feature

Physics education in Canada

An overview of recent developments

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Abstract

This paper aims at outlining a physics education scene in Canada. However, instead of providing a comprehensive and exhaustive account, we attempted to give the readers a lead on where they might get started should they want either to pursue a degree in physics education, implement the findings of the physics education research (PER) in their classrooms, organize physics outreach programs or help establish and run the in- or pre-service teacher training. We purposefully focussed on Canadian resources, since even in the age of the internet, the vast size of our country makes many of us feel isolated and unaware of what is happening not only south of the border, but also in other Canadian provinces. We hope this paper will be of use to both physics students and faculty.

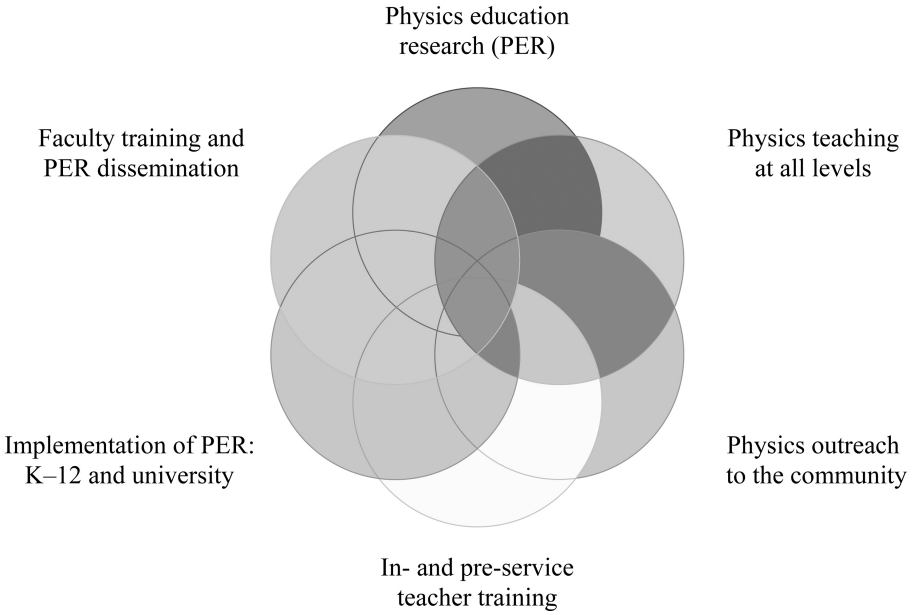

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Figure 1: Different facets of physics education.

A few case studies of physics education in Canada

In this paper, we will define physics education research (PER) as a field that uses scienctific research methods to investigate how:
(a) students learn physics from middle school to college and university;
(b) instructors can teach physics more effectively at all levels;
(c) modern technology can be used to improve physics learning;
(d) to attract more students of different backgrounds into studying physics;
(e) to train pre-service and in-service physics instructors more effectively.

Eventually, the results of PER translate into the development of new, more effective, teaching materials and revitalized curricula.

The term physics education here will be generalized to include PER, physics teaching at all levels, training of in- or pre-service teachers and physics educators, and designing and implementing physics outreach activities for the general public (see Figure 1).

Addressing a need for continuing revitalization of undergraduate physics education in the changing world, the Canadian Association of Physicists (CAP)/Division of Physics Education (DPE) committee developed a recommended undergraduate physics curriculum for Canadian universities that can be found at CAP website: CAP/DPE Undergraduate Physics Curriculum Project (*https://www.cap.ca/edu/curriculum/curr.html*).

By virtue of being a multidisciplinary field, faculty involved in physics education can be found all over high school, college or university campuses. Most of them are involved directly in physics teaching. However nowadays, a growing number of faculty members today are involved in PER and other facets of physics education. For example, less than a year ago, the University of British Columbia was able to attract a Physics Nobel Laureate, Professor Carl E. Wieman to launch a $12 million Science Education Initiative (*http://www.publicaffairs.ubc.ca/media/releases/2006/mr-06-032.html*).

Among many educational contributions of Carl Wieman's PER team from the University of Colorado at Boulder, the most notable one is the Physics Educational Technology (PhET) web site, featuring free physics interactive computer simulations (*http://phet.colorado.edu/web-pages/index.html*) and educational resources[1]. Additionally, UBC has a very strong physics outreach program, which includes public science shows, teacher professional development events, popular summer physics and astronomy camps, Saturday physics lectures for high school students, physics Olympics, Junior High School Physics Competitions, etc. (*http://www.physics.ubc.ca/links/outreach.php*). For example, the last Faraday Science Show conducted by the members of the department attracted more than 500 guests from the community.

Another illustration of the growing PER team can be found at the Department of Physics at Ryerson University. During the past three years, two full-time physics faculty members were hired specifically to conduct PER (see *http://www.physics.ryerson.ca*). Their focus is studying the effects of modern technology such as Logger Pro microcomputer-based data collection equipment[2] on student academic achievement and interest in science. Physics faculty members at Ryerson University collaborate with the Ontario Physics Teachers Association (*http://www.oapt.ca*) and the Toronto District School Board and actively contribute to professional development activities of Ontario physics teachers. For example, the Department of Physics sponsored an invited talk of the Ontario physics teacher at the 2007 CAP Congress in Saskatoon.

Although physics faculty at Simon Fraser University in Vancouver, BC (Dr. S. Johnson *et al.*: *http://www.sfu.ca/~physhelp/newstudents/studio.html*) and at two universities in Maritimes (Professor R. Hawkes *et al.*: at the Department of Physics at Mt. Allison University in Sackville, NB – *http://www.mta.ca/faculty/science/physics/courses.html* and Professor P. Williams from the Department of Physics at Acadia University in Wolfville, NS – *http://ace.acadiau.ca/science/phys/faculty/wil-*

liams/williams.htm) are separated by more than four thousand miles, these three teams were able to successfully implement studio physics in their first year physics courses[3].

In Alberta, Professor Robert Thompson from the University of Calgary (*http://phas.ucalgary.ca/~thompson/*) developed many innovative lower and upper level undergraduate physics courses, as well as led multiple professional development events for local physics teachers. For his outstanding achievements in physics education, he was honoured with the 2007 Canadian Association of Physicists Excellence in Teaching Medal (*http://www.cap.ca/awards/press/2007-Thompson.html*).

Professor of Science Education A. Stinner and his colleagues at the University of Manitoba (*http://home.cc.umanitoba.ca/~stinner/physics.html*) study how the history of science can be used to design authentic and more meaningful physics courses. Professor Stinner is also actively involved in the training of future teachers and supervising graduate students in science (physics) education.

At the University of Toronto, Dr. D. Harrison, a Physics Senior Lecturer who often teaches classes of more than thousand students, developed an All Canadian In-Class Question Database (*http://cinqdb.physics.utoronto.ca/*). This database aims at helping science (and not only science!) faculty to make large and small classes more interactive via the use of clickers[4]. In addition to that, Dr. Harrison created a number of very popular physics flash animations (*http://www.upscale.utoronto.ca/GeneralInterest/Harrison/Flash/*).

Professor Ernie McFarland from the University of Guelph, ON has been responsible for the development of many physics courses, demonstrations, and experiments used in undergraduate and high school physics teaching. Currently, Professor McFarland and his colleague Professor J. O'Meara are working on implementation of innovative physics curriculum at the University of Guelph (*http://www.mcmaster.ca/3Mteachingfellowships/1987/mcfarland.html*).

Professor Alan J. Slavin from Trent University was a recipient of the CAP Medal for Excellence in Physics Teaching and the 3M Teaching Fellowship (*http://www.trentu.ca/academic/physics/aslavin/welcome.html*). Among his many physics education interests is promoting peer instruction[5] in a large lecture setting (*http://www.mcmaster.ca/cll/posped/pastissues/volume.1.no.1/peer.instruction.lecture.setting.htm*).

In Montreal, at Concordia University, Professor Calvin S. Kalman, who has been teaching physics at that university for almost forty years, investigates how a student-centred physics teaching approach, based on journal writing and in-class use of small collaborative group methods, affects student academic achievement, motivation and interest in science (*http://physics.concordia.ca/faculty/kalman.html*). Although he has taught most of the undergraduate physics courses at that university, first year undergraduate physics course for general students is one of his favourites. Professor Kalman's new book entitled *Successful Science and Engineering Teaching in Colleges and Universities* was published last year.

Dennis Tokaryk and Ben Newling from the Department of Physics at the University of New Brunswick at Fredericton, NB have been actively involved in physics education via designing and teaching innovative physics courses and conducting professional development activities for physics teachers (*http://www.unb.ca/fredericton/science/physics/faculty.html*).

There are many other Canadian physics educators who could have been mentioned here, had we had more space. Canada has a number of colleges and universities where physics faculty members successfully implement innovative physics teaching methods and study how physics teaching can be improved. In the next section, we will outline the challenges currently faced by the Canadian physics education community.

Looking into the future

While the overview above provided some idea about what is happening on the physics education scene in Canada, it is important to mention the challenges we are currently facing. The first challenge is the nonexistence of the departments of physics where students can pursue graduate degrees in physics education, while more and more current students express their interest in this field. This problem has been resolved south of the border more than a decade ago.

If we want Canadian PER to be competitive internationally, PER faculty have to become part of the departments of physics where they can contribute the most by helping improve undergraduate physics teaching and studying new innovative physics teaching methodologies and their effects on student learning. PER has to become accepted as a valuable and rightful contributor to the knowledge database created by the departments of physics all across the country. However, this cannot be achieved without appropriate funding.

Funding is the second challenge. While the National Science Foundation (NSF) has one of its mandates to fund science education research, a Canadian counterpart of NSF, NSERC, does not fund physics education. The funding to physics education should come from the science budget. Without appropriate funding, the progress in the field will be painful and slow. As a result, the lack of PER funding is the second challenge.

The third challenge, in our view, is the way physics teachers are trained. Very often, departments of physics have little to do with the training of future physics teachers and with the professional development of the in-service teachers. The lack of communication, collaboration and cooperation between the faculties of education and the departments of physics is a serious impediment for improving physics education in Canada. The only way of addressing a challenge of improving physics education in Canada is to start effective dialogue between all parties involved in physics education: from teachers and teacher educators to physics faculty.

More than 2500 years ago, Confucius noted that "a journey of a thousand miles begins with a single step." Today, we are living in a very exciting time: each one of us has a chance to shape Canadian physics education of the 21st century. To do so, we invite you to make the first step and join other physics educators in a Division of Physics Education of the Canadian Association of Physicists (*http://www.cap.ca*) to start our all-Canadian physics education journey.

References

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[5]E. Mazur. *Peer Instruction: User's Manual*. Prentice Hall: Upper Saddle River, NJ. 1997.

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