

PROPOSITIONS OF NUCLEAR ISSUE EDUCATION FOR TEACHERS AND STUDENTS

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Abstract. It is well documented in the literature that the *project method* is the most effective among other active methods of teaching science. In this paper we described our experience, which we got during planning and execution of four projects aimed at the increase of nuclear issue knowledge and awareness among students and teachers: Computer aided investigations of radioactivity with the use of GM detector; Project RADONET – radon in our homes – is the risk acceptable?; Competition on interdisciplinary educational project “Radioactive World”; Distance lecture on “Radioactivity Around Us”. We hope that they may serve as an inspiration for others planning similar projects in their countries.

*We have to be persistent and believe
that we are able to do something well...*
Maria Skłodowska-Curie

1. Introduction

In our continuous quest for better and more efficient process of education, we should always try to confront our present day tools and methods with future needs of our students, when they enter their creative life. Not engaging deeply into detailed estimations, one can expect with reasonable confidence that young perspective workers, starting their jobs after 2010, besides deep understanding of physical principles should be very well prepared to cope with abundant, omnipresent and diverse information using the most sophisticated aids and methods. This should be applied in all science disciplines, but especially when we are dealing with nuclear knowledge (information) management.

Besides renewable energy forms, the nuclear energy seems to be of the greatest potential for future needs. Recently the nuclear technology has developed almost in all domains of human activity. Unfortunately, common knowledge about physical processes involved in the nuclear energetics and furthermore, about the specific, nuclear radiation effects on the living tissues, is still very poor among the secondary and university students. We can find proofs for this statement in everyday situations and in the literature [1-8]. Conforto [4] investigating nuclear problem awareness gave the Italy students the same kind of questions before and after Chernobyl accident; the quality of answers was alike, sometimes even worse after Chernobyl. The same was found for the students' radioactivity awareness in Poland [7,8]. Thus, we should take every opportunity to speak about the complex nuclear problems, and that much more of the school time should be spend on teaching radioactivity phenomenon. We should acquaint students both with benefits and risks of the nuclear energy applications. We are convinced that knowledge and competencies are certainly the cheapest way to prevent any nuclear danger! Taking this into account we designed several projects aimed at the increase of nuclear issue knowledge and awareness among teachers and students from the secondary as well as from the university school.

2. Computer aided investigations of radioactivity with the use of GM detector

Since the phenomenon of radioactivity was discovered by Henry Becquerel, Marie Curie-Skłodowska and Pierre Curie we know, that the “ionizing radiation” is around us. It can be the

stream of particles of the distinct kind – alpha, beta, protons, ions, neutrons and stream of high energy - X or gamma rays. But, naturally some problems arise: where does this radiation come from, how long does it live, is it dangerous to the human body, can we measure its amount and behaviour? In this paper we report our attempt to answer mainly the last question aimed at increasing of students' awareness concerned with positive and negative aspects of ionizing radiation, permissible radioactive doses for people and safety rules related to radioactivity sources usage.

For this purpose we designed and constructed computer controlled Geiger-Mueller counter with the dedicated software to measure ionizing radiation intensity. The menu of the dedicated MS Windows software contains the following options: characteristic of detector, intensity of the ionizing radiation and its dependence on distance and type of absorbing material as well as statistical distribution of ionizing radiation [9]. Having this simple and very cheap computerised GM device to our disposal we can perform different demonstrations and experiments with radioactivity in the real time.

First of all we can study the dependence of the average counts rate on the supply voltage set on the GM tube, thus to find "plateau" range (working regime) of the detector. Then, we can monitor the ionizing radiation level (number of counts per minute) of background as well as natural and artificial sources of radioactivity as for example: uranium and thorium minerals, potassium chloride, different fertilisers and building materials containing radioactive elements and so called Auer's mantles (use e.g. in tourist gas-lanterns), which contain radioactive thorium oxide (ThO_2). In the Figure 1. we can see the typical results of this kind of measurements.

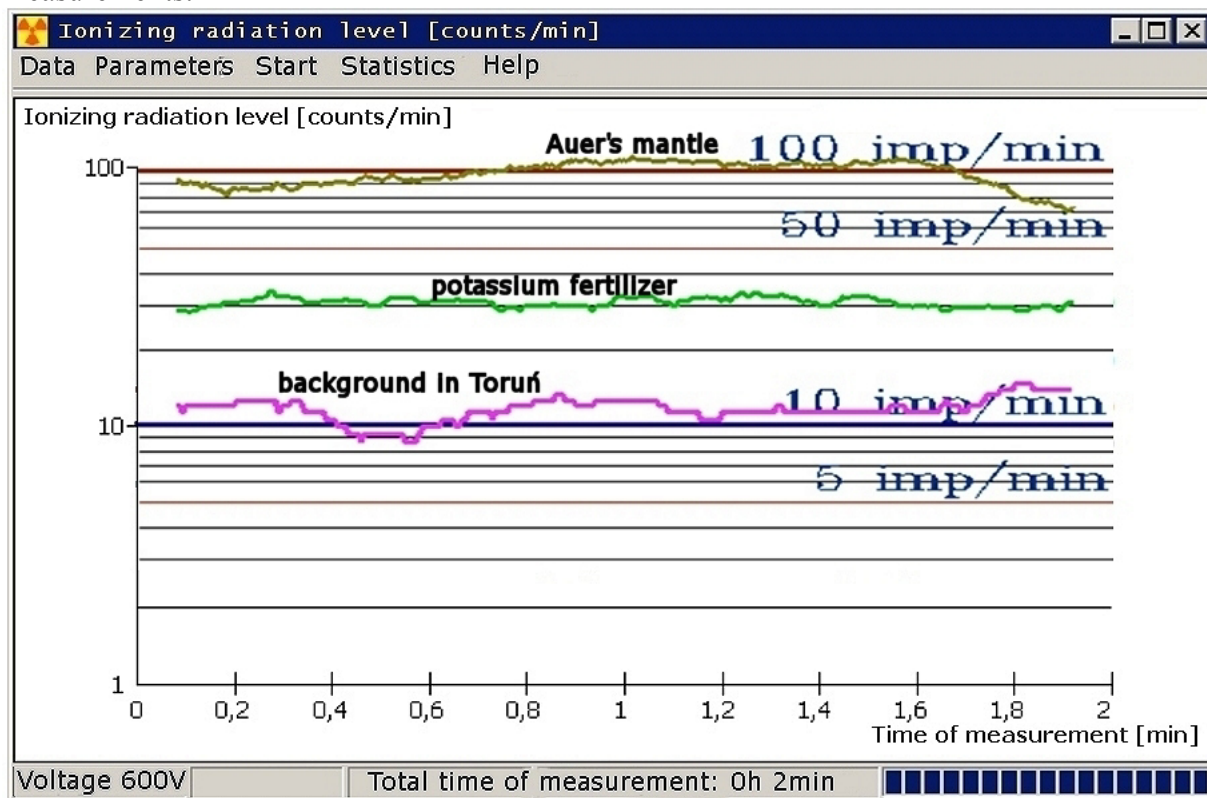


FIG. 1. The results of ionizing radiation level measurements for potassium fertilizer and Polish Auer's mantle compared with a typical background level in Toruń.

With the use of the same menu options we can demonstrate how the ionizing radiation interacts with different materials, when the distance and thickness of the absorbing materials

are changing. Besides that, using the digital multimeter option we can immediately evaluate and display the ionizing radiation doses and dose-rates in the SI units and check if we are exposed to the safe amount of ionizing radiation energy from a given source.

In addition, the radioactivity is perhaps one of the best examples of physical processes, which give us a possibility to demonstrate stochastic character of some apparently deterministic physical laws. It needs indeed some intellectual breakthrough for the young students to grasp the idea that in spite of pure random (“chaotic”) character of the individual fission process in the microscopic samples of radioactive nuclei, some laws are obeyed with astonishingly high precision. In this respect, some specific computer simulation programmes, illustrating this fact are of a great educational importance [10-12]. It seems to us however, that even deeper understanding of the radioactivity phenomena can be achieved by performing of the on-line experiments, showing the statistical character of the radioactive decay. As the result of using menu option *Number of counts at interval* we are able to investigate the statistical distribution of the individual counts at given time intervals. To enhance the educational value of this experiment, an appropriate histogram visualising investigated statistics is produced in the real time giving students the opportunity to observe how this distribution slowly evolves from seemingly chaotic counter ticks. The example of such typical histogram fitted by the theoretical Poisson distribution is shown in the Figure 2.

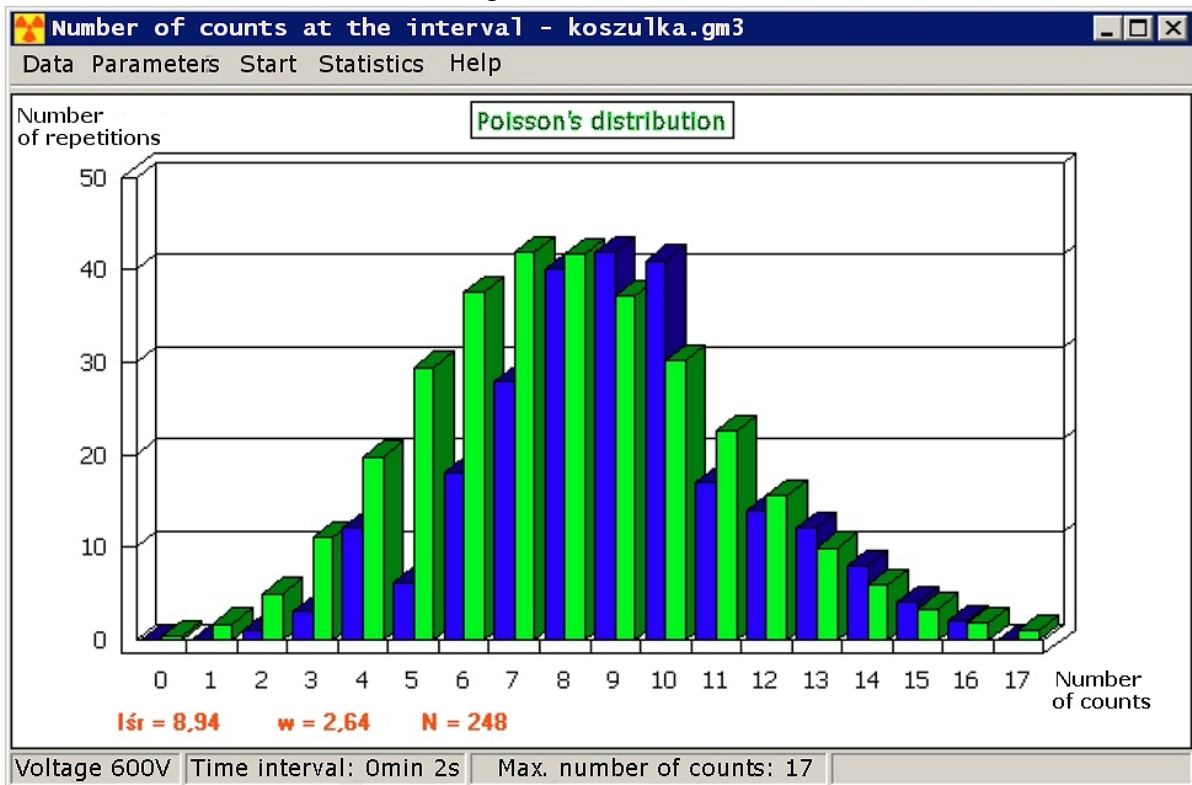


FIG. 2. The distribution of number of counts recorded at the interval of 2 seconds (dark columns) and the best fit of Poisson's distribution (light columns)

In this way students can investigate the obtained results with all mathematical rigor (the programme enables to evaluate all parameters of the obtained distribution). The Poisson's distribution is described by the formula:

$$P(n) = \frac{s^n \times e^{-s}}{n!}$$

where: n – number of counts, s – the mean value of counts, $P(n)$ – probability of occurring of n counts. In addition, from the experimental data we can get such statistical quantities as: N – number of all measurements, l_{sr} – the mean value of counts, w – variance.

When the number of counts is very small as for the background radiation, we can plot the number of events as a function of the time interval between them is approximated by the exponential distribution.

Last but not least is worth to add, that with the use of the above described tool it was possible to investigate the radon daughters level in student classrooms (homes), as it was reported in paper of Toth [13] and compared with Camplin's, Henshaw [14,15] and Turlo et al. methods of radon survey [16]. The last method was used by school students from Wieluń and their results were published in the Polish journal "Science Education" [17].

3. Project RADONET – radon in our homes – is the risk acceptable?

Radon is the most abundant radioactive element naturally occurring in our environment. The main objective of project RADONET (RADON + NET) was concentrated on answering the question: Radon in our homes - is the risk acceptable? It was based on the concentration of radon investigations in indoor air, ground and drinking water and in the vicinity of TV and computer screens, made by the science teachers from Toruń, within the EC Programme of PHARE/TESSA Postgraduate Course on Environmental Studies [18]. In our opinion, the knowledge about radon and its health risk as well as about the processes used to detect and eliminate the excess of this substance in the home should be implemented to the interdisciplinary science education as early as possible. Thus, inspiring by English [14,15] and Hungarian [13] researchers, we proposed the method of environmental education related to the radon issue, based on the study of Toruń physics teachers [19]. This project was developed during the ICASE Seminar in Tartu (Estonia) and was planned according to the philosophy of Science and Technology Literacy (STL) materials [20]. With the use of the Internet it has started also as the Polish project RADONET [21]. Through electronic networking, the project creates an extensive research community of students, teachers and scientists similarly to the Global Laboratory Projects idea [22].

We assume the following main educational objective of the RADONET project: Students have to realise, that there are probable correlations between the concentration of radon in homes and cancer diseases. This require:

- to develop student skills of making individual science investigations,
- to develop students' ability of analytical thinking and making rational decisions based on the evidence based on these investigations,
- to develop skills of using information presented in different forms (tables, diagrams etc.) and from different sources (journals, encyclopaedias, multimedia, including foreign literature),
- to develop students' ability to co-operate with medicine and environmental centres in town and with other students,
- to integrate students' knowledge and skills from physics, chemistry, biology, medicine and health education.

The educational research project RADONET was performed in collaboration with 35 science teachers from different regions of Poland. The concentration of radon was measured by the use of passive method (TASTRAK detectors). For communication of researchers, teachers and students as well for discussion of the obtained results e-mail, WWW pages, etc. were used. As the result we created the preliminary map of radon concentration in Poland made by students. The results of about 1000 student investigations of radon concentration in their homes are shown in the part of histogram shown in the Figure 3.

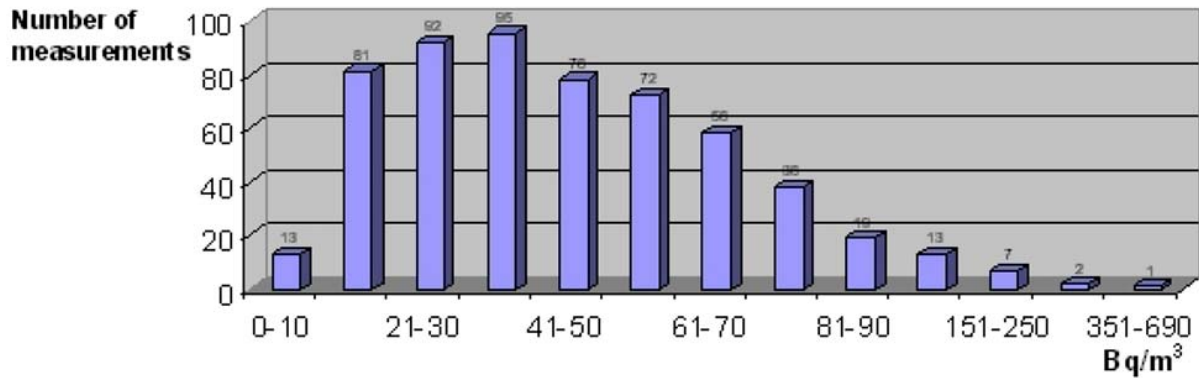


FIG. 3. Histogram of radon concentrations in students' homes.

Concentration of radon in most students' homes varied within the range of 6 - 689 Bq/m³, the mean value was about 70 Bq/m³. In three cases (in the south of Poland) we have noticed the concentration values as high as 2000 Bq/m³!

To our satisfaction we got the evidence that the increasing number of teacher and pupils wish to take a part in this kind of educational investigations.

In addition to these investigations we start to study the influence of electric and electromagnetic fields on radon daughters concentration in air [23]. We found that depending on different factors (e.g. electric field lines distribution, distance from the source of fields, geometry and isolation of source, value and sign of potential and humidity of air in which the investigations are taking place), the relative values of radon daughter concentrations near the electric and electromagnetic fields were from few up to hundreds and even thousands higher, what we can see in the Figure 4.



FIG. 4. TASTRAK plates exposed to high electric field with different electric field line distributions (the left one was placed on homogenous plate, the one in the middle on two pins and the right one on two metal strips).

4. Competition on the interdisciplinary educational project "Radioactive World"

Last year we celebrated the 100th anniversary of Maria Skłodowska-Curie, Pierre Curie and Henri Becquerel Nobel Prize in the field of physics awarded for investigation of the radioactivity phenomenon. Second Nobel Prize Maria Skłodowska-Curie received in 1911th in the field of chemistry for separation of two new chemical elements: polonium and radium. Furthermore, from her private lesson notes we know, that she was one of the first science teachers, who tried to apply the active methods in teaching process [24]. The science and teaching genius of this amazing woman was an inspiration for the Education of Physics Laboratory to organise the competition for interdisciplinary educational project, addressed to

Polish students and their teachers, under the general title “Radioactive World”. The logo of the Competition is presented below (Figure 5).

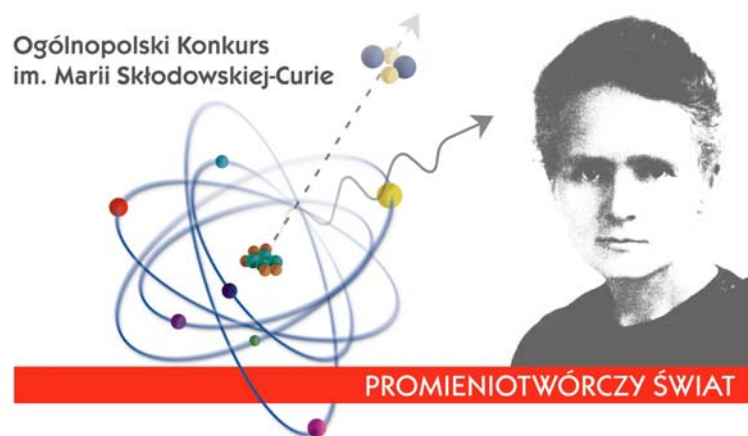


FIG. 5. The logo of the competition “Radioactive World”.

The organizers set to the participants the following tasks:

- to present the original and attractive types of teaching methods and techniques applied to the radioactivity issue,
- to integrate the science, literature, history and art teachers environment at schools, realised during the work on an interdisciplinary project,
- to stimulate the natural students’ fascination on the technological and social aspects of science and motivate them to the development of scientific process skills,
- to raise the local communities’ knowledge about the problems concerned with the radioactivity, its applications and protection.

The Competition Committee received 44 projects from upper and lower secondary schools. Most of them engaged teachers of various disciplines including science subjects (physics, chemistry, biology, mathematics, computer science, literature, art, history). The Committee awarded 15 projects which were the most valuable and their results were presented to the wide local community by press, radio and TV. A few examples of the innovative teaching methods from the best projects are presented below.

The laureate in the category of upper secondary schools, project entitled “In the XIth Upper Secondary School in Wrocław we live in the Radioactive World” discover the presence of the radioactivity phenomenon in the whole world around us. During the project Students were exploring the different spheres of life and knowledge: culture, technology, medicine and ecology to find the evidence of this fact. They prepared plenty of materials: posters, presentations (with the use of multimedia) and WWW pages illustrating the advantages and disadvantages connected with the existence of radioactivity in the environment. The teachers of various disciplines (e.g. chemistry, biology, physics, IT, history, literature and foreign languages) were realised interesting lessons related to the theme of project.

Another awarded project “The People in the Radioactive World”, performed in Tadeusz Kościuszko Upper Secondary School in Wieluń, gave emphasis for the students own investigations of different kinds. One of these was an examination of knowledge level concerned with the radioactivity phenomenon in the wide population of school students, their families and teachers. The questionnaire was examined an understanding of the physical aspects of radioactivity, the threats connected to the radioactivity as the energy source and the use of radioactive materials in medicine and technology. The results of the questionnaire

clearly showed the necessity of undertaking the educational actions related to the radioactivity issues in the society, as it was stressed by Eijkelhof [2]. The second area of students investigations were the radioactivity measurements of natural sources (coal, ashes, furnace sludge, fertilizers, materials used in preparation of building construction materials) with the use of ICT based Geiger-Müller counter and discussion of these measurement results.

In the course of one of the best projects, performed in the 1st Upper Secondary School in Bolesławiec, students and teachers visited the health resort near Świeradów Zdrój SPA. One of its radon containing springs was given the name of Maria Skłodowska-Curie. Students collected the information about the radon therapy and observed the radon concentration measurements in laboratory of Świeradów. After the visit they had the opportunity to discuss the advantages and disadvantages of using the low ionizing radiation doses in medicine.

In the majority of the awarded projects teachers applied innovative teaching methods like dramas, panel discussions with scientists and local authorities, visits in the scientific laboratories performing the ionizing radiation measurements or observing the radiation therapy in medical physics laboratories in hospitals. Students prepared their own web pages, animations of radioactive decays, posters and reports. The results of the projects were published in school and local press.

The most valuable competition materials e.g. lessons plans, PowerPoint presentations, posters, computer animations and WWW materials had been already presented at the conferences and workshops addressed to science teachers, published in the form of booklet [25] and are actually in preparation for the publication at our Laboratory web page as the resource, inspiring materials for the interesting lessons on radioactivity, alike to Maria Skłodowska-Curie lessons, which she was given together with Jean Perrin, Henrietta Perrin, Paul Langevin, Henri Mouton, Alice Chavannes, Jean Magrou to children in 1907 – 1908 in Paris [24].

5. Distance lecture on “Radioactivity Around Us”

The use of distance teaching and learning is increasing dramatically in all sections of educations and training all over the world. We would also like to explore its potential for teaching radioactivity issue. For the exemplary lecture we selected the topic “Radioactivity Around Us”. First of all we prepared scenario of this lecture (see Table 1) and prepared all necessary educational materials with the use of ICT tools and methods.

TABLE 1. The scenario of lecture on “Radioactivity Around Us”.

o.	Teaching sequence	Activity	Application/Re sources	Remarks
1.	QUESTIONNAIRE - RECOGNITION OF PRIOR KNOWLEDGE AND PRECONCEPTIONS ON RADIOACTIVITY	Execution and answer the questions	Q&A LearnLinc for questioning and Whiteboard for presentation of the results	Display of the statistical data
2.	Historical introduction Discoveries of: a) H. Becquerel b) M. Skłodowska-Curie	Presentation of picture	WWW browser (e.g. Microsoft Internet Explorer)	Centenary of M. Curie Nobel Prize Award (1903). Competition for students in Poland on <i>Radioactive World</i> .
3.	Description of radioactivity: a) schematic model of radioactive decay b) sources and forms of ionizing radiation c) interaction of alpha, beta and gamma radiation with matter	Presentation of pictures, table and explanation of phenomena	WWW browser (e.g. Microsoft Internet Explorer)	Introduction of half-life time $T_{1/2}$ concept.
4.	Characteristics of statistical	Computer	LearnLinc	Examination of the

	radioactive decay of nuclei: - exponential decay - half-life time	studies of law of radioactive decay	AppShare The use of EPL (Torun) simulation software Whiteboard LearnLinc	formula: $N = N_0 e^{-\lambda t}$, $\lambda = \ln 2 / T_{1/2}$, λ – decay constant, $T_{1/2}$ – half-life time.
5.	The units used for the measurement of radioactivity	Presentation of tables and explanation.	WWW browser (e.g. Microsoft Internet Explorer)	Only SI units will be presented
6.	Display of equivalent radiation dose / year / person caused by different ionizing radiation sources	Display of MS Excel diagram	WWW browser (e.g. Microsoft Internet Explorer)	The data were taken from Poland. They can differ for different countries
7.	Tasks for students concerned with the average radioactive doses / year / person in their countries	Completing the table	Whiteboard LearnLinc	Eventually homework: Find the data in the Internet
8.	Radon – the most important source of natural radioactivity a) where radon can be found? b) radon risk c) radon in our homes d) investigations of radon concentration at students' homes e) students' results of radon studies in Poland f) limits of radon concentration in students' countries	Presentation of pictures, explanation and questioning	WWW browser (e.g. Microsoft Internet Explorer) Audio	Students can measure radon concentration in their homes themselves Eventually homework: Find the limits of radon concentration in your country using the Internet
9.	How can we measure the beta and gamma radiation intensity with the help of computer? Additional question: Can we measure the concentration of radon with the use of GM detector?	Display capture of screens from on-line measurements taken by digital camera showing pictures of: a) GM detector b) different ionizing radiation sources c) measurement of radiation intensity of background, fertilizer, Auer mantel, watch, etc.	WWW browser (e.g. Microsoft Internet Explorer) Possibility to display the clip from on-line measurements taken by digital camera Whiteboard LearnLinc	The most effective would be the real-time investigations of ionizing radiation with the use of GM detector and suitable software by students. They could answer the question: Which materials are radioactive?
10.	Homework: Please describe profits and risks concerned with the applications of nuclear energy.		Whiteboard LearnLinc	

For presenting the lecture to the science teacher trainers from EU countries we used LearnLinc 6.02 software obtained due to the STEDE (Science Teacher Education Development in Europe) project, within the group 10a, synchronous distance education. We used the following ICT tools and methods for the presentation: chat, voice communication, synchronized Internet browser, whiteboard, tools for Q&A, Appshare, Windows Media Player and tools for recording and displaying the multimedia files. During the lecture we asked our listeners the questions as for example: 1) Radioactivity is a phenomenon: A. caused by temperature, pressure, magnetic field, B. radiation of solid bodies, liquids and gases, C. characterising only atomic nucleus, D. describing all reactions taking place at the Sun surface, 4) The greatest part of ionizing radiation dose is caused in our country by: A. background radiation, B. medical treatments, C. radio and TV antennas; 6) Is the food exposed to ionizing radiation radioactive? A. yes, B. no., C. it depends on the power of radioactive source, D. I don't know.

As an example of lecture in action we are presenting one copy of computer monitor screen presenting the simulation of radioactive decay (see Figure 6).

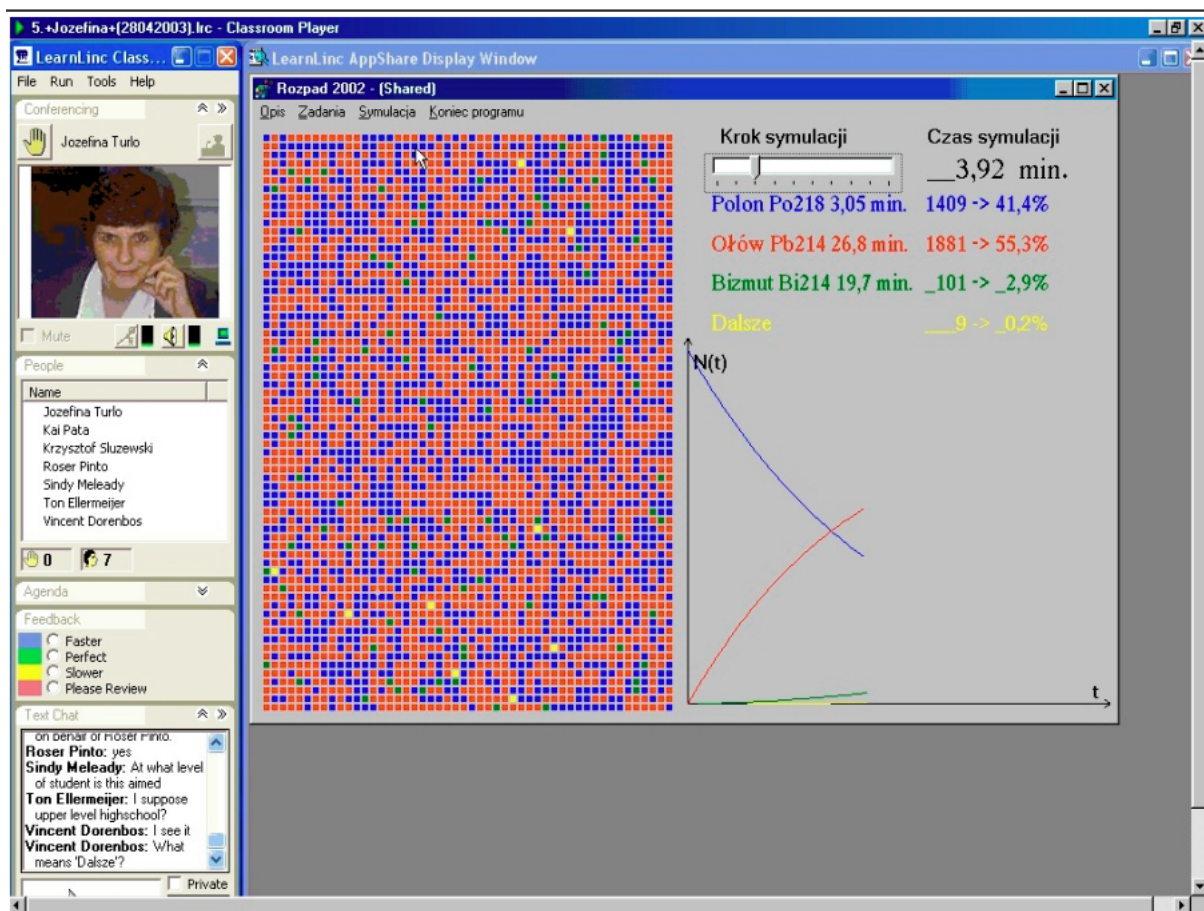


FIG. 6. Exemplary screen of the LearnLinc 6.02 presenting the simulation of radioactive decay.

By the interaction and discussion with our session participants we got experience sufficient to create the wider database of resources, which we are planning to make for the network of science teachers learning on distance from our University.

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