for better teaching strategies together with teachers. The new initiative that arose from this project will be the subject of our recent paper bringing teacher’s view on innovation in mathematics teaching, while linking it to the science and French curriculum so building richer interdisciplinary connections: after having rich experience with an action research on 1-to-1 laptop use in 2004-2006 conducted with researchers form the Research and Development Center in Education from the Université de Moncton, we were willing to continue exploring the possibility to use project-based learning (PBL) in the classroom.

A learning scenario was initiated by teachers willing to improve their students’ learning in three major aspects of the New Brunswick reform school curriculum – use of better strategies of reading for better understanding of complex texts, developing better competences in scientific investigation and fostering a better understanding of mathematical relationships analyzing real life related problems. Teacher’s comment: In the context of project-based learning, a learning scenario presents to the students a real-life related situation. It puts emphasis on the practical use of mathematics and information communication technology (ICT). We had to find for students a research problem that would stimulate their scientific learning by putting them in a real context of investigation as well in a situation of reading and writing significant scientific texts.

To construct a theoretical framework of our new study, we were looking at the combination of three new ideas that recently attract many educators going beyond problem based learning principles used in our previous study: collaborative research with teachers, interdisciplinary teaching approaches, and innovation in teaching (Novotná, J., et al., 2003, Korey, J., 2002, Lerman, 2004). As a starting point for our inquiry, we used a Grade 8 New Brunswick science curriculum that foresees a topic on light and optics. One of the notions that are being introduced is a source of the light and related costs of electrical energy. In a section of the OMNISCINCES 8 textbook (Clancy et al., 1999) the students are asked to reflect on the cost of the use of sources of light at home comparing incandescent and fluorescents bulbs. The textbook gives a definition of the watt and kilowatt as units of power shows on a concrete example how to calculate a cost of the use of 60 W bulbs during 10 hours if the power costs 8 cent per kilowatt-hour. The text concludes that fluorescent tubes would give a better energetic outcome than incandescent bulbs providing a corresponding mathematical explanation.
Being taught in a more traditional way, the text would probably be used by the science teacher as a narrative base for her classroom presentation with the example being solved together with students and some exercises helping to practice the procedure. Instead, we were looking for a different way to teach this in order to develop students’ scientific curiosity, better understanding of mathematical concepts and their utility in science. Teacher’s comment: We decided to explore the incandescent and fluorescent bulbs. Students had to find advantages and disadvantages of both types of bulbs. The project developed by teachers together with researchers had natural links to the New Brunswick science, math and French school curriculum in terms of learning outcomes (general, specific and transdisciplinary) In this way, in April 2007, students from the Grade 8 of the and their Centre d’Apprentissage du Haut-Madawaska (CAHM) together with their teachers started this beautiful adventure. Some skeptics would argue why to do so? Our answer is to improve students’ knowledge!

From the point of research methodology, this exploratory collaborative study included data collection by means of classroom observations, reflective journals, Internet blogs, and interviews with students and samples of students’ work have been used in our analysis that has been conducted together with teachers. The goal and the format of the conference and limited space led us to focus on descriptive aspects of mathematical part of the project. Future publications will report on its other aspects, namely, developing of reading skills and abilities of scientific investigations.

The text of the problem that students had to investigate has been published on the school’s blog: http://cahm.elg.ca/prof/DanisMichaud/2007/04/les_ampoules_1.html

Here is the English translation: The bulb in your bedroom is burned out. You are looking to replace it but there is no one at home. You decide to go to the local store to buy it but there are no bulbs of the same type available. Therefore, you need to make a choice among the types that are exposed on the shelves of the store.

Teacher’s comment: Following the announcement of the problem and its investigation in several steps, the students had to experiment, solve and reflect on the problem. The results, conclusions and recommendations have been published in a local newspaper (Le Madawaska) and the blog of each student. The goal was to inform and the population and make it conscious on a better choice of bulbs to meet its need in lighting the house. At the first stage of the investigation, students had to brainstorm the problem situation. Teacher’s role is to nurture discussion about student’s spontaneous ideas. Here is how the teacher describes it in her blog: Students will have to compare different types of bulbs and make some hypotheses about the problem. My task is to question students putting them into cognitive conflict based on their intuitive ideas (http://cahm.elg.ca/prof/DanisMichaud/2007/04/les_ampoules_1.html).

In order to foster student’s reflective activity, the strategy KWLN (know already - want to know – what is learned – what do I need to know more) have been proposed by researchers. Students were also asked to analyze how they light up their own room. A schema on a scale was used to represent real measures proportionally. Teacher’s blog suggests students to look for information about scales on the wikipedia using following link: http://fr.wikipedia.org/wiki/%C3%89chelle_(proportion). Looking for explanation why the distribution of the light is so unequal in different parts of the Earth, each team of students had to put a comment on the blog. Many students were using several terms expressing mathematical relationships. For example, one team wrote: ‘In the North America, there are more big industries than in Africa because Africa is poorer than North America. There are much lighter parts in the continents that have more money and less on those who are less rich’. In order to get more insight into relationship between the cost of the bulbs and their duration for both types, incandescent and fluorescent ones, students were asked to analyze a graph and conduct their own investigation (http://www.led-fr.net/images/fluocompacte_vs_incandescence_7000h.gif).

The role of the ICT integration mentor was very important to support for teachers’ innovation. A note left in her blog by the ICT mentor clarifies this aspect: ‘They found a formula
to calculate the costs of enlightening in their science textbook but then realized that the information about unit costs is outdated. Further, students have learned form the recent bills that the costs have been increased and also (since the book comes form another province) that the costs vary form province to province in Canada. Using paper and pencil, as well as EXCEL software, they made necessary calculations. Working in this way, without being explicitly taught, students did calculations by themselves making tables in EXCEL. They surpassed our expectations. When we were thinking if the task can be accomplished by students, they did it better than we thought they would be able to do. Moreover, their tables were made with necessary information (titles, axes, etc.) with the use of nice fonts and colors making their work more attractive.

Technology played yet another important role in the project providing a socially oriented medium for collaboration and sharing between all participants, students, teachers, mentors, school administration and researchers. Besides sharing material and comments on the blogosphere, a wiki-based collaborative tool has been used. Video documents with the results of students’ investigations created by students have been shared through the youtube.com web community.

Among comments left by participants in this common collaborative virtual space, one is particularly interesting because it presents another valuable aspect of this project - the support from the school principal: “What is fascinating to me is the time you devote to do this research. I know also that you work collaboratively as a team with other people who also try to contribute to the improvement of students’ learning. The use of technology is still young and unknown field of teaching and your project would design new ways to advance in this in future. All this kind of project helps us to understand, to explain and to improve ourselves. Bravo and thank you for your interest. I appreciate and welcome your research and wish a success. http://cahm.elg.ca/classes/larechercheaction/2007/03/projet_de_reche.html”

The parents were also involved in the project and were sometimes surprised by students’ sudden interest in home lighting as it witness the following teacher’s comment: “The final result has surpassed our expectations. The articles, videos, and comments in the blog have succeeded to inform the population and at the same time did a promotion of their new knowledge which lets us to conclude about the success of the project. There is evidence that students are able to make knowledge transfers and explain what they have learned to the members of their families. Some comments we collected from the parents can be resumed as following: ‘My child has convinced me to change bulbs in our house … My child is interested now in electricity bills and is making a moral to us to save energy – what do you do in your classroom?’ – they look happily surprised.

Students’ work was very productive in terms going beyond mathematics curriculum making explicit links with language art and science. This observation is consistent with others made by researches. Already at the end of 90s, Schmitt (1997) noted about a close relationship between reading and mathematics: ‘...I’m working with teachers who are purposefully emphasizing more realistic and relevant problem solving situations rather than the controlled one- or two-step word problems. As a result, math students are more engaged in reading, writing, speaking, and listening. When problem situations depend on gathering information from a variety of everyday sources, such as articles and advertisements in newspapers and magazines, prose literacy and mathematical literacy are hard to separate. Understanding the problem becomes much more complex than knowing a list of key words -- ‘more’ means add, ‘less’ means subtract, ‘of’ means times -- to solve formulaic word problems’.

An important role mathematics may play in scientific investigations have been underlined by Coulter (2002): ‘By combining this (scientific, V.F.) background knowledge with thoughtful analysis of the data, they (students, V.F.) are able to achieve a deeper understanding of how tornado formation is influenced by specific weather patterns most commonly found in certain parts of the country at specific times of the year. Without this use of data, the textbook descriptions of how tornados form are much less likely to take root in students’ growing conceptual understandings. As is true for students’ development of science skills, these investigations provide opportunities to
experience the power of mathematics in helping to understand the world—hardly an inconsequential lesson.’

While a detailed analysis of our collaboration with teachers is still underway, the conclusive teacher’s comment indicates some of its positive outcomes: this research project allowed us to work as a team and to discuss with other people who want to improve students’ learning. This kind of project allows students to develop the autonomy, communication abilities, transversal competences, as well as abilities to do transfers, to use their knowledge. As teachers, we can conclude that the project was a success.

References:


