UDC: 373.5.091.3:537.1/.3
Original scientific paper

ANALYSIS OF THE SECOND-YEAR PHYSICS TEXTBOOK: SECTION ELECTROSTATICS AND DIRECT CURRENT

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Abstract

The physics textbook for the second-year high school education was published in 2001. In the last 23 years, many things have changed in society and the world, starting from the geopolitical situation and technology, all the way to the needs of society. This research tries to determine how much the textbook manages to respond to the new needs in society. For this purpose, the part of the textbook that refers to electrostatics and direct current is analyzed. Physics has not been changed during these two decades and the content covered by the textbook corresponds to the needs and the curriculum. However, it is concluded that in the part of the methodical approach, the textbook is outdated, and many adjustments are needed to adapt to changes in society.

Keywords: textbook, critical thinking, electrostatics, direct current, high school.

1. Introduction

Some of the main tasks of education are to respond to the needs of society, to prepare children for life in the future, and to monitor changes in science and implement them in the education process. For this purpose, critical thinking is the most important skill that children should acquire and develop during education. That skill will help them to successfully analyze new and unfamiliar situations and solve new problems that did not exist when they were students.
In the last few years, artificial intelligence has become more and more relevant, which has started to affect all spheres of life. In a very short time, it became clear that critical thinking has never been more important than now, with the advent of artificial intelligence (Carucci, 2024). To develop higher-order thinking skills proper activities for students are needed. Those activities can be: answering questions, performing projects, solving problems and situations, and many others, but what is important for all activities is that they have to require the students to apply the knowledge in new situations, unknown to the students, to analyze the phenomena, to find out the pieces and important quantities and to search for the relations between them. Moreover, they have to evaluate those relations, make conclusions, and create new procedures for further research and activities.
Although the new technology has brought new sources of knowledge and information, textbooks still have a very important role in schools, particularly in regulated systems. In many cases, textbooks are the primary source of information for teachers in deciding how to present the content. There is a large body of literature that points to textbooks as driving teachers' pedagogical behavior. In 1990 Sweden, Australia, Denmark, the United Kingdom, Estonia, Finland, Ireland, Italy, the Netherlands, and Norway started the process of deregulating textbooks (Reichenberg, 2016). This led to increased teachers' autonomy, but at the same time, students had to struggle with difficult texts on their own. Yet, in Estonia and Finland teachers rely heavily on the textbook while planning and preparing their lessons (Lepik et al, 2015).
But, if a science teacher uses a particular textbook, it does not mean that the teacher necessarily favors that textbook. One research shows that more than half of physics teachers are partially

https://doi.org/10.62792/ut.jnsm.v9.i17-18.p2845

satisfied with the textbooks for regular physics in US high schools (Tesfaye & White, 2010). To choose the most appropriate textbook, Dake involves students as textbook assessors (Dake, 2007). This research shows that students appreciate "real-world" examples and want explanations of the answers—many books simply provide the correct answer with no explanation.

One of the biggest problems with textbooks is that they can give incorrect information and thus initiate misconceptions, which requires extreme care by the teachers to correct errors and to clearly explain concepts to the students which are blurred and inadequately explained (Zajkov et al. 2017; Swartz, 1999; Hewit, 1999; Serway et al, 1999).

Some of the problems with textbooks can be solved by using online material. Of course, it belongs to deregulated material, but given the huge choice, the teacher and the student can choose exactly what suits them best, per the curriculum and the defined goals. But teachers must be cautioned against using the technology simply because it is there. Verifying the credibility of each material that is used and evaluating each one for quality as well as being cautioned with copyright infringement is a must when maximizing the online experience for students (Jones et al, 2011). Online material is usually multimedia, which is also a very big advantage over classic printed textbooks. The majority of the multimedia material targets the solution to the pedagogical content of the subject of interest and the user audience of the solution while the success of the different multimedia tools that have been used on the various target groups and subjects can be attributed to the technologies and components embedded in their development (Abdulrahaman et al, 2020). On the other hand, teachers may be resistant to using this material because of a lack of basic knowledge and ICT skills, lack of technical, administrative, and financial support, and lack of physical environment are some of the barriers identified in the various articles reviewed. These barriers affect the integration of multimedia in education (Abdulrahaman et al, 2020).

YouTube videos are very popular and suitable since content can be versatile, ranging from texts, whole lessons, and short explanations, to experiments with explanations and video experiments. Videos that are supported by documentation and external consistency are more appropriate than videos that lack appropriate sources (Haris, 2010). Even parents like YouTube videos, since they feel helped by YouTube learning media. YouTube can be accessed easily. In addition, YouTube learning media can be accessed anytime and anywhere so that parents can still accompany learning even though they are working (Rahmatika et al, 2021).

In this research, we analyze the current physics textbook for the second-grade gymnasium (Jonoska, Ristova-Vaseva, Zajkov, & Jakimovski, 2002). Electrostatics gives basics for many phenomena that are not part of electrostatics, such as electric current, voltage, electric circuits, semiconductors, and alternating current. That is the reason to analyze the activities proposed in this textbook in the section *Electrostatics*.

2. Analysis of the textbook and discussion

The first chapter of the textbook – Electric field, consists of eight units, while the second chapter – Electric current, consists of 15 units. For discussion and other activities, three classes are planned in the curriculum.

To introduce the students to the new matter and to prepare the students for further discovery of the new knowledge, at the beginning of each unit the authors give the minimum needed information and describe proper experiment with picture. They explain in detail the effects, results, and consequences. This does not leave space for the students for further discovery. But, one can understand this, when one discovers that there is not any other source of knowledge and activities in the form of a manual for the laboratory or any other literature, which will guide the students through the process of research and discovery. Let us analyze one example from the textbook.

It is well known from ancient times that when one rubs objects, then they attract other objects. Objects can be charged by rubbing. There are two types of electric charges. The objects charged with the same charge as a glass rod rubbed with silk, are called positive charges. On the other side, objects charged with the same charge as an ebonite rod rubbed with wool are called negative charges. If a charged object is in contact with another neutral object, then the charge is transferred to the second object. It is called charging by contact. By the forces that are exerted between charged objects, we can test whether an object is charged or not. These forces are called electrical forces. We suggest you perform the following experiment. Hang two cylindrical objects made of aluminum foil on two threads (figure 1). Touch the objects with previously charged ebonite rods and bring the objects close to each other. What do you see? Repeat the experiment, but now one of the cylinders touches with the charged ebonite rod (negative), and the other with the charged glass rod (positive). The experiment will show you different behaviors. We conclude…

In this case, experiments are proposed, and the effects are not mentioned. But, at the end, a conclusion is given. This is something that students already learned in primary school and the authors do not spend too much time giving details.
Let us take a look at another example.

The left electroscope is charged and the right one is not (figure 5). If their heads are connected through the metal rod, the indicators will show equal deflections. How do you explain this? Repeat the experiment with a glass or ebonite rod instead of a metal one. In this case, the left electroscope will stay charged and the right one will stay neutral. If the experiment is performed with a fresh wooden rod, the deflections will become equal again, but it will take much longer time. What can you conclude? Objects through which charged particles (in this case, electrons) can move relatively with a big speed are called conductors, such as metals. There are objects in which charged particles are almost impossible to move. They are called insulators. There are also objects in which charged particles can move, but very slowly…

Again, the experiment is proposed, but unlike in the first example, the expected effect is explained, as well as the result.
At the end of each unit, there are additional sections, which widen the view of the students. There is a list of the key concepts in the unit, where students have to explain each of them and give examples. It means that they do not have to repeat what they have heard in class or read in the textbook, but they must explain the notion, which is the second level skill from Bloom's taxonomy while giving examples is already a third level. It is a good introduction to higher levels because the students are expected to explain why this example is good. How this process will be developed, depends mostly on the teacher's skill and experience.
Further, follows the section called *Activities*, which consists of problems, activities for experimenting and research, and questions, where explaining, interpreting, and concluding are required. In this chapter, there are 14 problems, 10 activities for experimenting and research, and 15 questions, which is a good balance. In the second chapter, *Electric Current*, there are 16

problems, 6 activities for experimenting, and 3 questions, which brings as to the conclusion that it is not well balanced. Let as take a look at an example.

Make your electroscope. Use a glass container (preferably with flat parallel walls), with an insulating cap, through which a metal nail or spike should be set. Attach two aluminum stripes at the end of the nail. On the back side of the container scale can be placed. The sides of the container should be covered with aluminum foil.

The procedure is not detailed but is more like a direction, which gives space to the students for their creation, which goes beyond the third level of knowledge and skills and enters higher levels.
Let us look at a few activities from the following unit, *Coulomb's law*.

1. Calculate how many electrons are in a negatively charged object of 1 C.
   (Answer: $6{,}25 \cdot 10^{18}$ *e*)
2. Electron is repealed by a charged object with a certain force. How much force will be changed if the distance between the electron and the object is three times bigger?
3. Is it possible for a charge of $1{,}7 \cdot 10^{-19}$ C to exist?

These activities are not of a type "calculate by the given quantities". These activities help students to look at the lesson from another point of view and give additional explaining and understanding of the concepts. Probably the most interesting activity is the one, in which using the masses and charges of the proton and electron, students have to compare the electrostatic force and gravitational force in the hydrogen atom.
In this unit, there is a lack of experimental activities. This is understandable because it is almost impossible to create research activities for examining the forces of electrostatic interactions. Here, simulations and virtual experiments can be used instead of real experiments, but we will analyze this possibility more in the section *Activities with Computers*.
Sections: *Little Bit of History, Activities with Computers, Physics and Biology, Physics and Technology, Physics and Earth, Curiosities,* and *for 5+* are not present in every unit, but only where the authors find relations with other areas of science and technology. These sections are mainly to arouse curiosity, to motivate, to show that physics is not for itself but is a part of everyday life, and maybe to answer a very often posed question "Why do I have to learn this, why do I learn physics".

3. Conclusions

The textbook makes efforts to compensate for the lack of additional literature. Depending on the style of the student, this "colorful" textbook, with various types of texts and activities, for some students can be robust and even maybe unattractive, but for other groups of students can be very interesting. This still indicates a need for additional literature, which will make the textbook easier to follow, interesting for bigger groups of students, and for various needs. But, to make those changes, first, the procedure for publishing primary and secondary school textbooks defined in The Law of Textbooks must be changed. Those changes should be in a direction that will attract more authors and will encourage more quality competition (Sluzben Vesnik, 2008). There is a need for experimental and research guides for the students. It should contain only directions for experiments and questions that will guide the students through the experiment and the processing of experimental data. This guide should not give solutions and conclusions but guide the students to bring them to conclusions. For this purpose, the Socratic dialog approach in education could be applied, which will encourage students to additionally develop their critical thinking (Knezic 2010, Kessels 1997). Moreover, since physics is an experimental science, this pre-dialog phase in this teaching approach could be in the form of a demonstration, demonstrational experiment, and even in the form of a research experiment (Zajkov, 2021). Also, support for teachers in the form of guidance and continuous training is crucial for this process.

The number of ICT activities is very small, which is understandable since the textbook was written twelve years ago. Although there are a few old software packages with excellent possibilities, one must keep in mind the fast development of this technology and the need for continuous updates of these activities. These activities are outdated, and upgrading is needed with new modern tools for learning: videos, animations, interactive activities, etc. Those changes will enable the students to discover the knowledge, instead of getting instant answers to all questions.

High school physics has not changed during these two decades. The basics and foundation that the children should acquire correspond to their age. The content covered by the textbook corresponds to the needs and the curriculum. However, there is a need for modernization of the teaching approach and the new technology that was developed during these two decades: augmented reality, virtual reality, artificial intelligence, etc. The textbook is outdated, and many adjustments are needed to adapt to the changes in society.

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