RAISING PUBLIC AWARENESS OF NUCLEAR SCIENCE IN ACTION

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Abstract. The activity and the present status of the Department of Training and Consulting of the Soltan Institute for Nuclear Studies at Świerk, Poland, are presented. The motivation for this activity, its methods and our experience of over 5 years in raising public awareness of applications of nuclear sciences among different social groups, are discussed.

1. Research institute or university?

The Soltan Institute for Nuclear Studies (SINS) is a government-operated nuclear physics and technology research institute. The Department of Training and Consulting has been created at SINS some 7 years ago, with the basic duty of disseminating the knowledge of nuclear physics and its applications, with special emphasis on

- the use of radiation in everyday life,
- biological effects of ionising radiation,
- risks connected with the use of nuclear technology.

Another important goal was to counteract social radiophobia. Last but not least, the newly formed Department was to inform the general public of the scientific and technological achievements of the Institute. In this respect, our Institute realizes the ideas of raising public awareness of nuclear science in a manner recently summarized by Oberhummer [1].

Although the Department of Training and Consulting also organises professional training courses on radiation protection, its main target groups are secondary-school teachers and their students, who have responded quite enthusiastically, despite the certain inconvenience of travelling to Świerk, some 40 km from Warsaw. The Department organises short continuous education courses, mainly for teachers of physics. The Department also hosts representatives of local governments responsible for risk management. During the last four years we received over 20,000 visitors from all over Poland. One can then ask what is the reason for such activity? Would it not be have been better to have it handled by an academic centre?

1.1 re-assumptions

1.2

Let us first summarize the basic motivation of our activity.

- Citizens are sceptical of modern science as a whole. In particular, they do not distinguish between basic research and technology, and are over-concerned with dangers rather than benefits of such activities.
- Modern science is too complex to be readily understood by laymen, especially if the general public is not exposed to good popularization of science. We believe this to be one of the main reasons for all kinds of para- or pseudo-sciences becoming so popular.
- There were too many unfulfilled promises from the scientists (e.g., to solve all energy problems, to eradicate cancer and other dangerous diseases, to solve the problem of unemployment, etc.), and too many disasters which had not been prevented by the scientists or even triggered by modern science. Therefore, a quite common attitude is that scientists can no longer be trusted, and that their growing demands for further subsidizing their expensive research is unwarranted.
- Nuclear science is perceived as being particularly dangerous because its development had to result in developing weapons even more destructive than the atomic bombs dropped on Hiroshima and Nagasaki. The present arsenal of nuclear weapons

available in many countries would not materialise if not for the activity of nuclear scientists. Moreover, even in what is called peaceful uses of nuclear energy, the nuclear accidents and nuclear waste produced are a threat to mankind over the next thousands of years.

1.2 Diagnosis

- Good educators and social communicators in nuclear science are absolutely necessary. They should be expert not only in nuclear science but also in the mechanisms ruling the world's scientific development.
- Of all possible target groups, people in the public media, politicians, lay people, high-school teachers, high-school students and even primary school students are the most important. From that point of view, most important and timely is proper education of teachers and high-school students, because they will decide about the society's future. Media people are to a large extent "blood-and-tears"-oriented, politicians are too concentrated on their own careers which depend on their voters, and lay grown-ups have been exposed to false propaganda for too long, so they are not very susceptible to information that goes against their fears and acquired "knowledge". One should not forget that even some physics teachers may have acquired deformed opinions, shaped for a long time by various media.
- Education of teachers and high-school students should go in parallel. However, particular care should be taken in order to convince students that:
  - Science is a value in itself.
  - Scientists as a rule are honest and dedicated people who are very critical towards newly published discoveries.
  - Nuclear science is central to life on Earth and to the development of the Universe as a whole, where "life" also means "personal life". This is what makes nuclear science so fascinating. One needs not to be particularly interested in physics in order to become intrigued, if not fascinated, by the world discovered through the "life" of nuclei.
  - The discovery of atomic nuclei radically changed our general knowledge of Nature because nuclei are objects of all elements on Earth. 19th century scientists certainly had no idea of this universality.
  - Risk is an inherent part of every person's life. The risk connected with radiation and with the nuclear activity can be objectively evaluated and compared with other risks, using a common base. The fear of nuclear science is due to the great overestimation of the actual risk involved which then over-rules the much higher every-day risks which are traditionally accepted.
- Nuclear research institutions are particularly well suited to disseminate the knowledge of nuclear science for the following reasons:
  - they employ experts in the field; the experts are people exposed more or less permanently to radiation, so they themselves are somehow exponents of the risk connected with nuclear radiation.
  - they can readily and competently demonstrate nuclear experiments and installations to the public,
  - students will willingly visit nuclear scientists at their research institution, so education becomes a natural component of such visits (note that here "education" is not the same as "information", offered as a standard to the visiting groups),
  - nuclear research institutions can play the role of "ask the expert" sites,
  - unlike university centre, which are usually overloaded with teaching duties, the staff at research institutes often look forward to regular teaching, as education of

- others will often give them unique opportunity to broaden their own perspective to research and scientific achievements.

1.3 The problem

We have pointed out that the fear of radiation is so strong that there is generally no acceptance of the nuclear risk however small. All educational efforts listed in the preceding paragraph are necessary but do not guarantee success. In order to overcome radiophobia one has to develop rational thinking which goes far beyond standard nuclear research. Therefore it is important to have psychologists, sociologists and generally teachers of human sciences who will be well acquainted with the mechanisms of fear and, on the other hand, with the particular problem of nuclear fear. These specialists should become a special target group for nuclear educators. Not enough attention has been given to this target group.

2. Educational forms

Nuclear education must be realized in particularly attractive manner. In order to make it attractive and effective, the following components of educational means should be applied:

- Lectures with convincing demonstrations of basic properties of nuclear radiation.
- Exhibitions with a number of "hands-on" experiments and animations, if possible.
- An atomic and nuclear physics laboratory dedicated to schools and teachers should be available. This is particularly difficult task. However, the nuclear research institutes, as a place for such laboratories, are unique in this respect because not only can they supply the proper equipment but they can also maintain the necessary radiation safety environment for students - one should remember that regular universities are usually too busy with their own students to be able to extend their laboratory facilities to high-school students. Besides, a variety of nuclear experiments can be organized more readily in a research institute than at a university where the whole field of physics must be covered.
- Video films.
- Internet platforms (see e.g. NUPEX European project started in 2003).
- Educational posters.

The above-quoted forms can and should obviously be used to train other social groups as well. It is my strong conviction that without direct demonstrations of nuclear phenomena it is impossible to raise public interest and awareness of nuclear science.

3. Everyday work of the Department of Training and Consulting

In addition to lectures themselves and lectures with experimental demonstrations two permanent exhibitions are displayed permanently. One is called "Nuclear Wastes: Problems, Solutions", the other one is a 1:10 scale model of a nuclear power plant (VVER-440-type), both extremely useful in discussing the problems of nuclear wastes, organisation and use of the nuclear power plants, the basis of nuclear energy.

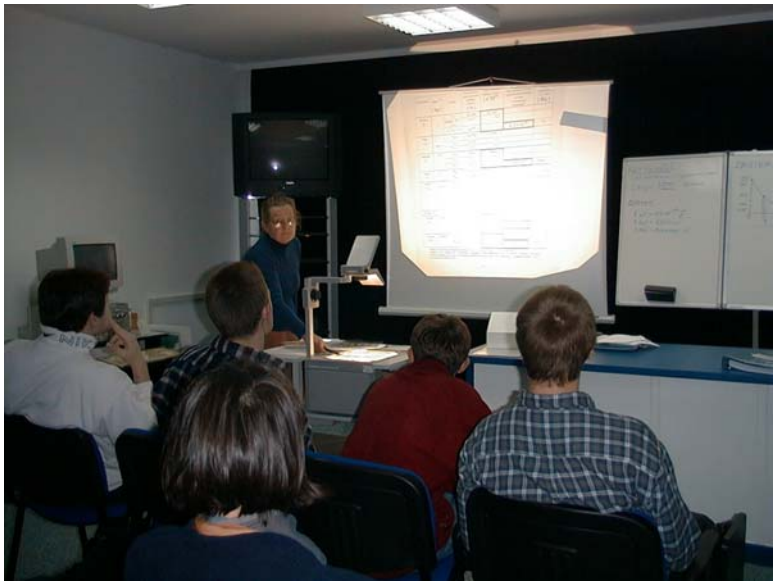

Fig.1 A class at the Department of Training and Consulting

Fig.2 The author explaining how a nuclear reactor works

Fig.3 Part of the exhibition "Nuclear wastes: Problems, Solutions"

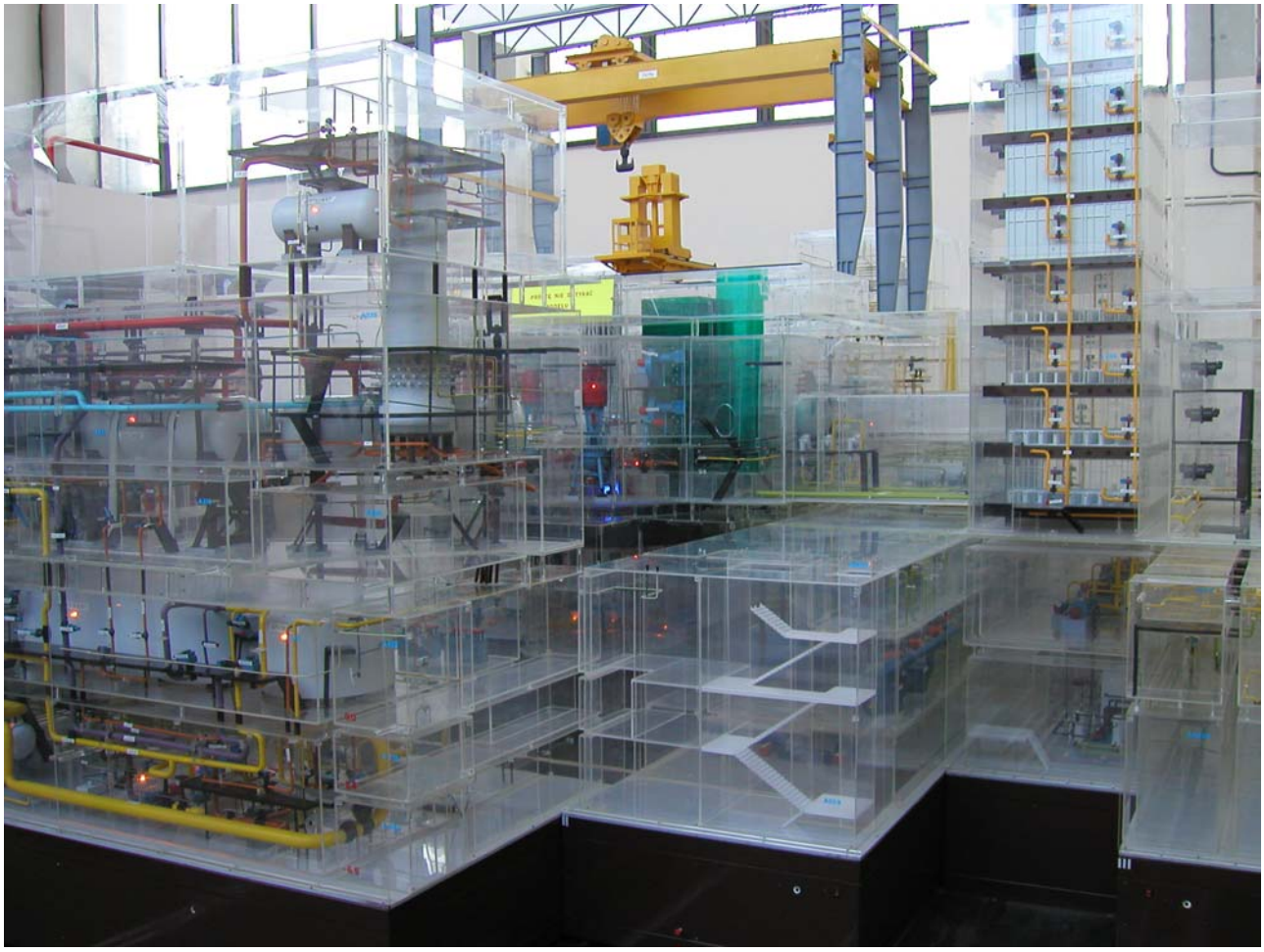

Fig.4 The model of a nuclear power plant

We have developed a quite unique Laboratory of Atomic and Nuclear Physics at the Department, dedicated to secondary school students. The Laboratory is well equipped, so is also used by university students and in teachers' trainings. A number of basic nuclear physics experiments can be carried out by students themselves, so the very basis of atomic and nuclear physics can be studied on an experimental basis. The following experimental fields are covered:

- production and properties of X-rays
- determination of Planck's constant
- wave-particle dualism (electron in magnetic and electric fields, electron diffraction; X-ray diffraction and Compton scattering)
- absorption of ionizing radiation in materials
- characteristics of nuclear radiation detectors
- search for and determination of radioactive pollution
- basics of radiation protection
- radioactive decay
- activation analysis using neutrons and protons; inducing fluorescence by gamma radiation
- excitation of luminescence, etc.

There are altogether about 20 different experiments which can be run in the laboratory. This experimental support can also be used in professional courses on, e.g., radiation protection. It has already been used for training physics teachers.

In addition to the aforementioned activity, we offer to our guests the possibility of visiting the scientific laboratories of our Institute and the reactor MARIA which belongs to the Institue of Atomic Energy, our neighbouring.

Within our activity we also developed a series of quizzes which are available on the internet (in Polish only: http://www.ipj.gov.pl). The students can check their understanding of basic properties of radiation, its use, benefits and risks. If the answers to questions in quizzes are not known, the student can find a block of self-teaching material, in which he or she will encounter precisely the same questions (in a different order). If the answer to the question is wrong, one gets the explanation why it is wrong, but the explanation does not indicate the correct answer; one cannot go to the next question without giving the correct answer to the current one. In this manner one can learn the whole material contained in our quizzes.

Last but not least, we supply teachers and students with useful printed material, posters and information about internet pages and literature of the subject.

4. NUPEX

Our Department actively participates in the NUPEX project, funded within the 5th Framework Programme of EU. Its main ideas have been described elsewhere [1]. The internet platform, a one-stop shop currently under development, will offer reviews of the following problems:

- Radioactivity
- Structure of matter
- Applications of nuclear physics
- Nuclei and the Universe
- Nuclear Science – War and Peace

Because NUPEX is not designed to replace regular textbooks and is addressed mainly to secondary-school students, mathematical formulations are not used and emphasis is on the descriptive and qualitative analysis of the problems. NUPEX content can therefore serve as a primer for anybody who wishes to acquaint himself with the very basics of the problems connected with nuclear radiation. The pilot lessons are already available at the

http://www.nupex.org site. To access these lessons, the author will provide the necessary codes for login to the files, to those interested. Obviously, the material to be should be treated as the first step to nuclear physics and its applications. One may wish to develop more quantitative material for more advanced and demanding students. Whether this will happen depends on the interest of EU, and EURATOM in particular. In this author's opinion, it would be great pity if the work of the NUPEX team were not further continued.

5. Results and conclusions

It is always difficult to evaluate results of the outreach activity. What we can observe, however, is a systematic growth of the number of schools who visit our Department. The number of courses requested by teachers' organisations also increases. In the all-Poland competition on radioactivity (organised on the 100th Anniversary of Marie Skłodowska-Curie's Nobel Prize), almost all main prizes went to the teachers who had visited our Department and stayed in touch with us. Many schools, after visiting us, organised minisymposia concerned with radioactivity problems. Very recently, a secondary school in Warsaw organized a regular exhibition in the field of radioactivity.

It may also be of interest to summarize our "negative" experience and reasons why we can fail in transmitting the knowledge to the young guests of our Department. These are as follows:

School teaching curricula are constructed in such a way that atomic and nuclear physics are taught by the very end of the course of physics. Often, the teacher has not devoted enough time to teach these problems, so school students, when arriving, are not familiar with any basic physics of radiation

In lower-grade classes such notions like atom, nucleus, ion, radiation etc., appear in the courses of physics and chemistry, but often incoherently

The students find it difficult to read and make graphs, which are a necessary part of laboratory work.

The knowledge acquired in the school seems to be given in separate quanta without emphasis on the links between various notions, ideas and phenomena. Therefore a simple question, such as "what may be the mass of all electrons in your body?" often causes panic.

The laboratories in secondary schools are either non-existing or very poorly equipped, so the students are not accustomed to making and understanding experiments.

It seems that some of teachers promote the ideology of the type: "I am humanist and do not understand all this; and electrons and nuts and bolts are of no interest to me".

The school does not teach the pupils that although people are equal, some of them know more than others, and that scientists generally know much more than journalists. Therefore sometimes even young people do not trust the scientists and refer to what they read or heard or saw in TV. They are much more critical with respect to the scientists than to the information they gather from the media.

In spite of our information in leaflets and in the internet, the visit to us is treated by many teachers, and their students, as sort of a week-end excursion. Therefore quite often the pupils are disappointed by what they meet: "we've been told that we are going to an excursion, so why are we to attend a class instead?".

We are strongly convinced that our work results in an increased interest of students in physics, and may result in more of them choosing physics and nuclear physics as their subjects of academic study. This is essential if nuclear energy is to be developed and used safely in our country. We also believe that similar educational centres should be organised in other nuclear centres in Europe, all of them forming a network. Thus, new teaching methods would be worked out and the experience could be easily evaluated and exchanged between the network's partners.

The importance of raising public awareness of nuclear science already in secondary schools is, regretfully, not properly recognized. This can be judged from the content of OECD report [2] on nuclear education and training, the content of calls for proposals announced by EURATOM, and also from evaluating the problems raised in this paper by the organisers of this conference. Apparently, poster presentation cannot provide the Conference participants with good illustrative material to. It is absolutely clear to me and my colleagues from the Department that the future of nuclear science depends crucially on creating an interest in this science already in secondary schools. To express concern at the university level is positively too late – it is like starting a building from the roof rather than by first constructing solid foundations.

The systematically growing number of our visitors, and their demand for educational material strongly support the need for developing educational centres at research institutes. The fact that very seldom do we encounter typical symptoms of radiophobia after a visit to our Department shows that our visitors are given a correct description of the actual risks connected with nuclear radiation.

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