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Audiovisual physics reports: students' video production as a strategy for the didactic laboratory

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Abstract
Constant technological advancement has facilitated access to digital cameras and cell phones. Involving students in a video production project can work as a motivating aspect to make them active and reflective in their learning, intellectually engaged in a recursive process. This project was implemented in high school level physics laboratory classes resulting in 22 videos which are considered as audiovisual reports and analysed under two components: theoretical and experimental. This kind of project allows the students to spontaneously use features such as music, pictures, dramatization, animations, etc, even when the didactic laboratory may not be the place where aesthetic and cultural dimensions are generally developed. This could be due to the fact that digital media are more legitimately used as cultural tools than as teaching strategies.

Introduction

For the last 50 years there has been a tacit agreement among science educators that experimental work facilitates the understanding and construction of physics concepts, encourages active learning, motivates the interest of the students and contributes to the development of logical reasoning and communication, thus encouraging enterprise, imagination and group work [1]. These arguments led many to associate good physics teaching practices to efficient strategies that help implement, as much as possible, practical work at school. It is also true that most of the research in physics education correlates experimental practice to improvement in students' learning and in the last few decades science education research work has pointed out experimental work as a major enhancer of physics learning, so for those reasons labwork activities performed by the student have been considered as a 'magic wand' needed to solve the many learning difficulties known in physics education.

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The experimental activities at the introductory physics level are expected to contribute to the development of procedural skills. Nedelsky [2] claims that their central goal is to bring the student to comprehend the relationships between science and nature. This aspect is corroborated by Kirschner's ideas [3]: '*it is the teacher's job to teach science, teach about science, and teach how to do science*'.

Lunetta, Hofstein and Clough [4] are sceptical and, searching for evidence in the vast literature of the field, argue that the main goals of the learning outcomes that should arise from the physics teaching laboratory are often not met. These goals involve conceptual understanding and procedural abilities (exploring arguments from the data), knowledge of how science and scientists work, interest and motivation, understanding of research methods and scientific reasoning, including the nature of science. According to Borges [5] the effectiveness of the didactic laboratory in promoting learning has been in question over the years.

The European survey [6] conducted in seven countries does not point to much improvement in science education as related to labwork, not even in those situations where schools have the appropriate conditions for experimental teaching. The report mentions that practical activities tend to be limited to the manipulation of objects/materials/instruments and they are frequently performed with procedures where the students follow precise instructions and methods of analysis provided by programmed teacher's instructions. One of the recommendations is related to the false pretence that a broad spectrum of goals can be attained 'at once', objectives that many a time may not be compatible with the type of activity carried out. It is also worth commenting that often teachers take for granted the ability of the students to perform certain actions for which they have not been instructed. Furthermore, the survey recommends that in introductory physics classes the tasks performed in a given laboratory session should always be designed to deal with only a few specific objectives [7, 8].

As in many countries around the world, laboratory classes in Brazil are seldom introduced in regular programmes and when this is done students follow a labwork guide that describes the experiment to be performed, while equipment is already laid out on the bench set up by the teacher or tutor. Observations, results and conclusions are already structured and so reported. Probably, the main reason for this choice is the allocation of a larger proportion of theory over practical assignments within the science teaching schedule of many schools.

This strategy gives little incentive for the students to reflect on the conceptual aspects of phenomena under study or to develop a deeper understanding required to overcome the eventual shortcomings of the experimental activity. The planning of measurements and the exploration of the relations between physical quantities involved are also poorly done. Frequently, the physical model underlying the phenomena and the possible disagreements between predictions and results are not shown in the conclusions, impoverishing data interpretation and theoretical explanation.

From tradition to innovation

Currently school education can be seen in transition from traditional to innovative methodologies and mostly the students still remain as the receivers of information. There are also good reasons to acknowledge the place taken by ICT (information and communication technology) resources because they are considered by political decision makers as a solution for the teaching problems of school science education. If this type of resource can be used it is important to recognize its place and limitations, because its role does not replace what labwork does for sound science learning. Because of the growth of ICT facilities and the amount of didactic material currently offered, there is a risk that they may replace the laboratory as the new educational 'magical wand' of this millennium.

So it could be expected that the accelerated technological revolution may contribute to the demands of changes in education [9]. Physics teaching can take advantage of these resources, since it is possible to videotape physical phenomena, opening a motivational strategy for the students who could become producers of their own activities.

Nowadays technological gadgets are within the reach of the common citizen, thus making it possible to introduce independent audiovisual production as a new strategy. From this perspective the school can be thought of as an irradiating pole of knowledge and the teacher as the mediator, leading the students to externalize their creative thinking while producing a video. This is a new way of thinking and doing, to make the students '*discover new possibilities of expression, performing group experiences in a collective creation effort*' [10].

This article proposes to discuss the role of video production by the students as an approach to the physics laboratory which has proven efficient when implemented in a Brazilian high school.

Students' video production project

The production of a video independently made by the students brings a fresh perspective to the practical work they experience in school. The strategy allows the implementation of objectives such as intellectual (academic), procedural (trying concepts to realize physical quantities) and cognitive–affective (motivating students to undergo a process of metacognition throughout the whole experiment).

The possibility of innovation changes the rhythm of a physics classroom, modifying the merely one way communication and introducing activities planned, organized and performed by the students. When using a video camera they can externalize creative thoughts as well as warrant the pedagogical potential, because it allows visualization of physical situations related to conceptual physical models, and so bring about the discovery of new possibilities of expression while experiencing exchanges while working in a group in an effort of collective creation [10, 11].

A strategy to develop laboratory activities based on students' video production of physics experiments can provide a feasible substitute for the traditional didactic laboratory [12]. When involved in the project the pupil engages in different activities, both instrumental and cognitive: hands on and minds on. They are responsible for all the steps to mount and test the experiment, which means involvement along the complete line of events necessary for the task: to identify and research key concepts, principles and laws that allow them to understand and create the experimental situation which will be tested and modified as required.

For the development of their project the students can either use the equipment available in the school laboratory or create their own setup. It is also essential to present a written outline of the general ideas and processes to establish a timetable for the activities to guide the production. This organization gives the students a flexible schedule to develop independent work as well as to allow the feedback that characterizes this kind of task.

It is important that students realize the assignment is not an amusing game, but it has the intention of developing a structured piece of work. Video attributes are anticipated in order to structure the intellectual component of the enterprise, so the following points are made clear from the start. The video produced should:

- pursue a set of a few main objectives;
- allow concept comprehension;
- be conceptually autonomous;
- present a logical sequence;
- integrate oral, written and visual languages (clarity of communication);
- be no longer than 4 min in length.

Several objectives define the project features:

- *cognitive*: the project may enhance (induce) students' cognitive processes for the learning of physics concepts;
- *motivational–technological*: to immerse the students actively in their learning process and to use technological resources (digital video cameras and other devices to record and capture images, audio and software for editing the video);
- *recursive–reflexive*: the project is developed in short related steps, which are not necessarily linear, allowing 'round trips' according to the tasks.

Project development

The complete implementation of this project takes about four months of school time, resulting in a video produced in groups up to five students each.

To begin with, written material with background information, objectives, video characteristics, timing/schedule and criteria of assessment is presented. Each group selects a topic and begins research of physical concepts and the choice of practical activities. Next, the groups plan, mount the set-up and test the experimental situation.

It is important to draw attention to the importance of guidance in order to produce a video as an audiovisual report. At this point they produce

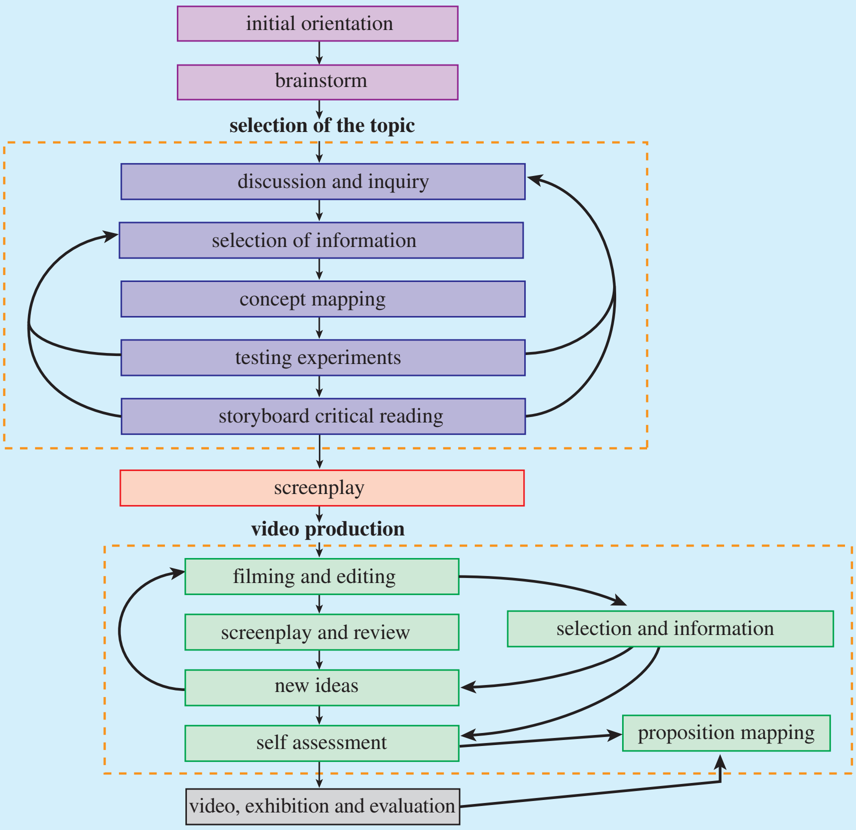

Figure 1. Video production flowchart.

a simplified storyboard, which is discussed with the teacher, to reflect the exploration of the phenomenon. The subsequent screenplay guides the steps of video production and editing. Once the video is produced it will be exhibited to the whole classroom and evaluations can be applied.

Figure 1 illustrates the project development, explicitly showing its feedback features.

Project implementation results

This project was implemented in five classes, totalling around 100 students of a technical public high school in Rio de Janeiro city. Regular laboratory classes in this school are frequently taught following traditional labwork guidelines.

Figure 2 shows representative images of the physics phenomena treated in the 22 videos. All videos were edited non-linearly and have captions as well as, in some cases, pictures and animations. They also present commentary (most of them as voice-over) and soundtrack juxtaposed with the images.

In this article each video is considered as an audiovisual report. For the sake of analysis the videos were divided in two components: theoretical components (TC) and experimental components (EC).

TC represents the objectives proposed, physical concepts, laws, principles and general ideas, needed for the development of the experiment.

EC involves mounting and testing the experiment, filming scenes and editing, where students are responsible for developing procedures, gathering and analysing data, discussing results and presenting conclusions. Initial and final credits are not included in the TC and/or EC.

Table 1 shows the title assigned by the authors (and the total length in minutes:seconds), place of production (PP)—school laboratory (SL) and/or home laboratory (HL)—and the discrimination between time spent developing TC and EC.

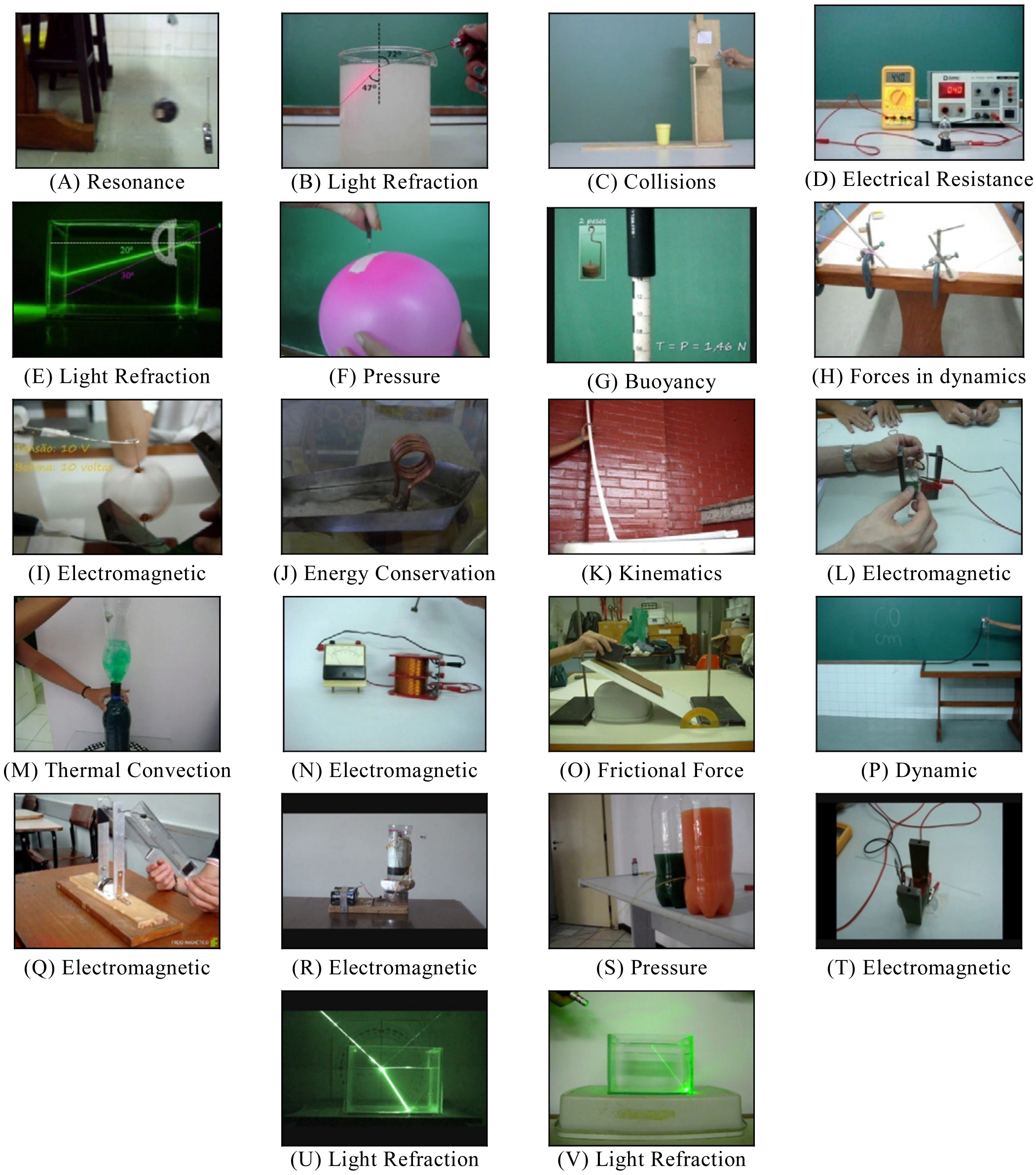

Figure 2. Videos produced.

The videos were filmed in different set-ups: 14 were produced in the school laboratory, four of them in a home set laboratory and four were recorded using both places. It is worth noticing that two videos produced in the school laboratory made use of dramatization resources: I and V.

In discriminating theoretical and experimental components, it was found that three videos, J, Q and R, did not fit these criteria, possibly due to the fact that they are strongly focused on the instrumental aspect of the experiment.

Most of the videos (14 out of 22) show predominance of the EC over the TC. The four videos which clearly develop the TC over the EC are associated to physical principles and laws (collisions and light refraction: B, C, U and V). From a cognitive perspective, this can be interpreted by the fact that these concepts are easier to understand and express theoretically rather than presented practically.

The audiovisual report allows a flexible structure when compared to the written report, as shown

Table 1. Classification of videos according to place of production (PP)—school laboratory (SL) and/or home laboratory (HL)—, theoretical (TC) and experimental (EC) components.

Video	Title (and length in min:s)	PP	TC min:s	EC min:s
A	Resonance effect in pendulums (4:50)	HL + SL	0:24	3:32
B	Understanding physics: light refraction (2:45)	SL	1:27	0:37
C	Collisions: energy conservation (4:30)	SL	2:55	1:05
D	Ohmic and non-ohmic resistance (5:00)	SL	0:40	3:47
E	Physics aquarium (2:20)	SL	0:08	1:49
F	Pascal's principle (4:15)	SL	1:05	3:02
G	Buoyancy (6:15)	SL	1:10	4:43
H	Centripetal and tension forces (3:30)	SL	0:30	2:30
I	Electromagnetic motor (3:40)	HL + SL	1:41	1:33
J	Chemie boat (2:25)	HL	2:25	
K	Horizontal motion and gravity (4:50)	HL	0:43	3:26
L	Direct current motor (3:20)	SL	0:52	2:13
M	Heat propagation: convection currents (3:20)	HL + SL	1:00	2:41
N	Electromagnetic induction: Faraday's law (5:00)	SL	1:35	2:55
O	Friction force (4:26)	SL	0:40	3:20
P	Mechanics: energy conservation (2:08)	SL	0:22	1:26
Q	Magnetic brake: Foucault's currents (3:25)	SL	3:25	
R	Magic diver (4:55)	HL	4:55	
S	Liquid pressure (3:02)	HL	1:00	1:48
T	Electric motor (3:59)	SL	1:10	2:30
U	The case of the bent straw (5:27)	HL + SL	3:10	1:03
V	Light refraction (4:07)	SL	2:30	0:45

in the following examples: (i) L presents the experiment after explaining the theory to discuss the results; (ii) U builds up a relationship between the experimental activity and its daily application; (iii) Q associates the activity to a problem situation. Another piece of evidence of this flexible structure is observed in four videos where the conclusions are discussed along with the performance of the experiment itself: E, F, M and N.

It is worth noting that resources related to the aesthetic and cultural dimensions (music, dramatization, picture/image, animation, etc) enrich the videos and are spontaneously used in an audiovisual report, indicating that the students regard them as necessary to better express themselves. This can be understood because audiovisual resources are deeply rooted in students as a cultural tool rather than as a teaching strategy, even when videos are produced as a physics laboratory task. It can be pointed out, as a positive aspect, that some videos exhibit elements of humour, an emotion that is rarely shown in relation to physics, seen by many students as the 'bogeyman'. Table 2 highlights these trends.

Most of the videos produced illustrate correlations between the physical quantities involved in the phenomena: B, D, E, F, G, I, K, L and N.

Table 2. Frequency (N) of resources used.

Resource	N
Music	14
Dramatization	3
Commentary	19
Caption/text	19
Initial and/or final credits	22
Picture/photo/image	15
Animation/simulation/movies	5
Editing effects	20

Video N presents an important feature of the magnetic induction phenomenon: the effect on the ammeter of the speed of a magnet when introduced in a coil is studied, but there is no date registered, just the motion of the needle is shown as evidence.

Video D makes a formal study of Ohm's law, showing tables and a graphical representation of the data gathered experimentally: current versus voltage for two different circuit components, a resistor and a lamp. The analysis allows the students to conclude from experimental evidence that the electrical resistance is dependent on temperature.

Correlations without explicit values of physical quantities involved are made in videos I and L—both dealing with the same system, an electromagnetic motor. These videos control physical quantities—radius, number of turns and tension applied—that modify the magnetic field generated in a wire loop and correlate them with the speed of rotation of the coil (motor shaft). The measurement of the wire loop speed is mentioned verbally instead of obtaining it from the frame to frame frequency of the video.

Archimedes' principle is the issue of video G which depicts the control of physical quantities and their correlations, discussing relevant and irrelevant physical quantities. In this video, students make use of the same experimental design in three different situations: a metal body attached to a dynamometer that measures its weight when suspended in air (reading 1) and its apparent weight when fully immersed in a liquid (reading 2). The determination of buoyancy, the difference between readings, is correlated with the density of the liquid and the volume of the immersed body (relevant quantities) and also the density of the body (irrelevant quantity).

Some videos, A, H, J and M, mix up description and explanation, as well as not making correlations between physical quantities relevant to the phenomena.

Table 3 provides the links to some of the videos produced in this project.

Table 3. Audiovisual reports on Youtube.

Video	Youtube link
B	youtube.com/watch?v=Z0jH0THNZAg
C	youtube.com/watch?v=3bxbKozNvA0
D	youtube.com/watch?v=NSKg23gM41s
E	youtube.com/watch?v=4GIvQK4cdgI
G	youtube.com/watch?v=LJmhDuDtGHQ
Q	youtube.com/watch?v=SUuqvPK2fHs
N	youtube.com/watch?v=8usBJnCZW9s
S	youtube.com/watch?v=4cygKYplrl4
T	youtube.com/watch?v=6uMMMJldxBE

Conclusions

One of the advantages of this strategy compared to the traditional laboratory is the responsibility assumed by the students. This is because making the video, which will be watched by others, requires the students' intellectual engagement through research on the subject, comprehension of key concepts and creation of an appropriate experimental situation, which will be tested, modified and checked as many times as necessary.

This feature reflects the operational necessity to deal with phenomena expressed visually that differentiates the video production labwork from the experimental activities conducted in a laboratory that, in general, it is an ordered process required by the programmed report carried out with a very low level of recursion. The technique draws in skills such as handling equipment, gathering, recording and analysing data, all of which lead to a concrete product—the audiovisual report.

The audiovisual report shows intrinsic characteristics which do not exactly match with the components of the typical written report (theory, objectives, equipment, etc), either due to the production process or because of the students' expression in audiovisual language. This fact is evidenced by the free-form chosen by the students to structure the physical phenomena, making free use of resources, not requested in the guidelines, which characterize the audiovisual format (narration, caption, animation, images, etc) to explain concepts, laws and/or physical principles while developing and manipulating the experiment.

Another advantage of the audiovisual over the written report is the fact that it does not require sequenced guidelines. In such a way it can be expected that this type of project may enhance imagination and creativity as well as having implicit cognitive aspects.

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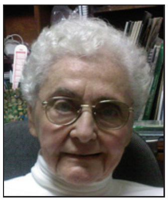

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