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# Teaching of Physics in the Specialist Officer Formation Courses: the potential of the activities, under an investigative perspective, mediated by the information and communication technologies (TICs)

*Enseñanza de Física en los Cursos de Formación de Oficiales Especialistas: el potencial de actividades, bajo una perspectiva investigativa, mediadas por las tecnologías de la información y de la comunicación (TICs)*

*Ensino de Física nos Cursos de Formação de Oficiais Especialistas: o potencial de atividades, sob uma perspectiva investigativa, mediadas pelas tecnologias da informação e da comunicação (TICs)*

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**ABSTRACT**

This article is an analysis of the use of the Information and Communications Technologies (TICs) as tools for teaching of Physics under an investigative perspective, and of the viability of their application in the Specialist Officer Formation Courses (CFOE). We performed a search in scientific publications that could identify the different possibilities of use of the TICs s in the processes of teaching and learning Physics, as well as the tendencies that arose, analyzing the scope, the pertinence and the importance given to the subject by prominent researches in the field of teaching of Physics in Brazil, with the goal of implementing this methodology in the different Physics disciplines taught at the CFOE. In order to do so, we performed an analysis of the articles published in a special issue of *Caderno Brasileiro de Ensino de Física* (Cad. Bras. Ens. Fís., v. 29, Especial issue 2). As the main result, we highlight the potential that the TICs have of contributing to the development of teaching strategies and activities, calling attention to the fact that, even though a significant portion of the analyzed articles had the goal of evaluating instructional materials that make use of the TICs in Physics classes, these activities are being established as an important object of study of the recent researches in this field, showing a high potential for the development of teaching activities under a perspective of scientific investigation that can be used in the Physics disciplines taught at the CFOE, fulfilling the current existing needs.

**Keywords:** Information and Communications Technologies. Teaching of Physics. Scientific investigation. CFOE.

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The acronyms and abbreviations contained in this article correspond to the ones used in the original article in Portuguese.

***RESUMEN***

*Es un análisis sobre el uso de las Tecnologías de la Información y Comunicación (TICs) como herramientas en la enseñanza de Física bajo una perspectiva investigativa y de la viabilidad de aplicación a los Cursos de Formación de Oficiales Especialistas (CFOE). Fue hecha una búsqueda en publicaciones científicas que identificasen las diferentes posibilidades del uso de las TICs en los procesos de enseñanza y de aprendizaje de Física, así como las tendencias que se presentan, verificándose el alcance, la pertinencia y la importancia atribuida al tema por importantes investigadores del área de enseñanza de Física en Brasil, visando a la implantación de la metodología en las asignaturas de Física de CFOE. Para tal, fue hecho un análisis de los artículos publicados en una edición especial del Caderno Brasileiro de Ensino de Física (v. 29, n. Especial 2). Como principal resultado, destacamos el potencial que las TICs tienen de contribuir para el desarrollo de estrategias y actividades de enseñanza, llamando la atención para el hecho de que, aunque una parte significativa de los artículos investigados tuviesen como objetivo evaluar materiales instruccionales que hacen uso de las TICs en clases de Física, esas actividades están consolidándose como un importante objeto de estudio de las investigaciones recientes en el área, demostrando elevado potencial para que se pueda desarrollar actividades de enseñanza bajo una perspectiva de investigación científica y con utilización en las asignaturas de Física del CFOE, satisfaciendo necesidades existentes hoy.*

***Palabras clave:*** *Tecnologías de la Información y de la Comunicación. Enseñanza de Física. Investigación científica. CFOE.*

***RESUMO***

*Trata-se de uma análise sobre o uso das Tecnologias da Informação e Comunicação (TICs) como ferramentas no ensino de Física sob uma perspectiva investigativa e da viabilidade de aplicação aos Cursos de Formação de Oficiais Especialistas (CFOE). Foi realizada uma pesquisa em publicações científicas que pudessem identificar as diferentes possibilidades do uso das TICs nos processos de ensino e de aprendizagem de Física, bem como as tendências que se apresentam, verificando-se o alcance, a pertinência e a importância atribuída ao assunto por importantes pesquisadores da área de ensino de Física do Brasil, com vistas à implantação da metodologia nas disciplinas de Física do CFOE. Para tal, foi realizada uma análise dos artigos publicados em uma edição especial do Caderno Brasileiro de Ensino de Física (Cad. Bras. Ens. Fís., v. 29, n. Especial 2). Como principal resultado, destacamos o potencial que as TICs possuem de contribuir para o desenvolvimento de estratégias e atividades de ensino, chamando a atenção para o fato de que, embora uma parte significativa dos artigos investigados tivesse como objetivo avaliar materiais instrucionais que fazem uso das TICs em aulas de Física, essas atividades estão se consolidando como um importante objeto de estudo das pesquisas recentes na área, demonstrando elevado potencial para que se possam desenvolver atividades de ensino sob uma perspectiva de investigação científica e com utilização nas disciplinas de Física do CFOE, suprindo necessidades hoje existentes.*

***Palavras-chave:*** *Tecnologias da Informação e da Comunicação. Ensino de Física. Investigação científica. CFOE.*

## 1 RESEARCH PREDICAMENT: INNOVATION, INFORMATION AND COMMUNICATION TECHNOLOGIES, AND THE SCIENTIFIC INVESTIGATION PERSPECTIVE IN PHYSICS CLASSES

The scope, presence and potential for innovation derived from technology in the daily lives of contemporary mankind are undeniable. Ever since the first scientific revolution, technology became an important component and one of culture's most powerful driving forces. However, the use of technologies in education, such as computers, multimedia projectors, digital blackboards and other devices, has proven to be of little efficacy to foster learning among students. Therefore, we consider that such technologies must be associated with a careful teaching plan and, consequently, they must be in accordance with a learning perspective, in such a way that they can be established as mediational teaching resources in which learning can take place.

The need to diversify teaching methods that counteract school failure has been the object of study of several scientists and modern educators, who see the computer as a useful and practical tool that has a vast range of possibilities of use in the educational field and in the teaching of Physics (FIOLHAIS; TRINDADE, 2003).

It is notorious, particularly in the teaching of Physics, the need to abstract many mathematical concepts and relationships, which can be usually better understood when visualized through a computer simulation or some other kind of resource derived from the information and communication technologies (TICs). Given the attention it has been attracting, *Caderno Brasileiro de Ensino de Física* published a special issue dedicated exclusively to this subject (Cad. Bras. Ens. Fís., v. 29, special issue 2), which discusses the practical, empirical and theoretical issues of the studies in this field.

However, in order for the use of these new technologies to contribute to improve the quality of the education provided, the need to investigate their impact or, better said, their potential to improve the quality of the Physics education becomes clear. In order to achieve that, we should take into consideration a teaching perspective that is innovative, but that has also been proven to be potentially efficient, like in the case of teaching through investigation. In this article, we aimed at contributing for a better comprehension of the potential offered by the TICs as a teaching tool and as one of the elements that constitutes the processes of teaching and learning Physics in accordance with a perspective of teaching of Physics through investigation. In order to achieve that, we propose the analysis of some publications in this field about the pertinence attributed to the use of the TICs in the teaching of Physics, particularly regarding the investigative potential of these activities, based on a survey of the articles published in the aforementioned special number of *Caderno Brasileiro de Ensino de Física*, which is dedicated to this subject.

## 2 GOALS

### 2.1 General goal

To study the potential of the information and communication technologies for the promotion of Physics classes under a scientific investigation perspective and the viability of their use in the Specialist Officer Formation Courses (CFOE).

### 2.2 Specific goals

- To analyze the recent national publications in the field of information and communication technologies (TICs) applied to the teaching of Physics, particularly a special issue of *Caderno Brasileiro de Ensino de Física* dedicated to this subject, in order to enable a better comprehension of the different possibilities, trends, perspectives, and the investigative potential of these activities, aiming at contributing to the work of teachers and researchers.
- To discuss the pertinence of using the TICs to teaching of Physics.
- To identify the proposals of use of the TICs that are compatible with the science teaching strategies, under a scientific investigation perspective.
- To analyze the viability of applying them in the Physics classes at CFOE.

## 3 TEACHING SCIENCE: PHYSICS UNDER A SCIENTIFIC INVESTIGATION PERSPECTIVE

The teaching under an investigative perspective has some features that go beyond traditional teaching. Even though there is no consensus in the literature regarding this teaching perspective, Zômpero and Laburú (2011) stated in their work that there are approaches with points of convergence regarding the necessary characteristics for investigative activities. Under this perspective, the activities planned by the professors are focused on the student, who starts to play a more active role in the teaching and learning processes. Therefore, the investigative activities have contributed to the development of the student's autonomy regarding the analysis of issues, the decision-making process, the evaluation of the activities, and the solution of problems.

In the teaching of Science through investigation, the students interact with, explore and experience the natural world. Under this teaching perspective, the students take part in exploration and research processes, they get involved in their own learning, they formulate questions, think up hypotheses, analyze evidences, draw conclusions, and communicate results. The goal is to make the students think, discuss, justify their ideas and apply their knowledge to new situations. Thus, the students have the chance to explore strategies and resources for them to learn how to think scientifically. It is also possible to foresee indirect advantages in the students' complementary formation, since they explore a much greater range of skills and competences developed and bolstered with these kinds of activities in comparison with the traditional ones.

Therefore, the perspective of teaching Science through investigation may contribute for a more efficient learning of the very process of production of scientific knowledge, because it has a high potential to foster debates in which this process can be questioned and pondered, on top of demystifying the general consensus that science has an absolute, ready and finished knowledge.

The focus of the investigative activities is in the learning on the part of the students, who follow a certain path in order to build their own knowledge, becoming active players in this process. One may realize that this isn't only a technique or a teaching tool; it is a change in posture and behavior on the part of the students and also on the part of the professor. Due to its particular features, it is becoming evident that activities with an investigative perspective have a high potential for the promotion, deepening and assimilation of scientific knowledge, exploring intangible aspects with traditional perspectives.

## 4 THE NEW TICS AND THE TEACHING OF PHYSICS UNDER A PERSPECTIVE OF SCIENTIFIC INVESTIGATION

In the field of teaching, we notice the presence of many technological resources that can be used to improve and/or make easier the teaching and learning processes in a way that is more playful, interactive, and possibly more effective.

According to Hestenes, Wells and Swackhamer (1992), the traditional methods of teaching Physics are inappropriate for a world that is ever changing. As Lawson and McDermott (1987) have stated, one cannot expect the students to understand Physics if the abstract and complex concepts are presented through verbalizations and pictorial displays with low communication power.

The TICs continuously change the way knowledge is passed on, spread and assimilated, because acquiring competences becomes a multiple and continuous process both in its sources and in its forms and entry points. The new technologies promote alterations in the power relationships because they broaden the times and places to seek knowledge and competences. The current process is not flat linear and unidimensional anymore, but broad, available through a network, and disseminated instantaneously throughout the corners of the globe.

In parallel with this process, in the current scenario, students are often interacting with a world filled with technological resources. Schools, teachers and other educators cannot ignore this reality. It becomes necessary that they are able to teach the student to understand, live with and use this technology properly. This challenge has gained relevance, and it is the object of concern and/or discussion in all teaching fields almost anywhere. The TICs may play an important role in this task, because when they are rigorously employed by the teacher, they become invaluable tools for learning and a source of stimulation for creativity.

Likewise, the activities of an investigative nature have been proven to be efficient because they favor the involvement, the interaction, the interest and the curiosity for the content that is being worked. The use of investigative activities associated with the use of the TICs can efficiently mediate these processes. With activities of this nature, one can value the answers of the students, instigate the development of their faculties of judgment, develop critique, and the ability to absorb the different concepts, procedures, attitudes and values. One can notice, therefore, the enormous educational potential behind the use of TICs in the teaching of Science under a perspective of teaching through investigation.

## 5 RESEARCH METHODOLOGY

Eleven articles were selected from *Caderno Brasileiro de Ensino de Física*, v. 29, special issue 2, a relevant national periodical in the fields of teaching of Physics; all articles obtained the Qualis B1 degree in the fields of education, teaching and the interdisciplinary field, according to the classification made by Coordenação de Aperfeiçoamento de Pessoal de Nível Superior (CAPES). Every article in this issue discusses the subject of TICs in the teaching of Physics, and that allows us to make a broader analysis of the works that are being developed in the field of teaching of Physics in Brazil, since articles from many authors and institutions located in different states of the country can be found. At the same time, these publications are markedly of easy access and are distributed nationally through one single medium specifically designated to deal with this subject.

In order to implement the research, we had to make a general survey of the articles, which were categorized in a table in which their main features were highlighted in six different categories: 1) problem/research goals; 2) methods/research methodology; 3) proposals for the uses of the TICs in the teaching of Physics; 4) features of the activities investigated with an investigative purpose; 5) obtained results; and 6) recommendations for the use of the TICs in the classrooms/Physics labs. This procedure was crucial in order to establish a broader and more general perspective of analysis because, even though they discuss the same subject (the TICs in the teaching of Physics), the articles present different ways of application, interpretation and teaching propositions, and, therefore, they must be considered rigorously.

The works were analyzed based on the vertical reading of the columns, through which detailed comparisons between the different articles belonging to the same category were made. Subsequently, each of these comparisons could provide data for the identification of points of convergence, divergence, or even a new and yet unexplored or unexplained perspective.

In order to make a consistent qualitative analysis and a successful discussion, we tried to identify, among others, the investigative potential of the activities identified in the articles, that is, the possibility to make adaptations so that these activities could be adapted with the goal of making their use with an investigative bias viable. We also tried to identify the educational potential behind the use and application of these activities, taking into consideration the mediations that come with the use of the TICs.

## 6 DISCUSSION AND ANALYSIS OF THE RESULTS

Generally, the articles featured in the table allow us to identify the teaching and research aspects,

explicitly stating the different methodological emphases associated with the analyzed works and the obtained results. These articles feature verifications of the school reality that are of particular interest for the teaching of Physics.

Initially, about the **Research problems/Goals** featured in these articles, we have identified two strong trends. On the one hand, studies that aim at evaluating instructional materials that use the TICs in Physics classes, with the goal of establishing new alternatives for the improvement of the quality of the teaching of this subject. On the other hand, studies in which the authors try to develop or build theoretical landmarks that help professors and, most of all, researchers to understand the role that the TICs play or could eventually play in the teaching of Physics.

As for the **Methods/Research Methodology**, we notice a certain opposition in the way of collecting data and in the search for answers to investigation problems. Considering that the research method can be understood as a procedure that is followed in order to determine the meaning behind the facts and phenomena to which the scientific interest is directed, in some cases we have observed that the methodology did not confront or validate the data, and did not even have a clear research strategy, limiting itself to the presentation and/or application of a software, simulation or model. In these cases, the methodology is not made explicit, and was inferred based on the procedures that allowed the authors to debate the results. In turn, other publications list the procedures followed in order to collect the data and unequivocally show the pertinence of the works.

Regarding the **Proposals for the Use of the TICs in the Teaching of Physics**, each article mentions the use of the TICs reported and studied in their respective works. Thus, one can perceive that the proposals for the use are divided into three main axes: one of them was developed for direct application in the classroom with the students (six out of eleven articles); the other axis focus on the professors for the planning and development of activities (four articles); and, lastly, a research without a proposal for the application, whose focus is on the situational analysis and on the study of the educational implications in the field of Physics in Long-Distance Learning (LDL). We must highlight one feature that becomes evident: even though most of the articles focus on the direct application/use with the students, a great deal of these articles was explicitly developed for college students majoring in Physics. Thus, the researches point to a certain concern regarding the formation of professors, demonstrating the need to instigate the new and future professors to use the resources that the TICs can provide.

As for the category **Features of the Activities Investigated with an Investigative Purpose**, one can perceive that most works show a high potential for the development of activities with an investigative purpose. Some articles explicitly mention or present a proposal of an activity that encompasses features of investigative activities (four articles), demonstrating the teaching potential of these activities. The other articles, in turn, present great investigative potential, provided that their element/object of study of the TICs is properly adjusted, parameterized to that end, in such a way that an activity that explores this potential can be prepared. One of these articles, for instance, discusses the use of a software that explores the history of Physics, but in a way that is not much interactive. As an example, we could explore the features of an investigative activity by preparing an activity designed to do so, as in the proposal contained in Chart 1:

**Chart 1** - Proposal for an investigative activity.

| PROPOSAL OF ACTIVITY |
| --- |
| A scientific problem that a certain great thinker tried to solve could be induced. After the definition and instigation of the problem, the mediator professor or the very own software could present some proposals for the explanation and solution of this problem, exploring each one of them, and allowing for reflections and deliberations on the subject. Subsequently, the properly debated and justified proposals could be included in a group discussion that could take place in an environment that may or may not be virtual. Lastly, after exhausting the subject and the possibilities of exploration of the problem and of the subject, a complete animation as a way of summarizing and closing the reasoning could be presented. |

**Source:** The author.

As for the **Obtained Results**, one can generally perceive that the theories and hypotheses supported throughout the texts are significantly confirmed and corroborated with the goal of improving teaching, within its respective axes of research and analysis. Even if indirectly, by instigating professors and students majoring in Physics, one can notice this concern with presenting new proposals/paths in order to achieve a better and more significant understanding of the concepts of Physics.

Lastly, the **Recomendations for the Use of the** TICs **in the Classrooms/Physics Labs** category indicates the practical role of the application of what was studied. In this section, we discuss the benefits, advantages and even the difficulties to implement the object of study in each work. One of the articles that talks about hypermedia in the teaching of Physics makes clear, for instance, that the real goal is to make viable an education that provides effective learning and that strives to value the different ways of presenting the contents, but this is a complex process that involves the formation of multidisciplinary teams, high time investment and resources.

## 7 THE VIABILITY OF THE USE IN THE PHYSICS SUBJECTS TAUGHT AT CFOE

The Specialist Officer Formation Courses (CFOE) are taught at the Air Force Instruction and Adaptation Center (CIAAR), in the city of Belo Horizonte, in the State of Minas Gerais (MG). They are college-level technology courses based on science, technology, culture, ethics and military values that aim for a responsible and sensible professional and military performance. The students graduate from the courses as Specialist Officers on Aircraft, Weaponry, Communications, Air Traffic Control, Photography, Meteorology and Technical Supply. They are two-year courses that encompass instructions on the General, Military and Specialized-Technician fields provided by Air Force Command Manual 37-58 (MCA 37-58) (BRASIL, 2008).

Since the courses integrate the Exact Sciences, their structure is composed of the subjects of Calculus, Chemistry and Physics. All of the specialties have to take the Physics I and II classes, and five out of the seven specialties have to take the Physics III and IV classes. According to the Air Force Command Instruction 37-316 (ICA 37-316) (BRASIL, 2015), The Minimum Curriculum of the courses has approximately 50 credit hours for each Physics subject, which in total make up an expressive and representative amount of credit hours in the basic formation of the students.

Considering that they are college-level technology courses in the field of the Exact Sciences, in which the need to know how to handle the different types of technologies is crucial, and also considering that the graduated officer must be at the technological cutting edge in his/her field, the ability to have a good command of the technological tools is justified. As Grinspun suggests,

> We must educate ourselves to learn and use new technologies, to develop and reflect upon the needs for these technologies, and turn them into allies and accomplices of the very well-being of mankind and society. (GRINSPUN, 1999, p. 22).

In the same manner as the courses are designed, focusing on lectures, we can infer that the inclusion and use of the TICs under an investigative perspective can contribute immensely to a better assimilation of the studied contents, and to a practical-conceptual exploration that would hardly be achieved through other means, bypassing possible laboratory infrastructural obstacles or issues of reduced credit hours.

At the CIAAR, besides having access to a computer science lab, each student gets a laptop containing all of the hardware and software tools they will need to perform well as students, and they get to keep the device throughout the whole course. Besides that, the facilities have a great information technology (IT) infrastructure, and high-speed Wi-Fi is available to all students and faculty, and that favors the large-scale use of the aforementioned TICs tools and makes their implementation in the teaching viable.

Also considering that the ICA 37-521 (BRASIL, 2012) recommends the adoption of the taxonomy of educational objectives to guide the learning evaluations, the understanding of the use of the TICs tools in teaching is coadunated. Bloom's taxonomy organizes hierarchical levels of learning in such a way that, if the professor wishes to reach more elevated layers of learning, he/she first go through levels that require less abstraction (BLOOM et al., 1988).

Thus, with the adoption of the TICs in the teaching of Physics, we can expect a greater effectiveness in the transmission, assimilation, sharing and manipulation of the information and Physics knowledge that are required of the future Officer of the Brazilian Air Force (FAB), as well as a higher level of insertion and skills with the new learning virtual technologies.

## 8 FINAL CONSIDERATIONS

In this article, we aim at contributing to a better comprehension of the potential offered by the TICs as a teaching tool and an element that forms part of the processes of teaching and learning Physics, under a

perspective of teaching Physics through investigation. In order to achieve that, we developed a study in which we tried to make a reflection of the pertinence of the use of the TICs to teach Physics, based on a survey of the articles published in the special issue of *Caderno Brasileiro de Ensino de Física*, which was dedicated to the subject of the use of the TICs to teach Physics.

In the group of articles analyzed, we noticed that there are many different possibilities of using the TICs in activities that explore investigative features. Most of the articles, even if they don't mention it explicitly, show a large investigative potential. Having as a premise that the same activity can be investigative or not, depending on how it is applied and explored, we observed that almost all proposals for the use of the TICs can prompt an investigative activity because they allow for the exploration of most of the features of an investigative activity. Thus, even though the authors do not discuss the proposal for the use of the TICs in their works as an investigative activity, their potential to do so becomes evident.

Much has already been studied about the TICs and the educational impacts and benefits their use can bring. We also saw that the TICs can be in line with these activities that have an investigative perspective, but even then we notice a limited number of articles that objectively discuss this issue and this relationship. A challenge is then what remains, and a void is open: what could be done to adapt a perspective of the instrumental use of the TICs to a perspective of teaching through investigation?

Therefore, we conclude this article highlighting the potential that the TICs have to contribute to the development of strategies and activities for teaching, calling attention to the fact that a significant part of the investigated articles has the goal of evaluating instructional materials that make use of the TICs in Physics classes, and that these activities are being established as an important object of study of the researches in this field, having also presented a high potential for the development of teaching activities under a perspective of scientific investigation.

Thus, we conclude that the implementation and use of the TICs under an investigative perspective in the Officer Formation Courses offered at the CIAAR is viable, and, for that, one needs to have at their disposal all of the necessary infrastructure and equipment to perform such an application. The use of the TICs also contributes to a broader formation in the field of Physics and Science for the Officer who graduates from the CIAAR.

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