Modern Physics Teaching Resources and Activities

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Abstract

Based on the conclusions of my previous research activity and on many previous studies related to attitudes of students to physics in high schools and in universities [1], it has become clear that physics classes should be made more colourful, attractive and interactive.
In order to improve our students' researching, questioning, critical thinking, problem solving, decision making and computational competencies we should focus more on different types of activities (hands-on experiments, ICT based activities, educational games, study of simulated phenomena). For increasing their motivation we can use different types of educational methods like cooperation, project method or peer instruction, flip classroom [2] etc.
The aim of this work is to show some examples of the resources from the online courses: http://www.sukjaro.eu/cikkek/cikkek.htm prepared to teach some of the fundamentals of modern physics. All free online courses - or parts of them - can be used separately to teach modern physics in high schools or at BSc level.
Each course includes gamification and group-work activities, contains students' and teachers' guides and self-evaluation tools, like multiple choice questions, interactive exercises with simulation, theoretical exercises etc.
All courses are related to study the properties of the radioactivity: the random behaviour, the exponential decay law, notions of half-life, decay constant and activity.
If we want to let our students leave high schools, universities and colleges with an adequate knowledge and with applicable skills in physics we should use the advantage of the ICT, multimedia and their applications [3].

1. Introduction

Nowadays Information and Communication Technology (ICT) plays a very important role in education. It is a natural part of student's everyday life. The use of ICT became a common requirement in education, and it has been introduced in the educational process in many schools.
We have many possibilities to use the technologies around us now, but we should focus more on the question how the new tools and devices may be used for increasing the students' motivation [3].
During my educational activity I have found that it is impossible to adequately teach some parts of physics without experiments, or without the use of computers, multimedia and its applications, video files and simulation programs [4].

2. Teaching methods used

The term "teaching method" refers to the general principles, pedagogy and management strategies used for classroom instruction. Our choice of teaching method depends on our educational philosophy, classroom demographic, subject area(s), available laboratories or resources, subject curricula, or school mission statement.
The main teaching theories can be divided into two big categories: teacher-centred and student-centred learning. Every user (teacher) can decide which method is more appropriate in teaching of modern physics in his/her educational environment, and which part of the online courses will be the best choice to teach some of the fundamentals of modern physics. Modern physics is the post-Newtonian conception of physics, which began in the early 20th century with the work of Max Planck in quantum theory and Albert Einstein's theory of relativity. The term modern physics refers to the study of facts and theories developed since then, and it concerns the interactions of matter, space and time.

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3. Target

The following courses, Learning Objects (LO), have been designed for teachers and for students (high school and BSc level) who study individually.
During the evaluation the following methods can be used: lecturing, collaborating, classroom discussion, Inquiry-based learning.
The images and simulations were made by the authors. In the "students' page" hints for solving the problems and answering the questions are also presented. The feedback questions and problems help the students to draw the conclusions.

4. Aim of the courses

Our environment is exposed to radiation of natural sources: the radiation of the natural radioactive elements and the cosmic radiation have always existed during the evolution of life on Earth, and they still exist even today. The amount of yearly dose from this natural radioactivity varies considerably on different parts of the Earth. In these years technology adds a small amount of artificial radioactivity of the existing natural ones: the annual dose coming from the excess radioactivity of the nuclear methods (like medical or industrial use of radioactive isotopes or nuclear power plants) is less than 1% of that of the natural radioactive sources. Since radioactivity became an inevitable part of our everyday life its laws and characteristics should also be taught to students. They are as important as Newton's laws or the laws of electricity.

4.1 Aim of the course "The exponential decay law"

Aim of the course is to teach some of the fundamental properties of the radioactivity: the random behaviour, the exponential decay law, notions of half-life, decay constant and activity [5].
The LO begins with recalling some of the fundamentals of the probability theory using multiple choice questions as a tool. A simple statistical game is used for modelling the behaviour of the decaying nuclei.
Students can also perform several instructive experiments using the interactive simulation of radioactive decay built and explained in the LO.
The aim of the simulation:

- To explain the decay of radioactive materials
- To demonstrate the fundamental idea of age determination based on the ratio of the daughter and parent atoms

4.2 Aim of the course "Radioactivity"

The aim is twofold: to teach the composition of the nucleus and some of the fundamental notions: atomic number, mass number and isotope. The second aim is to teach the changes in the nuclear composition during the different radioactive decay modes: the alpha, beta and gamma decay [6].
The LO begins with multiple-choice questions. In the second part the decay types are explained.
Students can perform knowledge tests again using multiple-choice questions.
The benefit of the project:

- This LO can be used by students for practice and training for better understanding and for getting to be more familiar with the terms and notations used in nuclear physics.
- The three different types of radioactive decays are also explained, and the students are also trained in recognising them.
- The glossary of the LO has a list of nuclear terms, including activity and half-life.

5. Suggestions of implementation of each part of the courses

Teaching strategies are the various techniques used by the teachers to facilitate the students with different learning styles and to develop critical thinking among students and effectively engaging them in the classroom. The selection of teaching strategies depends on the concept to be taught and also on the interest of the students. When selecting the teaching strategies it is important to develop and continuously improve the key competencies of the students [7], [8].

5.1 Lecture Method

Lecturing is one of the traditional ways of teaching Physics. This method is teacher centric; the teacher has the main role. In some cases, like introduction of a new material, or explaining a new phenomenon the method can be applied well. On the other hand, this method is really ineffective in developing critical thinking and scientific attitude among students. The use of this method is promising in the introduction part of the course: for describing the structure of atoms, the concept of the atomic number and mass number.

5.2 Cooperative method (Jigsaw)

In the beginning of this activity students are divided into informal cooperative, heterogeneous, learning groups [9]. Students are working in a team of four to become "experts". Group-work assessment is based on gamification, and is supported by shared workspaces at an online platform, which is used for collaborative learning. Students can tutor their peers and provide them feedback during the group-work project [10].
To model the random nature of radioactivity each group of students do the followings:

- Toss a large number of the coins
- Select the coins with heads and put them away. These are modelling the decayed nuclei (decay probability is ½).
- Count the coins remaining on the table, and note the result in a table.
- The previous 3 steps should be repeated until no more coins remain.
- Plot the number of the coins in function of the steps (x –axis: number of steps, y-axis: number of coins) and compare to the “theoretical” curves found in the literature [11], [12].
- Students can use their own devices, and ICT competencies (e.g. MS EXCEL), upload their work to online shared workspace.

Each “expert” student in each group could change place and the whole class could be rearranged, forming new groups, keeping one “expert” member from previous groups. The new group will be informed and taught by the “expert” member.
Similar experiment can be done, using a large number of dices instead of “coins”. If you throw a 6, it will represent ‘decay’, and this dice will be removed (decay probability is 1/6). A quick way to find out how many remain to decay is to weigh them, instead of counting them. Each group can compare their results and activities done, mentored by their teacher. Both activities are analogue experiments linking probability with decay rates.

5.3 Inquiry-based learning

Inquiry-based learning involves the followings: developing questions, making observations, find out what information is already recorded, analysing and interpreting data, outlining possible explanations and creating predictions for future study.
All these stages are embedded in the simulation program shown in the course. There are some questions, task for data analysing. Students should exercise, answer their questions, and make predictions, conclusions.
Computer simulation programs offer a unique opportunity for students to see and work with systems and substances that they would rarely, if ever, be able to actually practice with in reality.
Dangerous substances and situations, expensive equipment, and theoretical, even fantastical ideas can be explored in a way that is more thorough than practical teaching has ever been able to do before. Simulation of radioactive decay can be studied in small groups or individually, using students’ own devices.
The use of the simulation has many advantages. Students, who are slower, or faster, have the benefit of working on more or less advanced experiments.

6. Conclusion

Teachers, who already used some of the courses and methods presented before, give me a very positive feedback. Their students were very motivated and enthusiastic.
I hope that these LO can be used very well in Modern Physics Education, and we can make the “hard sciences” more attractive and understandable to more students with the help of use of own devices, ICT and specific pedagogical instructions.

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