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Challenges in teaching and learning physics for first year students

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Abstract
The authors analyze the methods of effective teaching of physics in the context of an increasingly weak preparation of students from the high school. They draw attention to the opportunities that in this field can offer new multimedia technologies, especially computers, applied to various forms of physical classes. The analysis is based on many years of experience in working with students of different specialties and in different countries.

Introduction

Curriculum reform in schools caused that on the technical universities increasingly are accepted graduates of the high school whose education of the physics comes to an end with the 30-hour course realized in the first year. The ambitious and optimistic intentions of the authors of the reform were that the 30 hours was to be treated as a multi-stage closure, a comprehensive course curriculum (middle school + high school). It is difficult to definitively determine the effect on the level of knowledge of physics that is made by a two-year break in the teaching of the subject (the second and third year of high school), but all tests carried out at the beginning of the first year of studies, show clearly that the level of knowledge of the physics students who have completed the so-called basic program is embarrassingly low.

This creates a serious problem, because the physics course, provided for first-year students whose aim was to prepare the theoretical understanding of the material necessary for the program realized in professional subjects, has to practically start from the zero level. In order to keep the academic standards under these conditions it would require substantial widening of the number hours foreseen for the subject in the curriculum. It is of course impossible for several reasons, although many universities for the sake of the student introduce a mandatory compensatory course, thus taking upon himself the task of the secondary school in this field.

But not everyone is aware of the fact that the compensatory course should not be kept in the form of a standard lecture. The specificity of teaching in high school and university is significantly different [1], and not every university teacher is able to cope with this challenge. On the other hand, the primary physics is based on the experiment, and not all universities have laboratories equipped to present the experience of the high school, which of course significantly reduces the form of conducted classes. You can also have doubts about the efficiency of two physics courses at different levels conducted simultaneously.

However, when the compensatory course [2] is carried out, taking into account all the considerations above, that is, in small groups with the experiments demonstrations its effects are very significant.

An example of this is compensatory course for first year students in the Mechatronics carried out in the Maritime University of Szczecin in the scope of program for ordered specialties. Participants of this course not only attained good results with the same physics, but in contrast to students not covered by the course did not have any problems with

the other objects that required a thorough knowledge of the laws of physics. Unfortunately, the compensatory course in such comfortable conditions was carried out only once in the academic year 2010/2011. The following year, the program has been finished and the same course took much less effective formula: many groups and optional classes in the late afternoon hours.

Because now it is difficult to rely on another program as in the case of Mechatronics so we need to find new forms of activity that will allow to increase the effectiveness of education in the range of hours included in the studies program, while maintaining the academic standards to the maximum possible extent. This applies to all forms of classes included in the program of physics, lectures and especially such important laboratory classes. Particularly wide possibilities creates the optimal use in the teaching of modern multimedia techniques.

Characteristics of multimedia system

The use of multimedia technology makes sense wherever information is communicated. The advantage of multimedia over traditional media, such as a classical computer, printed materials or a movie, lies in the integration of different media in the using of interaction techniques [3]. Application of interaction means that the computer responds to input from the man, giving him the opportunity to choose what, when, where, how often, and in what order he wants to see and hear. Thus, only a computer provides the ability to connect a variety of media to interactive transmission of information, thus creating a completely new way of communicating and solving problems.

Multimedia technology also carries risks for teaching, because the computer integrating other media, and thus replaces it. This may be perceived by some teachers as an impoverishment of the forms and means of expression used by the teacher. It is known, however, that the computer is no substitute for direct contact between the teacher and students. Important here is an experience, that allows the teachers using the multimedia presentation find the right relation between what shows the presentation and what he has to say.

Modeling and simulation in the teaching of physics

Modeling is based on a mathematical description of a natural phenomenon and then obtaining new information about it. The purpose of modeling is to facilitate thinking about a particular phenomenon, and what is most important aspect it is to build a relation between the known laws governing phenomena and the same model. A model can contain one or more complex systems of equations. After creating the model it should be checked experimentally by comparing the data obtained in two ways, namely by the data generated by the model and the actual results of the experiment. Thanks to this method, students can check their hypotheses based on the results of modeling. The advantage of the modeling is the ability to edit the model and its changes, which allows you to study how the system due to changes made in the model. A completely different character have simulations, which show the selected physical phenomenon or a specific experience. Simulations are virtual experiments, in which you can change some parameters and observe the effect of those changes. Might want to use simulation experiments that are difficult, dangerous, too expensive, or impossible to achieve in school. They facilitate the introduction of difficult concepts.

The appearance of modern data processing (computer) and the availability of information on the Internet caused a revolution in the methods of their practical use [4]. Computerization and informatisation invaded every aspect of life, including education, which the school could not ignore. IT education is seen as a new item, the purpose of which is to show the capabilities of modern computing resources and their use in solving multiple problems and as a means of supporting teaching, in order to improve its efficiency. A student solving a problem, usually has a certain amount of knowledge, but it is often insufficient to resolve it. The gaps in his knowledge student complements, reaching out to other sources, primarily to the computer. The computer not only provides the missing knowledge, but also it can help identify the hypothesis and its verification, making it a center of teaching about unattainable by other means possibilities. Computer education is a tool that can organize the process of learning – as a tool to support existing educational program. Use a computer in teaching gives a number of advantages, most important of which seems to be quite rapid development of learning outcomes. Working with a computer requires from the learner keeping the principles of collection, processing and presentation of information, which gives rise to logical thinking, precision of expression and right formulation of the problems.

The value of the computer as a means of teaching is huge, because more than 80% of information reaches the human through the eye channel. In addition, the computer can present processes or

phenomena that are impossible to observe in a natural environment, because normally these processes are too fast or too slow. Research performed on the effectiveness of teaching using a computer showed that the learning process is increased by 40% and the rate of learning is faster by 60%.

Some will no doubt complain that this technique of "active learning" forces the lecturer to cover less material. It is indeed true that the lecturer talks about less material with this approach; the challenge to the lecturer is to choose between the material that is worthy of discussion during the lecture and the easier material that the students can learn adequately on their own from the textbook. Thus this technique does not require that any material be deleted from the course syllabus. Employing "active learning" in the lecture keeps students engaged in the lecture. More importantly, as shown in several studies conducted in this area it yields substantially better student performance on exams than does conventional instruction.

Teaching physics in Polish schools is a theoretical dimension. It's true obvious to most teachers of this subject. Another truth is that it should not be, because an experiment is the essence of classical physics. Nothing else, but that experience should be the starting point of the theory or illustration and ignore it, not only should, but actually must not! Physics is for students considered to be one of the most difficult subjects, and the reasons for this assessment are quite obvious. This subject requires a thorough understanding very difficult problems and the efficient use of mathematics. The fact that there are elements of mathematics included in a separate field of knowledge, which has its own characteristics, causes an additional problem. Physical model operates not only in the numbers. Mathematics is treated as a tool, but the numbers, patterns relate to realistic, not abstract phenomena. Each number in mathematics, in the physical formula has the character of a unit: kg, meters, Jouls, Newtons. Efficient conversion of units makes students extra great difficulties. If you also take into account the fact that some physical values are scalars, and other vectors for which there is quite a different algebra you come to the only right conclusion: physics can not be taught theoretically, physics you need to see in her practical terms. A sensible way to teach the subject in schools requires mathematical foundations, then the understanding of phenomena and presentations of theoretical problems in the form of tasks, equations and calculations. Many physics faculty come away from teaching introductory physics deeply dismayed with how little the majority of their students have learned. Even worse, the growing importance of technological literacy in the workplace makes it increasingly important for us to provide value to more of our students. Introductory courses are often designed for the prospective professional with many topics treated superficially to provide a context for later study, and with an emphasis on mathematical manipulations and structures. These mathematical structures may later serve as a framework for building a strong and well-organized understanding of the subject in which concepts and knowledge structure are tightly woven into the mathematics.

Physics can not be learned by heart. It is impossible to teach physic in such a way to make student become familiar with the typical tasks which will be solved, without a fundamental concept of the essence of phenomena. A characteristic feature of modern education systems is to look for more and more attractive and effective methods and forms of work with the student. This property applies to all stages and levels of education. Among the various trends and tendencies of modernization of education systems, concepts which call for better use in the educational process of teaching (aids), and especially the media (video, television, computer with appropriate software), used in combination with conventional measures, occupy a special place.

Didactic means in the teaching- learning process play an important role making the thought processes easier, assisting in the performance of students exercises and obtaining their practical abilities. The choice of measures in the learning process is dependent on many factors. One of the most important is transferred content and the recipient. The content transmitted through educational measures should not include ready-made solutions, but only indicate the multiplicity and variety of news categories that affect the solution to the problem.

New form of Lecture

The lecture is one of the most ancient of teaching methods. In the teaching of physics, it is typically used to demonstrate physical phenomena, to present derivations; and to show examples of how to solve problems. The first of these uses of the lecture is an important one, and is often neglected by instructors who feel compelled to "cover more material" or who regard the demonstrations as a distraction [5]. My own experience is that good lecture demonstrations are absolutely indispensable as tools for helping students to relate physical concepts to the real world. Good lecture demonstrations also have the strength of being memorable.

By contrast, the use of lecture time to present derivations is typically ineffective. A derivation presented on the blackboard is less useful to the student than the same derivation presented in the textbook, where it can be traced through repeatedly at the student's leisure. On the other hand the level of commitment of present students sometimes authorizes instructors tend to present derivations in lecture because they doubt that their students read the book.

Numerous instructors, myself included, have found that lectures become more useful when students are forced to become active participants in the lecture [4]. In my own classes, I speak briefly about each new topic then I define all of the new concepts typical for analyzed problem trying to take advantage of all the knowledge of students resulting from their everyday experience. Contrary to established ideas, the first years students do not begin their physics course in a state of nearly perfect tabula rasa. Even taking into account the shortcomings and drawbacks of the education system I mentioned earlier, students arrive in their first physics course with a set of physical theories that they have tested and refined over years of repeated experimentation. Students have spent over a dozen years exploring mechanical phenomena by walking, running, catching footballs, and riding in accelerating vehicles. Therefore, the appeal to the typical situation in the mechanics course makes the presented theory and equations assume more realistic dimensions. Another important element of an active lecture is the use of the students to perform certain simple transformations. This allows you to maintain concentration among students, no one knows when he can be asked to the blackboard, on the other hand to stimulate the rate of the lecture.

You can decisively improve the efficiency of the lecture if you join a short film, or a demonstration that shows up most intriguing experience related to the realities that are known and understood by the student, and show some phenomena in a slightly different aspect. Analysis of the experience always leads to an interesting discussion, which skillfully stimulated by the teacher helps students to develop interest and inspiring them to deepen their knowledge.

Multimedia in laboratory

The main role, in this modified by necessity curriculum, have to play laboratory classes. Unfortunately, the economic criteria force the universities to increase the number of students in groups, so that the teacher often has to deal with a group of a dozen or so. Because the programs of the technical studies are constructed, so that the physics laboratories are among the first if not the first classes of this type which the first-year student faces, one should think carefully about a set of laboratory exercises that should be carried out at this stage of study. Full of electronics, the laboratory sets, in this situation, are quite impractical because students are not able to follow a sequence of events occurring in them and to understand very substance of the measurement. On the other hand, entrusting the specialized and therefore expensive equipment to totally unprepared students dramatically increases the probability of its destruction. In this situation much better suited are simple exercises, where students making relatively simple measurements can observe the phenomenon directly.

With a little help of teacher the students are able to make such measurements relatively quickly [6]. This allows to supplement the performed experiments with appropriate computer simulations. Since these computer simulations are generally available on the internet, you can supplement them practically every experience. This form of experimental activities is particularly important in the case of classes with electricity [7]. While with the mechanics, we can always call upon the experience of everyday life and so-called common sense, whereas in relation to electricity, such parallels might be completely unreliable. Emphatic in this regard is test, carried out among American students and relating to a simple circuit.

The first electrical circuit consists of a battery connected to two identical light bulbs A and B in series. In the second, the battery is connected to a single bulb C which is identical to bulbs A and B. McDermott and Shaffer [8] asked students in introductory physics courses to compare the brightnesses of bulbs A and B in first circuit and to compare these with the brightness of bulb C in second circuit. The results of this investigation were incredibly disappointing. The correct answer, that bulbs A and B in first circuit are equally bright and that bulb C in second circuit is brighter still, was given by only about 10% of the students. The same question asked students of the first year of Maritime University in Szczecin has made an even bigger problem, only less than 5% of students answered it correctly.

The most remarkable result of this simple test is that the types of student errors made on this question are unrelated to, and unaffected by, conventional instruction. One common student error is the belief that in first circuit, bulb A will be brighter than bulb B because bulb A "'uses up' the current

first." Another common error is that the brightness of each bulb will be the same in either circuit because the battery provides a constant current in all cases. Neither of these incorrect ideas are learned from an introductory course, but neither are they discredited in a standard introductory course.

Investigations of this sort show that it is not enough to merely teach students the right way to think about physics. Rather, the challenges to the instructor are to identify possible student misconceptions, to confront these misconceptions head-on, and to help students to unlearn these misconceptions at the same time that they are learning correct physics. Failure to do this will invariably leave students with their erroneous "common sense" ideas intact. Therefore, an important element of the comprehensive preparation of students in the field of electricity seems to lead in preparing a number of laboratory sets oriented not at traditional measurements, but at the demonstrations that students can do themselves. The typical experiments involving this scope of physics must include:

- the magnetic field due the conductor with current;
- inducing of alternating currents;
- Lenz rule checking;
- the phenomenon of self-induction;
- electrodynamics force.

The purpose of these exercises is to perform simple experiments by students and draw the correct conclusions. The same exercise we can then show in the form of a short film or a computer simulation paying attention to the key elements. A significant advantage of classes in the formula is the possibility of making a substantial part of computer simulations outside the laboratory, in the student's individual work.

Conclusions

Physics curriculum reform in schools has caused that the vast majority of students going to technical college has huge shortcomings in this subject. Due to competition in the labor market and the requirements imposed by the technological advances on the future engineers, universities can not afford to reduce drastically the level of teaching in the basic subject which is the physics. On the other hand, the economic criteria decide on a limited number of hours devoted in the curriculum to this course.

All this makes that the teachers are facing tremendously difficult task, as in the intact and usually a small number of education hours to achieve satisfactory results starting from a much lower level than earlier academic programs could predict. One of the possibilities to achieve success in these conditions, it is a significant modification to the teaching methods of physics with the optimal use of multimedia techniques. Great opportunities in this field provide the present computer programs that allow to perform a difficult, or even impossible experiments in virtual reality.

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