https://doi.org/10.36315/2023v2end072
Education and New Developments 2023

INTERACTIVE TEACHING OF PHYSICS BY VIDEO ANALYSIS METHODS

Peter Hockicko
Department of Physics, Faculty of Electrical Engineering and Information Technology, University of Zilina (Slovakia)

Abstract

Teaching physics during the pandemic did not allow full-time teaching and became challenging for both students and teachers. The inability to perform real experiments was complicated by the building of new students’ knowledge and the development of their abstract thinking.
Video analysis is a possible substitute for experiments - analysis of real physical events recorded in the form of videos using the program Tracker. In the lectures, we applied an interactive form of teaching - video analysis - analysis of real physics experiments recorded in the form of video in the experimental group. Lectures and presentations using videos of real demonstrations combined with video analysis using the interactive program Tracker and active discussion of students were carried out using the Peer Instruction method.
The following article describes the teaching of physics using the video analysis method and finally offers an assessment of the students applying the Peer Instruction method.

Keywords: *Interactive teaching, video analysis, e-learning, STEM education, PI method.*

1. Introduction

As mentioned in previous works, elementary school students' basic skills in physics (but also in mathematics) have decreased dramatically in recent decades (Pinxten et al., 2017). Physics is often considered a difficult subject because the fundamental laws are expressed in the language of mathematics. Teachers are constantly trying to make pupils better understand and comprehend various phenomena and basic laws. One of the creative methods of teaching physics that makes science more interesting for students is video analysis (VAS method) using the program Tracker (Hockicko et al., 2014, 2015). Group projects based on digital video analysis are a motivational, educational, and cost- and time-effective alternative to traditional activities associated with a basic physics course (Laws et al., 1998).

Traditional lectures have been shown to help acquire only basic knowledge without deeper understanding and problem-solving skills. The traditional teaching of Newtonian mechanics in the first years of undergraduate studies only slightly eliminates the misconceptions students acquired during their high school studies. Students do not demonstrate the conceptual understanding of the subject matter that should result from sufficient quantitative problem solving and logical lectures (Redish, 2002).

Many video-based tasks are suitable for demonstrating simple mathematical analysis, and the use of integrals and derivations in physics. The use of video-analysis-based problems in physics can significantly impact the knowledge gap compared to students solving traditional problems from a printed textbook (Hockicko et al., 2015).

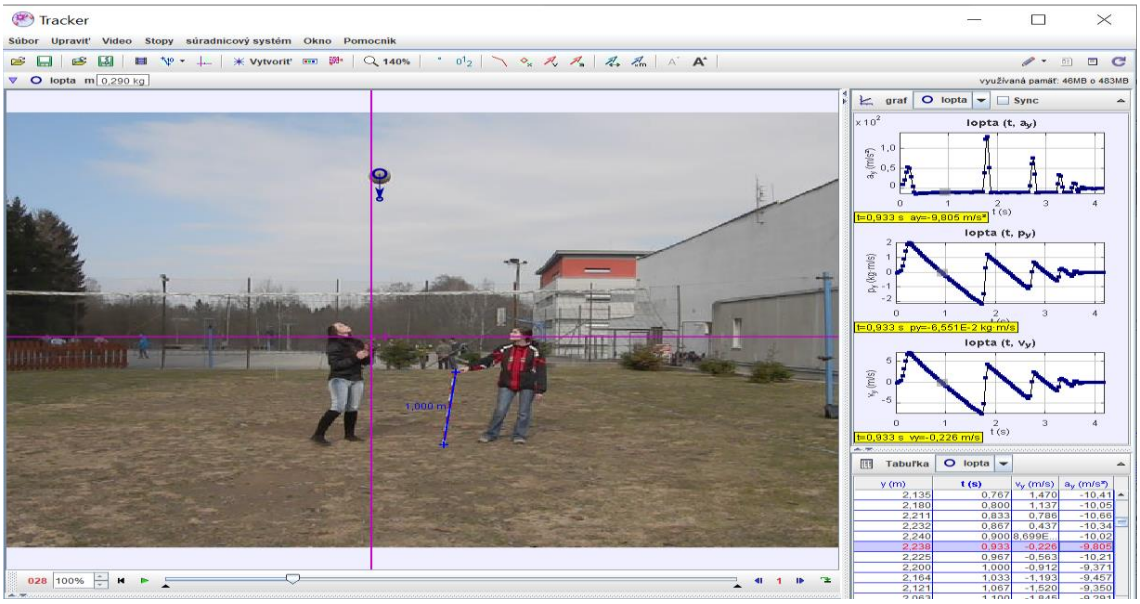
2. Video analysis of motions by program tracker

The Tracker is a free, open-source program (https://physlets.org/tracker/), that can be installed on a USB stick and runs directly from the USB stick. Working with this program is intuitive, the program includes help in several languages. Students can work with the program by inserting a video into the program, performing a subsequent calibration, and capturing the position of the moving object (either automatically after marking the moving object or manually).

The student’s task is to describe the event from a physical point of view - to perform a mathematical analysis of the dependencies obtained (the program offers 24 predefined time dependencies, other dependencies can be defined and not only time dependencies can be investigated, as the program also allows to change a predefined physical quantity). The subsequent analysis should describe the motion in the *x*, and *y*-axis direction, and determine the initial velocity in the *x*, and *y*-axis. From the analysis of the velocity in the given directions, we can determine the instantaneous and average acceleration (examples from kinematics).

Figure 1 shows the analysis of the movement of the throwing ball in the program Tracker. The student's task is to analyze the force(s) acting on the ball.

Figure 1. Video analysis of motion – the movement of throwing the ball.



3. Video analysis versus traditional teaching

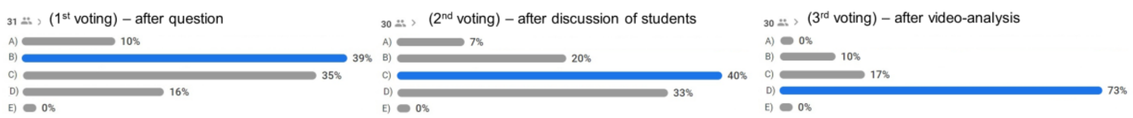
The use of video-analysis-based problems in physics significantly improves the understanding of basic laws and knowledge acquisition compared to students who solved traditional problems from a printed textbook. Video analysis and simulation (VAS method) of problem problems using the interactive Tracker program is one of the methods that significantly helps to form conceptual thinking while eliminating misconceptions, developing students' manual skills and intellectual abilities, and increasing students' knowledge (Hockicko et al., 2020). These results have been found and confirmed by using pre- and post-FCI (Force Concept Inventory) tests (Hestenes et al., 1992).

4. Using the PI method and discussion with students

The Peer Instruction (PI) method was used to motivate the students (Crouch et al., 2007): Each conceptual question during lectures has the following format (under PI):

1. A question is posed
2. Students are given time to think
3. Students record individual answers (1st voting)
4. Students discuss their answers
5. Students record revised answers (2nd voting)
6. Feedback to teacher: Tally of answers
7. Explanation of correct and incorrect answers using methods of video analysis (3rd voting)

Figure 2. Development and evaluation of students' answers to question 13 of the FCI test.



The student vote was organized using the Slido platform: https://www.sli.do/. It should be pointed out that the teacher never told the students which answer was correct. The students had to find the correct answer themselves. During the lectures, only 2/3 of the students present actively participated in the voting.

4.1. Evaluation of the students themselves

After the exam, students had the opportunity to comment on the course of the semester, from their answers we selected some of them:

- I liked the lectures, a lot of things were from everyday life, I got a different perspective, it was experiential,
- I understood a lot of things thanks to the analyses in Tracker, it was more vivid, I liked the applied physics,
- the demonstrations helped me, I understood a lot, it was good because I didn't have much physics in high school,
- it was more interesting than theory, an interactive form of explanation, I liked the physics, it was the connection between theory and practice,
- I had a difficult beginning in physics, but this form helped me - not only the explanation but also the video, it was clearer,
- interesting way of learning, it made online learning come alive, it was lively and interactive, and many people engaged in discussions and were forced to think, I liked the link with practice - I learn when I see something,
- finally, it was proper physics from practical life,
- I slept through some of the online lectures, but not yours, I didn't.

5. Conclusions

Watching real physics videos, active student discussion with the application of the PI method, and subsequent video analysis of physics problems had a positive impact on the growth of knowledge and improvement of the concept of Newtonian mechanics at the end of the semester. This fact has also been declared in our previous studies as well as in studies by other authors (Tarjanyiova et al., 2022).

Acknowledgements

This work was supported by the Slovak grant agency KEGA through project no. 023ŽU-4/2021.

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