Video Analysis to Scaffold Collaborative Inquiry Learning

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Abstract

The current world is characterized by the complexity of the problems that people have to face, which is why people must have a series of skills that allow them to solve them. Therefore, the purpose of the present study is to evaluate how video analysis can help students in acquiring skills related to the scientific inquiry process while working collaboratively. In this case, 61 students enrolled in Theoretical Physics university course, out of who 23 belonged to the control group, and 38 to the experimental group. In this way, the students of the experimental group had to work as a team to solve a problem following the phases of the scientific inquiry, while the control group followed a traditional approach. Also, during the process, the experimental group received the support of teacher assistants, especially in data collection and processing phases where Tracker software was used to analyze the videos of the experiment. To evaluate students' learning level of scientific skills, a test was applied before and after the intervention, where an experiment was proposed. One of the most outstanding results obtained is that, in the post-test, the experimental group showed some advance in the learning of scientific skills, whereas the control group hardly showed any advance. This might suggest that the traditional approach in Physics theoretical courses excludes the scientific inquiry process, which makes it difficult for students to be able to solve problems related to real contexts.

Keywords**:** *Physics Education, Scaffolding, Science Process Skills, Collaborative Learning, Problem Solving;*

1. Introduction

In scientific education, the use of videos has revolved around the observation and analysis of different phenomena of nature in theoretical classes, however, today there are other uses that can be highlighted in Physics teaching. Such is the case of measuring through videos, which consists of recording a specific phenomenon or experiment, to be analyzed through software that allows making measurements in the video to obtain graphics or create physical models.
In this sense, the relevant question is: how the analysis of a video of a physical phenomenon can help students to acquire skills related to the data processing phase of scientific inquiry in a collaborative way?

2. Theoretical framework

To answer the above question, the research was based on three fundamental ideas. Which are: scaffolding, collaborative learning, and science process skills.

2.1 Scaffolding

The word Scaffolding was first used by [1] to define "the process that allows the child or the novice to solve a problem, to perform a task, or to achieve an objective, which would be far from their reach without any help". In Didactics, the scaffolding is a structure designed to support the student during the learning process, but it must be gradually dismantled until it disappears when the student can perform the desired task by himself.
Regarding this, [2] has identified three forms of scaffolding; the first, *one-to-one scaffolding,* corresponds to the direct interaction between the teacher and the student; the second, *peer scaffolding,* is characterized by the interaction between students; and finally, there are the aids provided by the computer, *computer/paper-based scaffolding*.

2.2 Collaborative learning

For [3] collaborative learning is any learning activity that includes the coordinated commitment of two or more students for the purpose of completing tasks that lead to meaningful learning. Therefore, it is

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important to train the teacher to promote reflection, dialogue, and dealing with possible conflicts that may arise while students learn to work as a team.
In addition, the teacher must provide students with tools that allow them to share with their peers the responsibility of an active participation in the raised tasks, as well as to respect the individual contributions by promoting an effective dialogical interaction. One way to do this could be by designing class activities in which they learn how to work as a team while solving contextualized problems.

2.3 Science process skills

According to [4], science process skills are indispensable tools for scientists to generate the necessary knowledge to solve problems. Therefore, the more inquiry process skills scientists acquire, the more significant their contribution will be, both in their discipline and throughout society.
To that extent, the inquiry process needs to be organized in such way that it establish the tasks inherent to each inquiry phase, and thus, the necessary skills to tackle each task successfully. This is how the following phases of the inquiry process arise: Problem statement, experiment design, data collection, data processing, drawing conclusions, and research dissemination.
In this study, the tasks related to the data processing phase consist of: performing the mathematical calculations related to the theoretical model, underlying the experiment along with their respective error propagation, as well as creating the graphs necessary to observe the possible relationships between variables.
In this way, a classification was done based on the one carried out by [5] in which scientific skills are categorized according to the level of complexity of the cognitive processes necessary to develop the tasks of the inquiry process. Specifically, Figure 1 displays those that are related to the data processing phase.

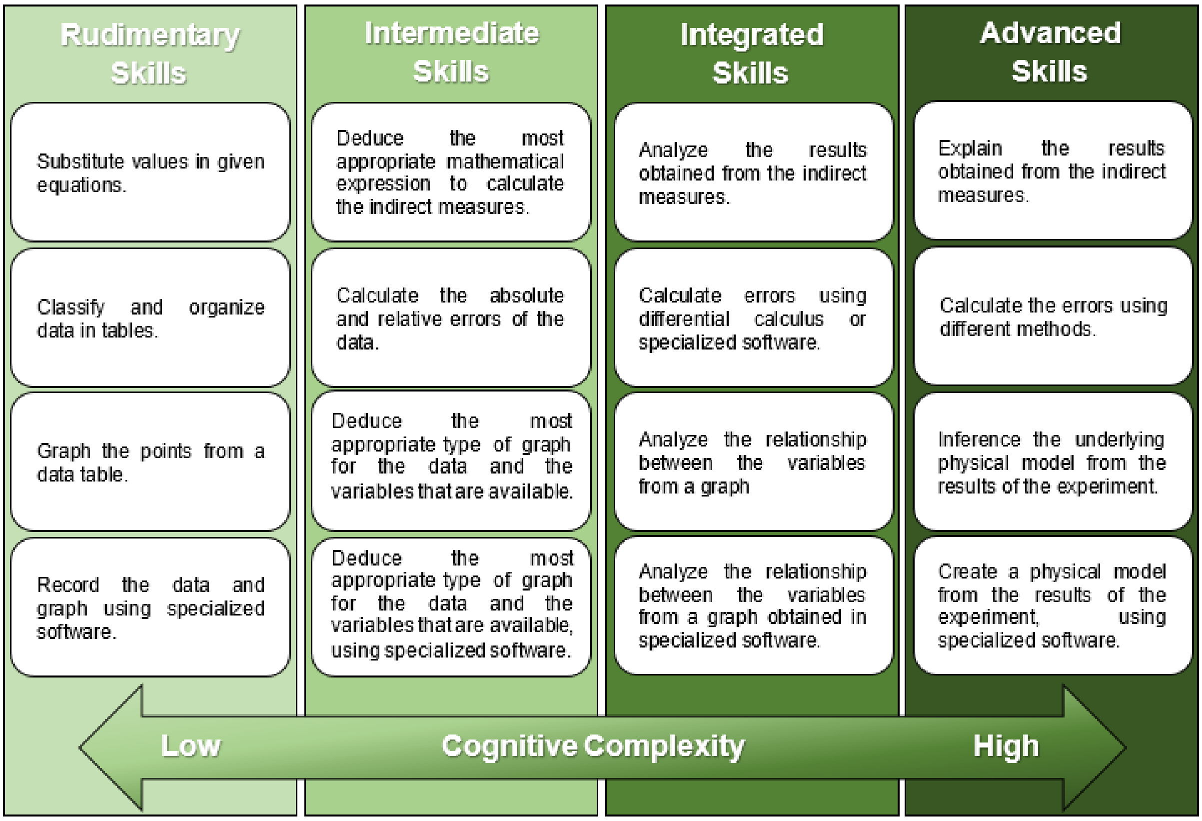

Fig. 1. Classification of science process skills related to the data processing phase, according to the degree of cognitive complexity. Adapted from [5].

3. Methodology

The present investigation was carried out under a quasi-experimental design, following a procedure divided into three phases: pre-test, intervention, and post-test. As for the participants, there was a control group (23 students) and an experimental group (38 students), both formed by students who belonged to the area of Industrial Technology and enrolled in the subject Physics I at university level.
Hence, the students of the experimental group had to work as a team (*peer scaffolding*) to solve a problem following the phases of scientific inquiry, whereas the control group followed a traditional approach. Likewise, the experimental group received the support of teacher assistants, especially during the data collection and processing phases, when *Tracker* software was used to analyze the videos of the experiment *(computer-based scaffolding*). This program was chosen because it had free access and it is easy to use, so no additional time learning how to use it was necessary.
On the other hand, to evaluate students' learning level of scientific skills, a designed test was applied before (pre-test) and after (post-test) the intervention, which consisted of 10 open questions corresponding to the phases of scientific inquiry. Specifically, this questionnaire presented a problem describing a laboratory experiment accompanied by the data collected in it.

4. Results

First of all, we present a description of the activities carried out during the intervention, and then, the results of the test applied before and after the intervention. It should be noted that for the purposes of this study only the results of the questions related to the data processing phase were taken into account.

4.1 Intervention

The students carried out a team project with the purpose of looking for the angle with which the maximum horizontal distance is reached, due to which they would have to follow the phases of the scientific inquiry to find it – problem statement, experiment design, data collection, data processing, drawing conclusions, and the research dissemination. It should be noted that all the phases were carried out within the class hours, in sessions called *tutoring*.
In this way, while laying out the problem statement, the students discussed about the concepts related to the problem posed by the teacher, which finished with the formulation of a hypothesis.
In the experiment design phase, they planned an experiment that would allow launching a projectile with different angles, which could also be recorded on video. It should be noted that although most teams had different setups, all of them had to follow the same parameters for the data collection meaning that everyone had to make at least three launches for each angle, for at least five angles, and for two different masses.
In the data collection phase, all the launchings were recorded on video so that the teams could use the best video to make more precise measurements using *Tracker,* the software for video analysis (Figure 2).

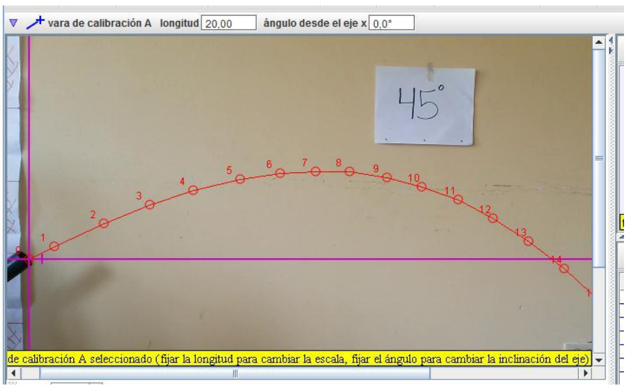

Fig. 2. Example of the measurements taken by one of the teams.

In the data processing phase, the students had to make a graph to analyze how the independent and dependent variables were related. In this case, it was expected that the students could make a graph that related the launching angle with the distance reached by the projectile as shown in Figure 3.

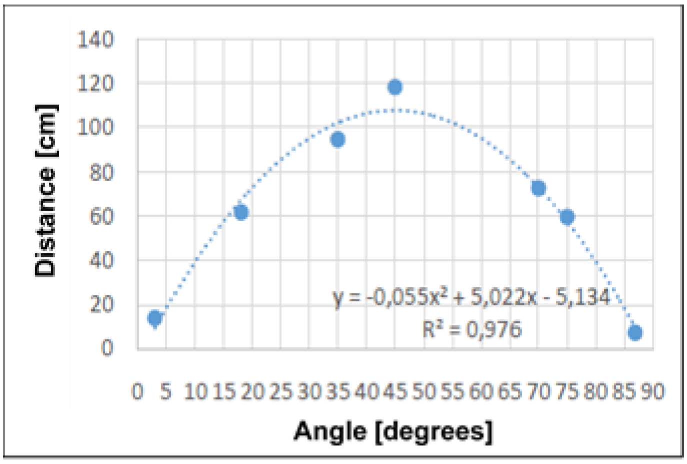

Fig. 3. Example of a graph made by one of the teams.

Subsequently, when drawing the conclusions, the students met to discuss the obtained data and evaluate whether the initial hypothesis was met. Finally, in the research dissemination phase, the students had to do a presentation to the whole class and deliver a written report in article format about the project that they carried out.

4.2 Pre-test and post-test

In order to analyze the influence of the use of the video analysis program in the acquisition of science process skills, the results of the test applied before and after the intervention to both groups are presented below (Figure 4), in particular, with regard to the results of the data processing phase.

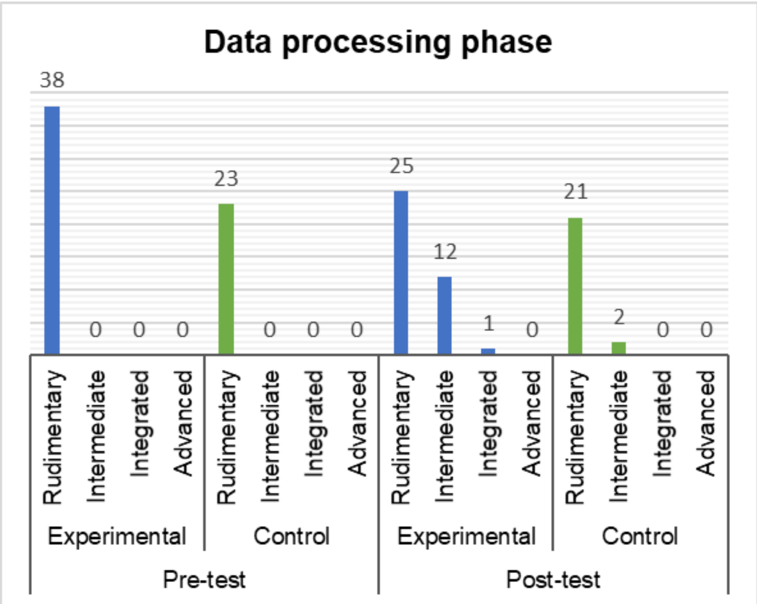

Fig. 4. Students' learning level of science process skills in the data processing phase, before and after the intervention.

5. Discussion

The results of the data processing phase revealed that, in the pre-test, all students showed a great lack of knowledge in this area. This coincides with [6] who states that, in general, students are not familiar with the forms of data representation and find it difficult to interpret graphs. However, in the post-test, it was observed that almost a third of the students in the experimental group mentioned the creation of graphs or the use of video analysis software, as valid tools for data processing, which allows us to affirm that the realization of a project supported by the use of technology had some influence on the students.

6. Conclusions

From the pre-test results of both groups, it can be observed that the students arrive to university with very little experience in the scientific inquiry process. This may be caused by the little or total absence of resources in Physics laboratories in many secondary schools, which makes teachers lose interest in conducting experiments.

However, the post-test results suggest that this situation could be solved by providing teacher training in the design and implementation of projects with low-cost materials and where technological tools such as video analysis software are incorporated.

On the other hand, the control group results show the little attention that is traditionally given to the process of scientific inquiry in Physics theory classes. As a result, students passing this subject may have the ability to perform a variety of textbook problems with some mastery, but they don’t necessarily have the ability to solve problems closer to everyday life.

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