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# Impact of a science and technology strategy on the learning of physics

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**Abstract.** The use of smartphones and some applications for educational purposes are valuable tools in the laboratory since they are motivating for students and the teacher can take advantage of this advantage for the teaching of physics. The experience is based on the anthropological theory of didactics and the teaching approach in science, technology, engineering, and mathematics. It is proposed to investigate a trigger question in physics. To respond, an application is used that uses the smartphone's sensors to record the simulation data. The experience is described, and results of its implementation are presented. Methodologically, a qualitative descriptive approach was used in a group of tenth grade students taking the physics course. Finally, it is concluded that the students felt motivated since they felt they participated in the construction of their own learning, supported using technologies that facilitate the integration of knowledge in physics.

## 1. Introduction

The process of teaching and learning science in the classroom that currently includes the use of technological tools, conceives the student as an active actor in their learning where the teacher assumes the role of counselor to strengthen the development of scientific competencies through interdisciplinarity, but for this it is necessary to change the traditional pedagogical approach, which requires meaningless mechanical learning for students for a pedagogy that proposes that students discover and build their concepts from investigative processes [1].

The approach described by López-Rivera [2], which aims to experiment in the classroom, a pedagogy different from the traditional one, supported by a science, technology, engineering, and mathematics (STEM) teaching approach and learning in the "questioning of the world". To do this, a didactic experience is designed that begins with a trigger question, which finds out what kind of relationship exists between the luminescence radiated by a spotlight and its distance. For this, students must carry out an experiment using smartphones to record pairs of experimentally found data that relate light distance to a light source, and then model them using various open access applications, and thus contrast the functional model found, with the physical law of the inverse of the square to distance.

The study is framed in the anthropological theory of didactics (ATD) proposed by Chevallard [3,4]. that proposes to address the curricular contents, especially physics, from seeking answers to questions. This is achieved through a contrast between the teaching paradigm, called "monumentalization of knowledge and loss of meaning of the issues being studied" by a pedagogy that he calls "of research and questioning the world." To do this, he proposes the implementation of a didactic device that is organized around a triggering, open and unbounded question, selected by the teacher, which has the potential to generate study and construction by students.



The approach to education STEM, which refers to grouping large areas of knowledge in which scientists and engineers work. The purpose is to develop a new way of teaching science, mathematics, and technology together, focused on solving technological problems [5]. This transdisciplinary teaching approach in which the student learns knowledge in an integrated way, connecting concepts from different disciplines, allows them to take ownership of the methodology with which science is developed, through exploration, inquiry, the posing of hypotheses and conjectures, to find solutions, and finally validate them [6-9].

In this approach, the use of technology is fundamental both to access the information that will become knowledge, and to promote the development of creativity and the capacity for innovation [10]; the STEAM approach is since the teaching and learning process focuses on the student as a constructor of their own knowledge through participation in work teams to solve problems in the context that surrounds them, integrating the concepts of science, technology, mathematics for the solution of the problems [11].

## 2. Methodology

The methodology applied is qualitative at a descriptive level since the objective is to describe the didactic device designed, contextualized, and implemented for tenth grade students, developed in four phases. Phase 1 begins with the individual or group presentation of the question that triggers the didactic device; then, in phase 2, the students go to the physics laboratory where they must carry out the experiment; in phase 3, the experiment is carried out using a freely accessible simulation application. Finally, in phase 4, a final discussion is held to answer the triggering question and to report on what has been done in the previous phases. For the didactic device used in this study, the following results are clearly presented in the results section.

### 2.1. Population and sample

The population is taken as the totality of tenth grade students of a public educational institution, taking as a non-probabilistic sample the 35 students of the morning class, characterized by having ages ranging between 15 years old and 17 years old.

### 2.2. Instrument

Technological resources used by students, such as smartphones, an application that takes advantage of smartphone sensors to record data as part of the simulation, were considered as support tools for this research.

### 2.3. Conceptual background

The physical contents addressed by the project are the methods and phenomena used to measure the intensity of light or photometry framed in the studies of optics [12]. The inverse square law of the distance, which states that any light source that radiates its luminous influence equally in all directions, without limit of range, will be governed by this law, Equation (1).

$$E = I/d^2. \quad (1)$$

In other words,  $E$  is the illuminance and lux are its unit (lx), where the luminous intensity measurement  $I$  is measured in candelas (cd) and  $d$  is the distance in metres (m). The inverse square law applies to various phenomena and fields of physics such as point sources of gravitational forces, electric field, light, sound, or radiation. And for mathematical modelling, this project deals with cartesian coordinates, the function of the functional model, as well as the least squares method, allowing us to start from a list of ordered pairs  $(x_i, y_i)$  to obtain a modelling that minimises the sum of the squares of the differences  $(y_i - f(x_i))$ .

Within the objectives of the article, the aim was to develop the anthropological theory of didactics in a tenth-grade technical secondary education course in a public school through investigative teaching, implementing a STEM study methodology that articulates the areas of physics and mathematics.

### 3. Results and discussions

The research is carried out through the execution of a series of phases that have been logically organized. This first phase begins with a motivating or triggering question: how does the photographer regulate the lighting of the camera? The students are organized into working teams of five students, for which they are asked other questions that guide the process of preconceptions and deepening before entering the laboratory, such as: what is light intensity or luminous intensity? How is the intensity of light measured and what are the units of measurement, what happens to the intensity of light when we move away from or towards a light bulb, and what science studies the effects of the intensity of light? In Table 1 the most common answers of the students were digitized.

**Table 1.** Operational.

Questions	Answers
What is light intensity or luminous intensity?	The flux of light emitted by a light source per unit solid angle is the luminous intensity.
How is light intensity measured and what are the units of measurement?	To measure it you need to know how the flux is distributed in a direction of space and its luminous intensity, a lumen is the measure of light, lumen per square meter is how luminosity is measured, it is measured in candles or candela (cd), the unit of illuminance is lux (lx).
What happens to the intensity of light when we move away from or towards a spotlight?	Moving closer increases the lx units and moving further away decreases the lx units, the environment in which the light flux is also affects the luminous flux.
The effects of light intensity are studied by which science?	Within optics photometry.

After reinforcing, clarifying, and deepening the preconceptions with the trigger questions; in phase 2 the students go on to carry out the physics experiment for which they are asked for the following utensils: mobile phone, with the light sensor application, downloaded, torch, or any light source and tape measure. The windows of the classroom are covered with black cloth to darken it, the mobile phone is placed in front of the light source with the light sensor program activated and the tape measure between them, data is taken every 10 cm and recorded in a Table 2, starting at 10 cm.

**Table 2.** Distance data and lux measurements.

Distance (cm)	Luminous intensity (lx)	Distance (cm)	Luminous intensity (lx)	Distance (cm)	Luminous intensity (lx)
10	950	60	105	110	37
20	564	70	78	120	31
30	350	80	57	130	25
40	237	90	47	140	22
50	151	100	42	150	17

In phase 3, Students advance the practice by using their smartphones to collect data derived from the simulation, where the data is modeled using the potential function of the form Equation (2).

$$f(x) = a * x^b. \quad (2)$$

It aims is to contrast the data found with the law of physics of the project and the concepts studied, it is expected that the value of the exponent  $b = -2$ , to validate the law. To do this, students enter the data into the application where the corresponding graph is generated from the list of points, to which they can apply various types of adjustments (potential and/or potential regression).

In phase 4, the student work teams are asked, after collective discussion, to write an answer to the initial triggering question, bearing in mind the previous phases carried out; they are also asked to present the resulting mathematical expression and contrast it with the law of physics that relates the distance of

a spotlight to its luminous intensity, an answer that is presented on electronic slides and shared in virtual plenary with their classmates. The trigger question was attractive and motivating for the students and contributed to them feeling involved in their own learning, agreeing with Costa, *et al.* [13] who also presented an attractive trigger question for their students and partially with what is suggested by Hernández, *et al.* [7], who state the need for teachers to start with interesting learning strategies for their students.

The implementation of new technologies such as mobile phones for experimental data collection, as well as the use of various open access applications, and new integrative methodologies such as STEM contributed to the enthusiasm and motivation of students in the educational process by raising the interrelation of mathematical concepts and their applicability in physics and facilitating the study of science and its relationships, in partial agreement with Ortega, *et al.* [9], who in their project used video to facilitate reading comprehension and in agreement with Costa, *et al.* [13], who implemented the same strategies.

#### 4. Conclusions

The results of the experience show the students' interest in using technology for the construction of their own knowledge, in which the intervention and help of the teacher is important, but they demand new forms of teaching that involve new strategies and resources that promote creativity. The above shows how students approach physical concepts in an articulated way using technology, which motivates them to study science. Furthermore, it is necessary, in the field of science didactics, to advance in research that guides the teaching and learning processes, and to expand research on the use of technology integrated into effective methodologies at the various educational levels and scientific disciplines. Finally, it is necessary to emphasize that the possible integration of scientific and technological content in the teaching of physics is an opportunity to reflect on its specific characteristics and its multiple connections, which can be useful in the teaching and learning process.

It is very important to highlight that science, technology, engineering, and mathematics-based education contributes to the development of skills in students so that one of the purposes is that they achieve a successful professional career, which allows them to compete with the current globalized economy. In addition, with the results of the guided inquiry questions, students take ownership of their learning and begin to produce their own reports as short articles and inquiries regarding specific physics topics and compare them with daily events, which are shared among working groups, thus encouraging group work.

One of the questions that we can ask ourselves regarding this research is: what contributions can we make as educators? And the answer can be very specific, “that we have the option of continuing to teach physics making some adjustments with new technologies and achieving an analytical perspective, constructive criticism so that our students achieve a better quality of life and a more humane world”.

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