MAKING IONISING RADIATION A REAL EXPERIENCE FOR HIGH SCHOOL SCIENCE STUDENTS

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Abstract

The Canadian public has little understanding of ionising radiation due in part to its treatment in popular media. In principle, students learn about ionising radiation in their school science classes. Developments in science curricula are providing more education opportunities for this subject. The Canadian Nuclear Society's program for introducing real, personal experience with ionising radiation in the classroom is starting to make a difference. The demand is expected to exceed the resources of the CNS and the program is being developed to facilitate external support. This paper summarizes the need, the history of this program development, and the path forward.

1. Why target high school science teachers?

The objective of improving public understanding of the issues related to nuclear technology is challenging. The CNS Education and Communication Committee (ECC) perceives that the best value for effort can be obtained by enabling and equipping teachers to develop improved understanding by their students of the basic science of ionising radiation. Armed with this knowledge, these students will critically challenge positions or policies that are at odds with what they have learned. Most teachers will instruct a minimum of 25 senior science students each year.

2. Learning from Virtual Experience

Increasingly the laboratory component of physical science education for Canadian high school students includes computer-based, virtual experiments. These substitute a computer program learning environment for the expensive and in some cases potentially hazardous equipment and substances required to perform conventional laboratory experiments. It is the opinion of the authors that the quality of the learning experience suffers with this transformation to a risk-averse approach common in contemporary society.

The CNS ECC has been promoting real, personal experience with ionising radiation for teachers and students alike since 1990. The CNS ECC uses a high-sensitivity Geiger detector with both Naturally Occurring Radioactive Material (NORM) and consumer products (e.g. KCl salt substitute, smoke detectors, Vaseline glass, vintage camera lenses) as sources of ionising radiation. This approach avoids the need for identified radioactive sources in schools, and makes the experience more credible for the students.

3. History of CNS Involvement in Science Teacher Events

For many years, AECL Chalk River Laboratories operated an annual "Science for Educators" program. The Chalk River Branch of the CNS provided a "Hands-on Ionising Radiation Workshop" [1] as part of this program, initiated by former CNS member (and CNS Council member) Aslam Lone. This workshop included:

- Simple cloud chambers using dry ice and alcohol
- Opportunities to use industrial "pancake" Geiger detectors to monitor check sources with shielding materials
- A demonstration of the measurement of a half-life with ^{137}Ba using a Geiger
- A demonstration using a sensitive Geiger to monitor the soft gamma from the ^{241}Am source in an ionisation smoke detector.

Some of these demonstrations were made available to the public attending AECL Open House events. All of these activities were terminated after the unfortunate events of 2001-09-11. During this period, the CNS ECC also donated a Geiger detector to the Madawaska Valley District High School. The CNS ECC's policy at the time was much as it is today: the value of Geiger detectors in classrooms merits their donation to sufficiently interested but budget-challenged high school science departments

For over ten years CNS member Jeremy Whitlock frequently made classroom presentations on nuclear energy as an AECL Speakers Bureau activity, often including demonstrations with a CNS-supplied Geiger detector. A few school teachers inquired about obtaining a similar detector for their schools following these presentations.

In 2006 the CNS ECC hosted a booth at the Science Teachers' Association of Ontario Annual (STAO) Conference [2]. The booth was staffed with volunteers – CNS members and others from the Canadian nuclear industry. The booth provided fact sheets prepared by the CNS ECC and material provided by the nuclear industry to interested teachers.

The Geiger detector demonstration was a key element of the booth and one was awarded as a draw prize to a teacher from Lester B. Pearson Secondary School (Burlington). Teachers visiting the booth were encouraged to contact the CNS and request a similar Geiger detector for their school. Despite ample enthusiasm evident in teachers visiting the booth, none followed up with the CNS. Senior STAO members recommended that the CNS provide workshops.

In 2007 February the CNS ECC assisted the Ottawa Branch with an exhibit booth at the Ottawa Carleton District School Board Science Professional Development day.

In November the CNS ECC again hosted a booth at the STAO 2007 conference. On this occasion a workshop on energy, targeting elementary science teachers, was also presented. Three Geiger detectors were awarded as draw prizes to teachers from St. Jean de Brébuf (York), C.W. Jefferys CI (Toronto), and Iroquois Ridge HS (Oakville). Once again, however, no teachers followed up by requesting a Geiger for their school, despite evident enthusiasm.

Concurrent with the Canadian Nuclear Association's (CNA) 2008 Conference and Trade Show in Ottawa, the CNA invited science coordinators from the provincial ministries of education to attend a meeting on the Nuclear Technology Education website being developed by the CNA to address the Pan Canadian Science Curriculum [3]. At this meeting the CNS ECC presented the CNS Geiger demonstration and advised that the CNS was interested in placing Geigers with interested teachers in high schools. Following this presentation, a request was received from a teacher from Fredericton High School, and a Geiger was presented by the New Brunswick Branch. Moreover, the representative from the NB Ministry French Language schools requested 30 Geigers. CNS Council approved a Special Project to meet this request. The CNS ECC advised both the English and French representative that funding was available for up to 30 Geigers, and requested that they coordinate their request. At this writing, 12 have been sent to the NB Branch for donation to the French NB high schools, and another 18 are on order for the English NB high schools.

In 2008 March the CNS ECC assisted the CNS Alberta Branch with hosting a booth at the Mighty Peace Teachers' Convention [4] in Grand Prairie, Alberta. A contact made at the booth lead CNS member Paul Hinman to follow up with teacher Clifford Sosnowski, and subsequently, the Alberta Branch donated a Geiger to St. Laurent High School in Edmonton.

In 2008 the CNS ECC hosted the STAO booth again. A new workshop was prepared, specifically on ionising radiation and targeting senior physics and chemistry teachers. A retired science teacher was recruited to assist with the development of the workshop and its presentation. Prior to the conference the workshop development team presented an early version of the workshop to the science department heads from high schools in the Renfrew County District School Board at a meeting in Pembroke, Ontario. Their encouragement and comments were appreciated.

Also in 2008, the CNS Alberta Branch organised a booth at the Alberta Teachers' Association Science Council (ATASC) [5] Annual Conference in Calgary, which is held each year during the same week as the STAO conference in Ontario. The CNS ECC assisted the Branch providing material, equipment and suggestions. CNS member Peter Lang presented the workshop in Calgary on the same day the same workshop was presented in Toronto. At both venues the workshop was well-received. No Geigers were awarded as draw prizes in these cases, but follow-up interest was finally demonstrated: eleven teachers from STAO (one responding immediately after the Pembroke meeting) and two from ATASC have requested Geigers to date. Geigers are being sent to the schools as they become available. The list of schools that have received Geigers from the CNS is posted on the CNS website [6].

In 2009 February the workshop was presented at the Ottawa Carleton District School Board 2009 Science PA Day to two groups of 11 teachers. The Ottawa Branch presented a Geiger to a teacher from Merivale High School during the workshop and hosted a booth at this event in Bells Corners. The workshop was well-received, but to date, no requests have arisen from this instance. It is scheduled for the Atlantic Canada Association of Science Educators (ACASE/AEESA) [7] Annual Conference in Moncton, NB in May 2009.

4. Ionising Radiation Workshop

The CNS Ionising Radiation Workshop is designed to include material useful for the introduction of the theory of radioactive decay. It enriches the curriculum with an introduction to the Interactive Chart of the Nuclides [8] and real classroom measurements using a Geiger detector. The workshop includes proposed experiments with examples of the data that may be obtained and an analysis of the results.

The workshop notes include detailed information on setting up the Geiger system and software. This is necessary because a teacher may use the system only once or twice a year, and may have to reinstall the software routinely. Supplementary material illustrates how the Geiger system may be set up using a variety of computer interfaces. The limitations of the USB interface option are illustrated, and means to reduce the intensity of some sources with shielding / collimation are shown.

The Power Point slide set and notes are made available to teachers for downloading from the CNS web site [1].

The experiments with NORM and consumer sources illustrate that real experimental results are more complex than the simplified illustrations in textbooks suggest.

The outline of the workshop notes is appended to this paper.

5. Aware Electronics RM-80 Geiger

The experience gained over almost two decades of presentations with these instruments has established that a high sensitivity Geiger detector interfaced with a MS-Windows®-based program is necessary. People in general and students in particular respond best to results that are obtained expeditiously.

The sensitivity of the RM-80 Geiger supplied by Aware Electronics [9] is sufficiently high to provide background count rates of 40 to 50 counts per minute in any Canadian venue. It is important for the students to observe that ambient background is readily detected. Moreover it is possible to introduce simple shielding and reduce the background – but not eliminate it. The information provided illustrates that detecting weak sources requires long counting intervals.

The software generates a time-series bar graph with alarm detection and annunciation features. Since the data is displayed on the computer monitor it can be readily projected on a screen for classroom viewing, and the data may be logged for subsequent analysis using a spreadsheet.

The Aware product interfaces to a computer serial port (or a parallel printer port) so as to generate a processor interrupt for every count event. Contemporary laptop computers include neither a serial port nor an internal bus interface where one may be added (e.g. PCIA slot). However, Universal Serial Bus (USB) connected serial ports may be used.

Unfortunately the USB interface data transfer is non-deterministic and consequently the statistical properties of the Geiger count timing are not preserved. Moreover, the USB interface scheme limits the maximum count rate and some experiments require measures to reduce the maximum count rates to minimize missed events. Aware Electronics also market a more costly, higher-performance microprocessor-based USB interface.

6. Scale of the Demand for Geigers

With each presentation of the workshop an additional demand for Geiger detectors is anticipated. 2009 will provide additional experience to gauge the success of this approach. Figure 1 illustrates the experience to date and the target CNS donation numbers for 2009 and 2010.

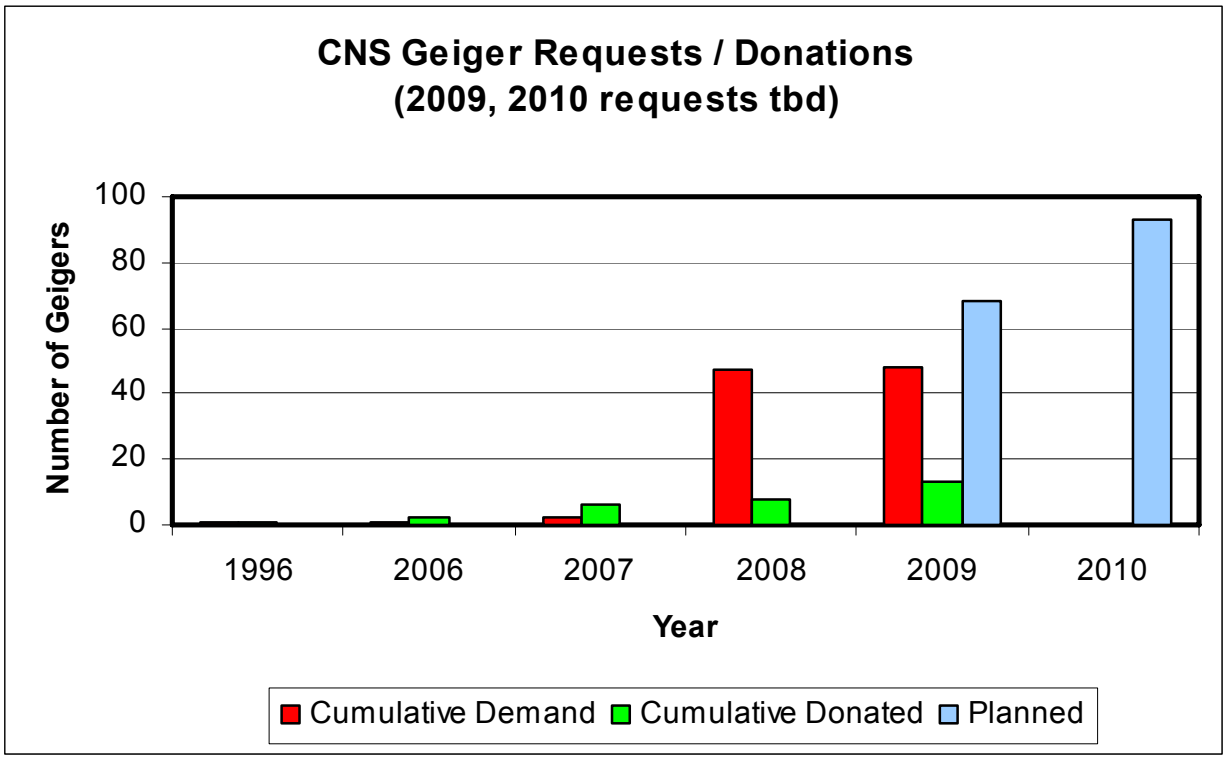

Figure 1 History and Projection of Cumulative Donations to Schools

Within a given school district there is the opportunity for teachers to share a Geiger among several schools. This is limited since all the teachers in a province follow the same curriculum and their requirement for these instruments will tend to be concurrent.

Table 1 lists an indicative number of secondary schools (in some cases K-12, and single-room schools) for the respective provincial / territorial ministries of education.

Some rural schools have very few senior students, while those in large centres may exceed 100. The opportunities to help improve science education in Canada are formidable.

A program that targets specific communities or districts important to the industry, and large urban secondary schools is thought to offer the best return on an investment of this kind.

Table 1
Indicative Estimate of Secondary Schools in Canada

Province / Territory	(Senior, K-12) Secondary
Alberta	654
British Columbia	364
Manitoba	320
New Brunswick	72
Newfoundland and Labrador	74
Northwest Territories	19
Nova Scotia	100
Nunavut	10
Ontario	892
Prince Edward Island	9
Quebec	478
Saskatchewan	151
Yukon	3
Total	3146

7. A Matter of Trust

The premise behind the donation of Geiger systems to the schools is that the teachers are to be equipped and enabled to provide improved science education. Consideration has been given to attempting to track the usage of Geigers in the schools. The reality in most schools is that teachers are frequently assigned to teach different classes. Moreover they have many administrative duties, and reporting the status of a donated item is not likely to be sustained. Rather than actively tracking the Geigers, the list of schools with Geigers is posted on the CNS website. Through regular presentations of the workshops, the CNS trusts that interested teachers will recover a disused Geiger and ensure it is returned to service in the classroom.

8. Moving Forward

This CNS ECC program is moving forward with the following specific objectives:

- Establishing a robust system to supply and distribute Geigers;
- Establish a dedicated kit for workshop presentations with a robust method of checkout, deployment and recovery;
- Maintaining a stable of experienced workshop presenters including:
    - CNS volunteers (free)
    - Retired or active senior science teachers (honoraria), and
    - Professional presenters (contract services);

- Developing a business case to encourage industry participation
- Developing a French language workshop, material, and French speaking presenters.

9. Acknowledgements

The continued support of CNS Council has made the development of this program possible. Chuck Cohen (Community Hebrew Academy of Toronto) provided encouragement and guidance starting at STAO 2006. Clifford Sosnowski (St. Laurent High School, Edmonton AB) provided useful comments and advice. The volunteers who staffed the booths at the events in Toronto, Ottawa, Grand Prairie, and Calgary are most appreciated. In particular, those who are not CNS members include: Cheryl Cottrill (WiN Canada), and Bob Walker (PWU, OPG). In 2006 and 2007 Candesco staff assisted with the booth (including members of the CNS and non-members).

10. References

[1] CNS website Education page, www.cns-snc.ca/ecc/cnsecc.html.

[2] Science Teachers' Association of Ontario, www.stao.ca.

[3] CNA website, www.cna.ca/curriculum/default.asp.

[4] Mighty Peace Teachers' Convention, mptc.teachers.ab.ca.

[5] Alberta Teachers' Association Science Council, sc.teachers.ab.ca.

[6] CNS website Education Page donation list, www.cns-snc.ca/ecc/Geiger_donations.pdf.

[7] Atlantic Canada Association of Science Educators, www.unb.ca/fredericton/science/physics/acase/.

[8] Interactive Chart of the Nuclides, www.nndc.bnl.gov/chart/.

[9] Aware Electronics website, www.aw-el.com.

Appendix

Table of Contents of the CNS Ionising Radiation Workshop Notes