HOLOS
ISSN 1807 - 1600

PHYSICS TEACHING USING VIRTUAL SIMULATORS: POTENTIAL FOR USE IN THE CLASSROOM

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Submitted October 14, 2022 - Accepted January 23, 2023

DOI: 10pts.15628/holos.2023.14365

ABSTRACT

Virtual simulators are software aimed at emulating a reality in which it is possible, above all, for user learning. In this context, virtual simulators, if used as teaching resources to stimulate students' interest and reinforce the learning of concepts of natural sciences, and in particular Physics, becomes an interesting strategy. Many
simulators have been developed in recent years, making them popular tools, mainly because some of them work online and are free. Despite this, we still cannot say that the use of this resource is a reality in Brazil. Several problems make it difficult or even prevent its use. In this work, we observed the behavior of a group of natural science teachers regarding the use of virtual simulators. The data show that there is still a lot to be done in order to popularize this resource among teachers and, therefore, in the educational culture of Physics teaching.

KEYWORDS: Virtual simulation. Physics Teaching. Computational tool.

ENSINO DE FÍSICA COM USO DE SIMULADORES VIRTUAIS: POTENCIAL DE UTILIZAÇÃO EM SALA DE AULA

RESUMO

Os simuladores virtuais são *softwares* com objetivos de emular uma realidade na qual seja possível, sobretudo, a aprendizagem do usuário. Neste contexto, os simuladores virtuais quando utilizados como recursos didáticos visando estimular o interesse dos alunos e reforçar a aprendizagem de conceitos das ciências da natureza, e em particular da Física, torna-se uma estratégia relevante. Muitos simuladores têm sido desenvolvidos nos últimos anos, tornando-os ferramentas conhecidas, principalmente porque alguns deles funcionam on-line e são gratuitos. Apesar disso, ainda não podemos dizer que a utilização desse recurso é uma realidade no Brasil. Diversos problemas dificultam ou até impedem sua utilização. Neste trabalho observamos o comportamento de um grupo de professores de ciências da natureza acerca da utilização dos simuladores virtuais. Os dados mostram que ainda há muito o que fazer no sentido de popularizar esse recurso entre os professores e, por conseguinte, na cultura educacional do ensino de Física.

Palavras chave: Simulação virtual. Ensino de Física. Ferramenta computacional.

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1 INTROCTION

Physics Teaching in Brazil has presented many possibilities for modernization and, therefore, expansion of methodologies and teaching strategies, however this reality is not present all schools and not even to all teachers. In most schools, students do not have the appropriate stimuli to be interested for physics, as would be expected, but have a repulsion for this science (Moreira, 2018). This behavior may be caused to contents are addressed, most of the time, in the most traditional way possible, that is, using a methodology that is totally centered on the teacher, based on the model of lectures.

Lesson plans based essentially on lectures biuld up a difficult way to the active and effective students participation, therefore, they find it difficult to fully exercise the role of protagonist in their learning process. In this way, the student is not able to develop skills, such as identifying problems, proposing solutions, associating content with experienced situations, logical reasoning, and also social skills, such as communication, teamwork , encouragement to take initiative and independence. These teacher-centered classes, in which the student is a passive spectator, only being able to ask questions and indicate that he did not understand part of the content are characteristics of what became known as traditional pedagogy. This conception of pedagogy is defined by Saviani (2007, p. 103-104):

> A Traditional pedagogy is guided by centrality of instruction (intellectual training), they thought of the school as an agency teacher-centered, whose task is to transmit the knowledge accumulated by humanity according to a logical gradation, leaving it to the students to assimilate transmitted contents. In this context, practice was determined by the theory that shaped it, providing both content and the form of transmission by teacher, with the consequent assimilation by student.

Despite many technological advances that, by one hand, could contribute to increasing students' interest in physics, not using these technological resources in the classroom in order to bring students closer to physics science can have opposite effect as a consequence, that is, traditional teaching during the age of information and technology distances student even further from physics science.

In a survey carried out with natural sciences teachers, that is, professors in areas related to physics teaching, they emphasized that the main problem in teaching physics is decontextualized way in which it is taught. Figure 1 shows survey result. In which the main results for the question are: “Lack of context in Physics teaching” (15.2%), “Teaching method” (12.0%), “infrastructure” (10.4%), “Teacher training” (9.6%), “curriculum” (8.0%) and “Teaching focused on testing” (8.0%).

HOLOS
ISSN 1807 - 1600

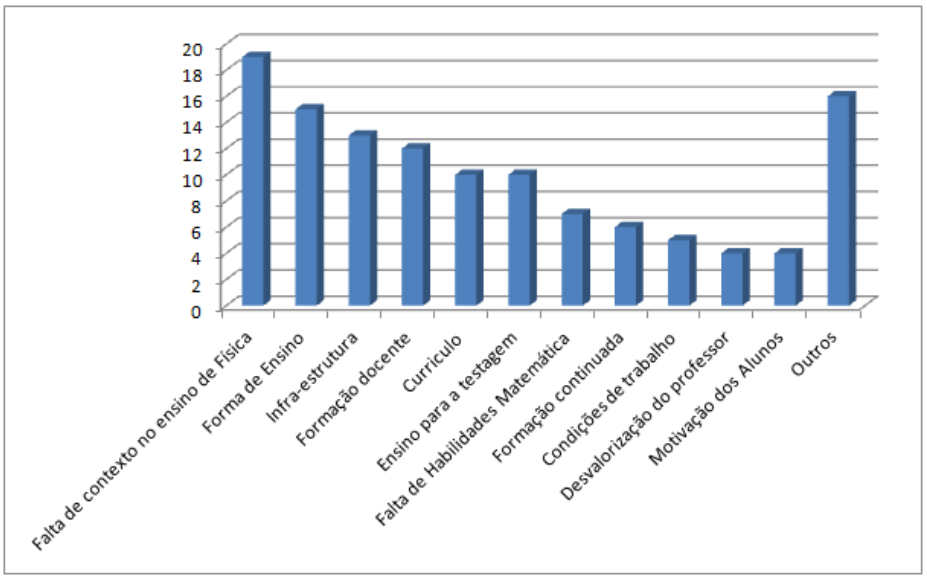

Figure 1 - Survey Result of Items identified as important factors that hinder Physics teaching in Brazil.

Source: Own elaboration.

Some results point to problems related to schools' structure and education systems, such “Infrastructure”, “Curriculum”, “Working Conditions”. That is, in teachers' opinion , there are structural problems in schools and problems in the basic education curriculum.

Other responses by teachers point to the consequences of public policies and society's decisions, such as "devaluation of teachers", "Teaching for evaluation" and "Students' motivation". In these perceptions, there are more complex problems that include how society and public policies have prioritized education in the country.

Other professors cited teacher training and the lack of continuing education as the most relevant problems that compromise the teaching of physics in Brazil. These problems stem from situations involving universities, since they have not always carried out activities that include parts of the pedagogical work.

Although all these items have already been observed in other situations, the most frequent answer given by the teachers who responded to the survey concerns the way Physics is taught. For 27.2% of respondents, problem of lack of context in physics teaching and other methodologies considered inadequate are the biggest problem in the students' learning process.

Trying to understand this result, we asked the following question: “How could we, even if we wanted to, develop a science class that studied natural phenomena in such a way that the student does not identify with anything during the class?”, in other words: what is the methodology that manages to talk about nature in a way that does not address anything that is related to student's daily life?

Moreira (2021) analyzes physics teaching and considers that the act of teaching and learning physics comprises some points, among them are experimental activities and scientific skills. For these points, Moreira (2021) concludes that the challenges of teaching physics include:

> “Incorporating digital information and communication technologies into teaching without abandoning face-to-face activities, maintaining social interaction and negotiation of meanings. use of virtual

> laboratories; computers and cell phones are part of the students' environment; virtual labs can be used in simulations, computational models, virtual experiments; experimentation should be part of physics teaching." (Moreira, 2021)

According to this, the use of virtual simulators in physics teaching seems an alternative that should be considered to further enrich teaching and, therefore, student learning.

Thus, the use of virtual simulators in physics teaching represents an alternative that allows students, among others, to:

• Interact with simulated everyday situations whose reproduction in the laboratory would be laborious and/or time-consuming, such as thermal processes that are slow;

• Reproducing situations involving expensive items that are sometimes unavailable in school environments, such as electronic circuits;

• Carry out experiments that are not possible to be carried out on the earth's surface, such as environments with different gravity acceleration;

• Faced with situations that would be dangerous to be carried out in practice, but which are carried out safely with softwares;

• Carry out procedures in which, without due training and attention, the student could easily damage the inputs and/or components;

• Simulating abstract concepts or situations, which are difficult for the student to construct, such as in the area of physics: magnetic, electric and gravitational fields;

• It allows the student to repeat the experiment many times and in different places in the classroom, since the software can be accessed from different places and ways, enabling training and favoring learning;

• Preparing an experiment more quickly, since there are cases in which the time required to prepare the real experiment is considerably higher than the time spent to start a virtual simulation.

These positive characteristics when applying simulators as part of the teaching strategy make the use of simulators in the classroom something attractive, and it can be imagined that it is something common and recurrent, however there are problems that make it difficult or even unfeasible to use it. of simulators in the classroom, among them we can mention:

• Teacher was not prepared or, in some cases, at least, instructed to use the simulator: This makes the teacher not feel comfortable using it and prefers to use other strategies in which his control of the instrument is more effective and the same feel safe in carrying out;

• Teacher has deficiencies or incapacity in the use of computational resources: When proposing the use of a computational system, the professor becomes "responsible" for guiding students not only in the content of the class itself, but in all other elements that may there are, for example, software installation, crashes, conflicting responses from the system, slow execution, control of computer use by students and this makes the teacher not opt for this strategy;

• Some schools do not block the internet and/or computer room: The lack of a network (internet) or computer room (computer labs) at the school does not make the use of simulators unfeasible, but makes it very difficult, as this environment is the most suitable for carrying out this activity. However, if this is not possible, the teacher can still perform a demonstrative activity or pass the activity home or in groups of students reviewing the computer, or even select some simulators that work from smartphones.

• Unavailability of students' computational resources: Many students do not control computers, this makes training difficult (repetition of the activity) in another location and class time.

It should be noted that, under accepted conditions, environments with the internet, computers and a teacher with technological skills, this alone is not enough. The teacher, as a mediator, must conduct the activity, so that the simulations cause cognitive conflicts, ideally related to the student's reality.

In this work we seek to list the possibilities and highlight the difficulties of virtual simulations in Physics Teaching.

2 VIRTUAL SIMULATORS

Virtual simulators are software whose objective is to emulate real equipment and situations for experimentation (learning concepts) or training (learning how to use them), such as what happens with flight simulators (Microsoft Fligth Simulator, for example), where you can perform take-offs and complete flights and landings similar to the real situation. The simulator reproduces a part of the real environment, in which one can know, learn and practice.

Many students have an immediatist profile, which is a characteristic enhanced by the high speed of information flow, through information technologies, in a globalized world. Thus, feedback or results are needed in a short period of time to keep the student involved and motivated to continue performing an activity, and virtual simulators effectively meet this need.

Educational virtual simulators are also developed with characteristics of virtual games, that is, the use of games as didactic resources, which has recently been called gamification. Silva and Sales (2017) define gamification as an active learning methodology that consists of using game elements in non-game contexts to engage, motivate, increase activity, promote learning and solve problems.

3 MATERIALS AND METHODS

This study carried out a research, in order to get information from bibliographic sources, but also data from the educational census issued by INEP (National Institute of Educational Studies and Research Anísio Teixeira). This research sought to group arguments so that it could answer questions related to potential use of computational resources (simulators) in Physics teaching. The methodology also use a survey applied to the group of science teachers who were taking the postgraduate course at the specialization level in Science Teaching. In this survey, they answered questions about their knowledge and the use of virtual simulators in teaching

activities. Chart 1 shows the unstructured questionnaire designed and applied to science and mathematics teachers.

Chart 1 – Survey applied to science teachers.

Have you ever used a physics simulator?
Under what conditions?
How was the experience?
Do you currently use?
Is it important to use the simulator in Physics teaching?
How did you learn to use the simulator?
If you've never used it, will you be able to use simulators soon?

Fonte: Autoria própria.

From the application of this survey, it is possible to understand the reality of teachers. The question “Under what conditions?” allowed us to understand whether the teacher knew the simulators while still a student of the degree or only after the beginning of professional activities.

The question "How did you learn to use the simulator?" allows us to understand how teachers find "training" to carry out based on the knowledge and mastery of the simulator to elaborate their teaching plans.

4 RESULTS

Of the 52 teachers who teach natural sciences and mathematics, 21 of them (40.38%) said they have already used virtual simulators in their classes. This percentage indicates that there is still much to be done with regard to making teachers aware of the importance of using simulators and what they can do for student learning.

When categorized by basic training, we found that biology teachers, who often teach the discipline of natural sciences, and mathematics teachers are the ones who least use simulators, as shown in Chart 2. Even physics teachers who have great potential of using this methodology, we still do not have a good adherence (56%).

Table 2 - Teachers graduate according to the use of simulators.

use Simulators	Teachers graduate				
	Biology	Physics	Mathematics	chemistry	Total
No	12	4	15	0	31

Yes	4 (25%)	5 (56%)	7 (32%)	5 (100%)	21 (40%)
Total	16	9	22	5	52

Fonte: Elaboração Própria.

In a way, this result corroborates Silva et al., (2016) who state that technologies are present in many schools; despite this, these technologies are still not used for teaching and learning purposes. There are many possibilities for the low use of these technologies in basic education. From the difficulties inherent to teachers, such as academic training or lack of confidence when using computational resources, to structural problems, such as the lack of adequate computer labs in schools.

Moreira (2021) points out the absence of virtual laboratories (laboratories suitable for classes with simulators) and methodologies related to digital technological resources as one of the main challenges for teaching Physics. This can be observed in practice, because according to the 2020 basic education census, whose data are available on the INEP website, among the educational institutions that offer secondary education, 74.85% of them have a computer lab and this percentage varies greatly between states and regions in Brazil. Table 3 presents percentage of schools that have a computer lab, it is possible to see that this percentage can reach from only 10% of schools (Municipal in the North region) to 100.0% of schools (Federal in the North region). Considering that most high school students are enrolled in state and municipal education networks, we realize that there is a deficiency in this regard for most schools. Considering all schools, Brazil has 74.85% of schools with computer labs.

Table 3 - P Percentage of Schools with a computer lab available by region and administrative area.

Region	Tipo de dependência			
	Federal	State	Municipal	Private
North	100,0%	53,8%	10,0%	70,43%
North East	98,9%	72,15%	30,2%	55,81%
Southeast	100,0%	81,63%	70,7%	65,72%
South	97,3%	78,8%	64,86%	78,97%
Midwest	100,0%	72,98%	50,0%	62,10%

Fonte: INEP.

This is a challenge that represents a complex problem that ranges from teacher training and interest to public policies that need to be aware of the demands and needs of society.

Getting to know computational tools and performing pedagogical transcription for their students is a fundamental mission of schools and should be carried out by teachers together with pedagogical teams. There are a large set of computational tools (simulators) available. Araújo et al (2021) presents a list of five digital platforms, in Portuguese: Physics at school (https://www.vascak.cz/physicsanimations.php?l=pt), Physics Virtual Lab (https://virtuallab .pearson.com.br/Laboratorios/Fisica), LabVirt Fisica (http://www.labvirt.fe.usp.br/indice.asp), Modelus (modellus.fct.unl.pt) and Phet (https: //phet.colorado.edu/pt_BR/).

DA SILVA and MERCADO (2019) expand the range of available simulator possibilities a little further. They created a list of 65 sites that contain simulators for teaching Physics on the internet.

One of the most used is Physics Education Technology (PhET), which was cited by a large part of the teachers responding to the questionnaire, this is probably due to, in addition to being open and free, PhET is simple, is in Portuguese and has a very visual appearance. well designed, which facilitates the use by those who have difficulty with other languages.

Physics Education Technology is a free, open source digital platform that provides interactive virtual simulators in Science. It was founded in 2002 and is maintained by the University of Colorado Boulder. They present small simulations of all areas of basic physics and are the result of research carried out at that university.

ARAUJO et al (2021) and BUDIARTI and LUMBU (2021) positively evaluate simulations available on the PhET website, as they provide an alternative to the lack of interactivity that some lesson plans provide.

It is also possible for teachers to build their own simulators. The PhET project is one such initiative. However, this path can become more complex and time-consuming, if we consider the skills needed to perform such a task. Usually this project needs a multidisciplinary team that can organize and carry out the different phases inherent to the process of building a software. COSTA (2021) proposes a script for building a simulator software, and presents the necessary characteristics for this multidisciplinary team. SOUSA, TRAVAIN and ASSIS (2019) describe the construction of a simulator called SimulAção, including the usability test of the proposed simulator, which in the version mentioned in the work addresses the topic of mechanical energy.

The efficiency in learning Physics concepts when using simulators seems evident, but the team paid attention to the fact that simulation is not the purpose of the class, but the means to achieve learning, so it is necessary for the teacher to build an interaction with the students in order to always highlight the physical concept and not the resource (simulator). RIBEIRO (2020) carried out an experiment with two first-year high school classes. In this experiment, he performs a set of intervention and test steps aimed at observing the efficiency of using film simulators, which presents good results, as De Vasconcelos (2015) already recognized that these resources learned for the understanding of scientific knowledge.

5 CONCLUSIONS

Simulators are an alternative and important alternative to aid teaching of disciplines that need experimentation and require abstraction for understanding, such as physics. It is observed that there is a great challenge to the use of these resources in schools, because the demand of teachers and schools conditions that are not always present. Many teachers are not even aware of this tool, even having completed their entire degree recently.

Every day more simulator options are created and made available on the internet, thus allowing more alternatives to carry out simulated practical classes. PhET (https://phet.colorado.edu/) is one of the most attractive options because it is a set of simulators in Portuguese, open and free, in addition to having a very intuitive look.

Despite all the advances in technology, the use of simulators as an alternative to the traditional methodology in the discipline of Physics in Basic Education is a great challenge and needs to be placed more and more in courses and training, so that teachers can include it in their plans education.

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COMO CITAR ESTE ARTIGO

Lopes, J. S., Silva, A. G. da S., & de Souza, G. F. de S. (2023). ENSINO DE FÍSICA COM USO DE SIMULADORES VIRTUAIS: POTENCIAL DE UTILIZAÇÃO EM SALA DE AULA. HOLOS, 1(39). Recuperado de https://www2.ifrn.edu.br/ojs/index.php/HOLOS/article/view/14365

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Editora Responsável: Francinaide de Lima Silva Nascimento

Recebido 14 de outubro de 2022
Aceito: 23 de janeiro de 2022
Publicado: 01 de março de 2022