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STATISTICAL STUDY OF IMPACT OF THE USE OF COMPUTER SIMULATIONS ON THE IMPROVEMENT OF STUDENTS' MARKS

BY

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Abstract. Since 2008 we have designed various computer simulations of physics phenomena which are addressed to first year students at the Faculty of Civil Engineering and Building Services. The main purpose is to improve students' understanding of physics phenomena and their ability to do the practical laboratory work. In the last decade, we have carried out computer simulations of physics phenomena with the aid of programs and technologies like Adobe Flash, HTML5 and JavaScript. We emphasize significant progress in our students' skills of work in both real physics laboratory and Virtual Physics Laboratory (VPL), and in the increase of their marks at the laboratory tests and in final exams. The present paper is focused on a statistical survey that we have performed to establish the improvement of our students' marks in the last three academic years. Further, an additional statistical study of the use of computer simulations and Virtual Physics Laboratory (VPL) has been elaborated.

Keywords: statistical study; computer simulations; physics phenomena; Adobe Flash; HTML5; JavaScript.

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1. Introduction

In recent years, motivated by the requirement of improving the teaching and learning processes we have designed computer simulations of various physics phenomena. Computer simulations are important learning tools in Civil Engineering and offer many opportunities of easy understanding of different physics phenomena and laws. One of the most important tasks at the physics laboratory is the improvement of students' marks at the laboratory tests. The activity in the real physics laboratory is certainly better accomplished by the use of computer simulations. For faster communication with our students computer simulations are placed on the Internet in the Virtual Physics Laboratory (VPL).

Internationally, many researchers carried out computer simulations which helped students to better understand the laboratory works and the curricula objectives (www.phet.colorado.edu; <http://wildcat.phys.northwestern.edu>; www.myphysicslab.com; <http://virlab.virginia.edu>; Gould *et al.*, 2007; Jong *et al.*, 2013; Uribe *et al.*, 2016). In the last decade, we have focused our efforts on the development of computer simulations of physics phenomena (Radinschi *et al.*, 2008a; Radinschi *et al.*, 2008b; Radinschi *et al.*, 2015; Radinschi *et al.*, 2016) elaborated in Adobe Flash (<http://adobe.com/products/flash>), HTML5 (<https://developer.mozilla.org/en-US/docs/Web/Guide/HTML/HTML5>) and JavaScript (<https://www.javascript.com/>). Computer simulations are useful tools that reproduce in a realistic way the real devices and facilitate our teacher-leader roles. The implementation of different computer simulations in our physics laboratory had a high impact on the learning process, and also led to a considerable improvement of students' marks.

Further, our first year students have shown a high interest in the use of computer simulations. They accessed the Virtual Physics Laboratory (VPL) from the physics laboratory and also from home and campus. We point out that most of the students have preferred to work both in the real physics laboratory and in the Virtual Physics Laboratory (VPL). It is worth to mention that almost none of the students have chosen to work only in the Virtual Physics Laboratory (VPL). As a result of the connection between the laboratory activities and the use of the Virtual Physics Laboratory (VPL) the students' scores at the laboratory tests and in final exams have significantly increased.

The present paper is organized as follow. In section 2 we perform a brief presentation of the Virtual Physics Laboratory (VPL). Section 3 is devoted to the development of a statistical study of the impact of the use of computer simulations on the improvement of students' marks at the laboratory tests and in final exams in the last three academic years. Further, a statistical study concerning the use of computer simulations and of the Virtual Physics Laboratory (VPL) is presented. Section 4 is assigned to discussion and concluding remarks.

2. Description of the Virtual Physics Laboratory (VPL)

Our computer simulations of physics phenomena developed in Adobe Flash, HTML5 and JavaScript are posted in the Virtual Physics Laboratory (VPL) at the web address <http://server.ce.tuiasi.ro/~radinschi/simulation/default.html>. Since 2008 to present, our interest in developing computer simulations of physics phenomena has considerably increased. Our first computer simulations were elaborated with the aid of Adobe Flash. As examples, we present in Fig. 1 and Fig. 2 the screenshots of the computer simulations developed for the study of the laws of the photoelectric effect.

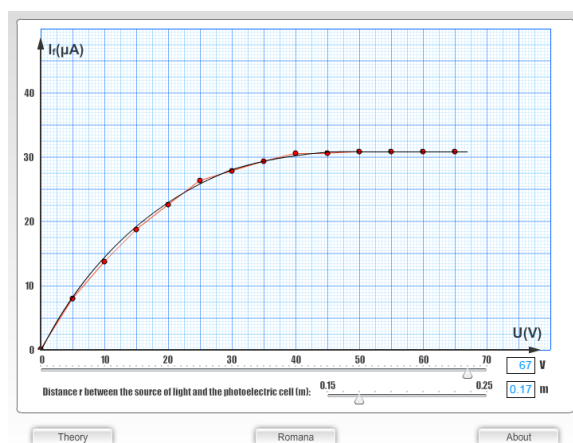


Fig. 1 – Study of the laws of the photoelectric effect, increase of the current up to saturation.

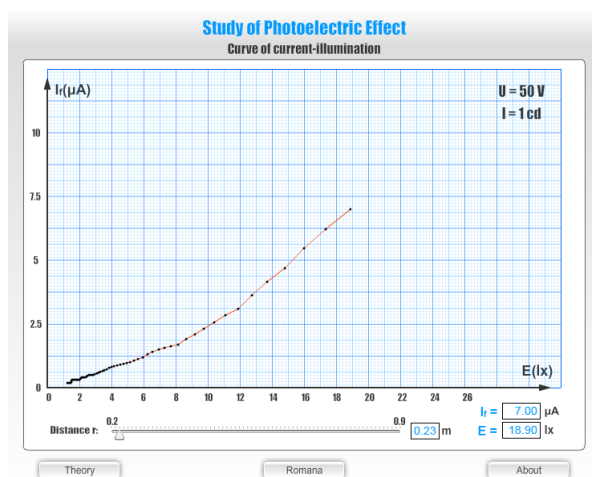


Fig. 2 – Study of the laws of the photoelectric effect, the current-illumination curves.

Fig. 3 shows the screenshot of the computer simulation carried out for the study of two perpendicular harmonic oscillations of the same frequency. This computer simulation has been developed in 2015 with the aid of the HTML5 and JavaScript technologies.

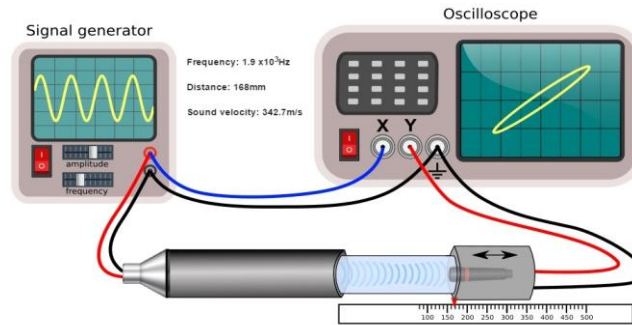


Fig. 3 – Study of two perpendicular harmonic oscillations of the same frequency.

3. Statistical Study of the Impact of the Use of Computer Simulations

We have performed a statistical study designated to establish the improvement of our students' marks in the last three academic years both at the laboratory tests and in final exams. We have focused our research on the results obtained by our first year students who study in Romanian (RO), and in English (EN), respectively. Further, we have also performed the statistical study for both series of students (RO) + (EN).

In Fig. 4 we present the relative frequencies of the marks in final exams for the two series of students (EN) – left panel, (RO) – middle, and in general (RO) + (EN) – right panel. The comparison is made for the last three academic years.

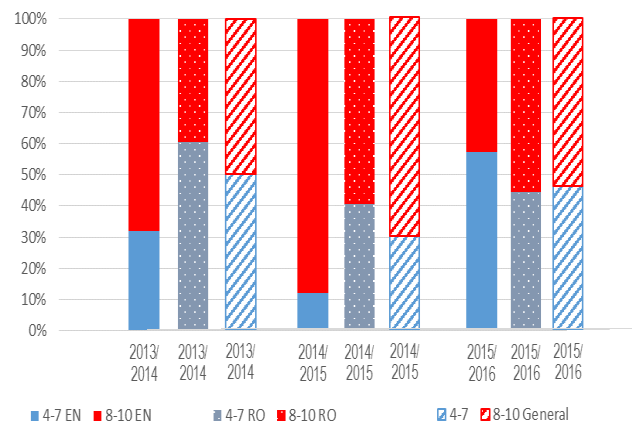


Fig. 4 – The relative frequencies of the marks for the two series of students (EN) and (RO), and in general (RO) + (EN).

The comparison for the last three academic years for the marks at the laboratory tests is presented in Fig. 5 in form of relative frequencies of the marks in general (RO) + (EN), and for the two series of students (RO) and (EN).

By comparing students' marks at the laboratory tests, we notice a permanent increase in the percentage of high scores (8-10). Thus, we have an increase of 36.88% in the case of the laboratories held in English, 26.55% for the laboratories in Romanian, leading to an overall increase of 29.68% between the academic years of study 2013-2014 and 2015-2016.

In Fig. 6 we present the maps of marks obtained at the laboratory tests by the first year students (RO) + (EN) in the last three academic years. These students have used the computer simulations. From this statistical study we conclude that there is a significant increase in the marks of the students. This increase is also due to the use of the Virtual Physics Laboratory (VPL).

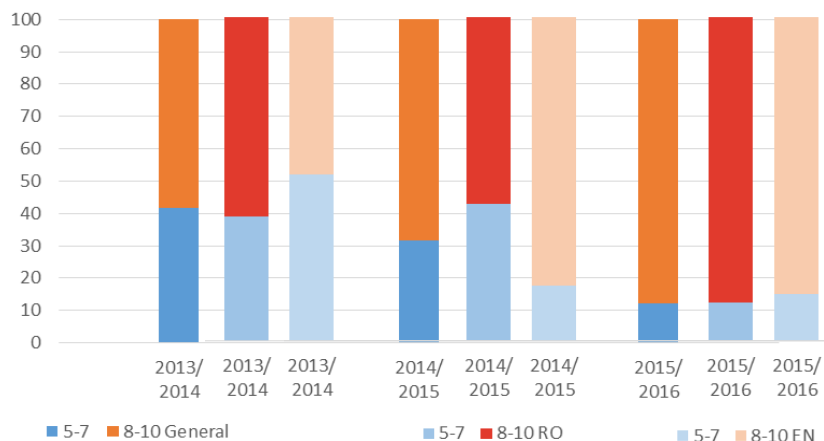


Fig. 5 – The relative frequencies of the marks at the laboratory tests in general (RO) + (EN), and for the two series of students (RO) and (EN).

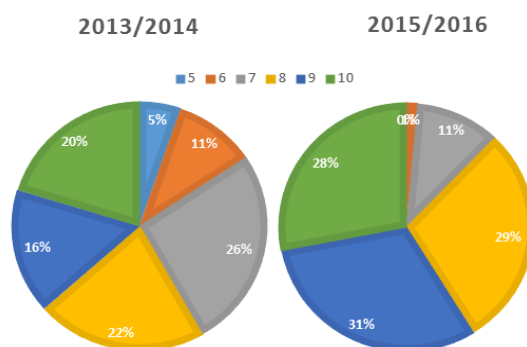


Fig. 6 – The comparison between the maps of marks at the laboratory tests in the academic years 2013/2014 and 2015/2016, respectively.

In Fig. 7 we show the increase of the number of students who used to work in the Virtual Physics Laboratory (VPL). We estimated this increase this academic year by comparison with the academic year 2013-2014.

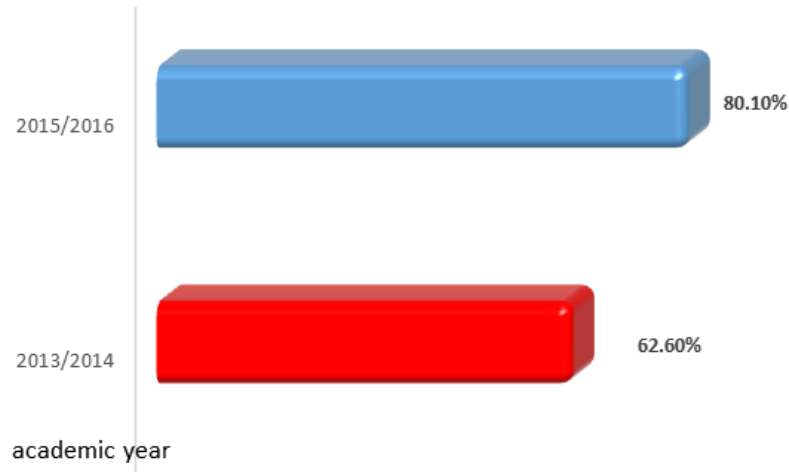


Fig. 7 – Comparison of the students who used the Virtual Physics Laboratory (VPL) [%].

It is worth to mention, that the development of our Virtual Physics Laboratory (VPL) has led to an additional increase of 17.5 % in the number of students who used the computer simulations. We notice an increase of the marks at the laboratory tests and in final exams for the students who have worked with computer simulations and the Virtual Physics Laboratory (VPL).

3. Discussion and Concluding Remarks

Considering the growing interest of our students' community in the study of physical phenomena with the aid of computer simulations we have developed new applications by using HTML5 and JavaScript technologies, and better organized the Virtual Physics Laboratory (VPL).

In this paper we present a statistical study performed to establish the improvement of our first year students' marks in the last three academic years. The statistical study comprises two parts. First, we have the statistics of the marks in final exams in the last three academic years. Second, we present the statistics of the marks at the laboratory tests. This statistical study has been performed for the academic years 2013-2014, 2014-2015 and 2015-2016, respectively. In addition, we present the increase of the number of students who used to work in the Virtual Physics Laboratory (VPL) in the last three academic years.

From our statistical study it results that the use of computer simulations and Virtual Physics Laboratory (VPL) help our students to improve their learning skills and get higher marks at the laboratory tests and in final exams. Further, together with the traditional work in the physics laboratory the computer simulations are useful tools to study physics phenomena and laws, and for learning physics.

From Fig. 4 it results an improvement of the marks of our students in final exams in the last three academic years.

Concerning the marks at the laboratory tests, from Fig. 5 we conclude that there is a significant improvement in the last three academic years of the percentage of high marks for the students who study in Romanian (RO), in English (EN) and in general (RO) + (EN), respectively.

Fig. 6 presents the comparison between the maps of marks at the laboratory tests in the academic years 2013/2014 and 2015/2016 in general (RO) + (EN), respectively. The increases in the percentage of marks are of 7% for 8 mark, 15% for 9 mark and 8% for 10 marks.

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STUDIUL STATISTIC PRIVIND IMPACTUL
UTILIZĂRII SIMULĂRII COMPUTAȚIONALE LA ÎMBUNĂȚĂȚIREA
NOTELEOR STUDENȚILOR

(Rezumat)

Începând cu anul 2008, am conceput diverse simulări pe calculator ale fenomenelor fizice adresate studenților de la Facultatea de Construcții și Instalații. Scopul principal este de a îmbunătăți atât înțelegerea de către studenți a fenomenelor fizicii cât și de dezvoltare a abilităților practice. În ultimul deceniu, am realizat simulări pe calculator ale fenomenelor fizicii cu ajutorul programelor și tehnologiilor precum Adobe Flash, HTML5 și JavaScript. Am observat progresul semnificativ a aptitudinilor studenților noștri de a lucra atât în laboratorul real de fizică, cât și în laboratorul virtual de fizică (VPL) și mai mult am observat creșterea notelor la testele de laborator și la examenele finale. Lucrarea de față se concentrează pe un studiu statistic pe care l-am efectuat pentru a stabili îmbunătățirea notelor studenților noștri din ultimii trei ani universitari. În plus, a fost elaborat un studiu statistic suplimentar privind utilizarea simulărilor pe calculator și a laboratorului virtual de fizică (VPL).