



Reconstructing the Ideas of Students of Pedagogical Departments Regarding the Concept of Speed and Rectilinear Smooth Motion

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Abstract. In this extended abstract, we propose an educational scenario for teaching the concept of speed and rectilinear smooth motion to students of pedagogical departments by using Inquiry based model. Initially, in the phase of introductory stimulus and hypothesis formulation, the aim is to record students' alternative ideas on the concept of speed and rectilinear smooth motion. In the second stage, of the experimental treatment, students use their mobile devices to record the rectilinear movement of a train on rails with the Video Physics application. Students record their observations on the worksheet, analyze their results and draw conclusions. Finally, at the stage of Consolidation and Generalization, the aim is to record the degree of understanding of the concepts of speed and rectilinear smooth movement by students. The students' answers are collected and processed and conclusions are drawn about the outcome of the implementation of the specific teaching scenario.

Keywords: Inquiry Based Learning, Kinetics, Speed, Teaching Scenario.

1 Introduction

The interdependence of the concepts of speed, displacement and time as well as their understanding by students has concerned many researchers [1-3]. Students find it difficult to connect the concepts of speed, displacement and time interval due to the fact that factors such as their language development and a set of algebraic rules are needed. For example, the use of multiplication is easier than division, therefore the relation of distance develops faster than the relations of speed and time. Furthermore, the explanations offered by students about natural phenomena depend on their experiences, on how simple, understandable and adequate are the explanations provided by others (parents, friends, teachers, etc.) and their previous knowledge. Sometimes the interpretation of phenomena is based on common sense (imperfect reasoning that usually does not lead to generalizations). Also, the information they receive from the physical world through the senses is limited and sometimes everyday language can be the reason for creating misconceptions in students. DiSessa [4] cites some misconceptions students have about body characteristics and speed. According to them, lighter objects move faster as well as smaller objects move faster. The results of Métioui & Baulu-MacWillie [5] agree with the first conclusion. Regarding the latter, however, when the children compared two identical cars of different sizes, most children argued that the one with the larger size will move faster because it has either a larger fuel tank, larger wheels or a larger engine. The perceptions of 400 French-speaking 5th and 6th grade students from Canada, France and Morocco on the concept of speed were divided into 4 categories: speed is related to "speed" and acceleration (Canada, 53%, Morocco, 73%, France, 51%), speed is related to vehicle characteristics (Canada, 5%, Morocco, 0%, France, 7%), speed is related to accidents, gain in road races or time (Canada, 17%, Morocco, 15%, France, 7%), no answer or incomplete answer (Canada, 25%, Morocco, 22%, France, 35%). The results of a survey of 120 6th grade students of Rhodes in exactly the same question showed that most students (50%) defined speed based on "fast" agreeing with the result of the survey by Métioui & Baulu-MacWillie [5], while interestingly 23.33% of students' defined speed based on the dipole "fast / slow". Alternative learning methods may facilitate a more effective understanding of such concepts by students. Research has revealed that the use of educational technology in educational laboratories has yielded positive results [6, 7]. On the other hand, some studies report that the use of educational technology does not significantly affect the understanding of concepts [8, 9].

Nevertheless, the combination of laboratory activities with inquiry-based learning has been shown to enhance the understanding of scientific concepts [10, 11]. This work studies the effectiveness of Inquiry based learning in teaching the concepts of speed and rectilinear smooth motion using both interactive activities and digital tools such as, automated object tracking applications, videos, simulations and digital games. Based on the above, this work includes a teaching scenario which is addressed to students of the Department of Education and aims to record and reconstruct their alternative ideas regarding the concept of speed in rectilinear smooth motion.

2 Teaching Scenario

This teaching scenario is proposed to take place in one (1) teaching hour and is addressed to second-year students of Pedagogical Departments in the context of the course Laboratory Exercises of the Compulsory Course "Basic Concepts of Physics" of the 4th semester. For the implementation of the activities, students are divided into groups of 4 people and will need computers and mobile devices. After completing the teaching scenario, students should be able to understand the rectilinear smooth motion of bodies, to experimentally establish the displacement-time relationship of a mobile body, to understand the concept of velocity, that it is kept constant in rectilinear smooth motion as well as its vector character and to understand the analysis of position-time ($x-t$) and velocity-time ($u-t$) graphs. This teaching scenario has been implemented by using Inquiry based model and consists of the following stages: the introductory stimulus – formulation of hypotheses, the Experimental treatment – Conclusion extraction and the Consolidation – Generalization. At all stages of the teaching scenario, students record their observations and conclusions in the corresponding worksheets.

2.1 Phase 1: Student Orientation – Motivation – Hypothesis Formulation (Duration 10 minutes)

Students first carefully observe some pictures given to them in the 1st worksheet as well as a video with the movement of a bubble (Fig. 1) at the following link: <https://www.youtube.com/watch?v=29gfgxg2sUys>. With all the above they will reflect and formulate various hypotheses about the speed and movement of bodies. Then they answer questions in the 1st worksheet in order to find out their ideas regarding the concept of speed in rectilinear smooth motion.



Fig. 1. Screenshot of the movement of the bubble.

2.2 Phase 2: Experimental Treatment / Observations (Duration 30 minutes)

In the Second Phase of the Teaching Scenario, students are initially introduced through a discussion about the rectilinear smooth movement of bodies as well as about the concept of speed and its relation to time and distance. The 1st Activity of the 2nd Worksheet includes a simulation in which rectilinear smooth motion can be studied and which can be found at the following link: https://www.seilias.gr/index.php?option=com_content&task=view&id=547&Itemid=32. After familiarizing students with the simulation environment, as is shown in Fig. 2, questions follow concerning the calculation of the speed of the motorbike in various positions on the tape measure. The aim is to find out how the speed of a

body can be calculated through the relationship of position and time with the corresponding units of measurement. In addition, the aim is to understand the proportional relationship between position and time through diagrams as well as the dependence they have on each other, while no matter how much they change, the speed remains constant.

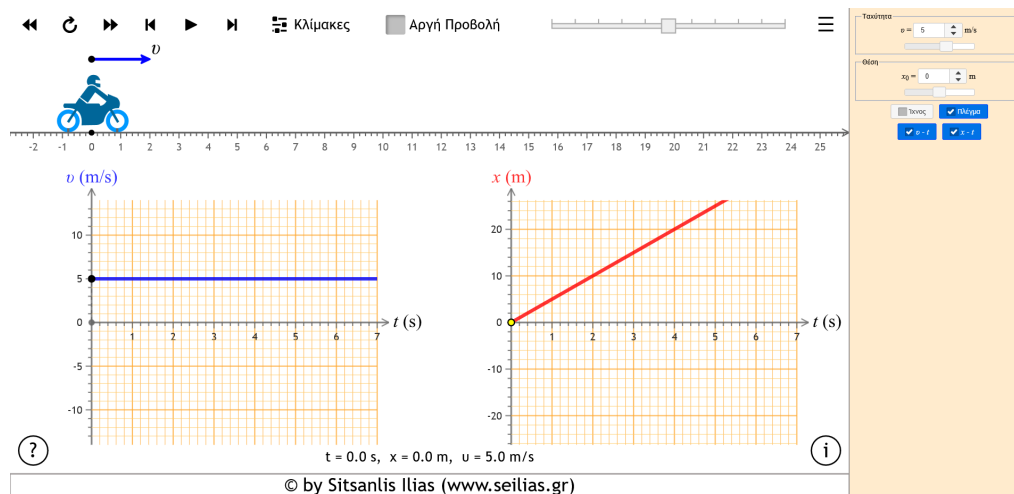


Fig. 2. The simulation environment.

Then follows the 2nd Activity which includes Simulation of Rectilinear smooth movement using a children's train running on straight track rails (Fig.3). The Video Physics application is used to carry out the 2nd activity. Video physics is an application that brings automated object tracking and video analysis to mobile devices and instantly generates trajectory, position and speed graphs for the object. Initially, the students place the train tracks on the lab bench to form a straight line, as shown in Fig. 3. Then they touch the train to the starting position and for better recording of the position they place a sticker on the train and form a bright red dot. Then they open the application and press at the top the (+) plus sign which when pressed comes out the option "Take Video". Once the train starts, they press on the screen the start of the video recording and are careful not to move the mobile device during recording. They also make sure the train moves to the left.



Fig. 3. The train at the start of the videography.

After recording the movement of the train and creating the position-time graph, it is requested by the students to observe the graph and based on it to calculate the speed at which the train moves on the rails. Fig. 4 shows the x-t graph where the position appears to have negative values as the body moves left. The aim is to understand how the position of the body changes in relation to time, how the speed is calculated through the graph and to understand its vector character as the slope of the line arises negative.

2.3 Phase 3: Consolidation - Generalization (Duration 10 minutes)

After conducting the experiments through simulations with the motorbike and the train, the students using their mobile devices answer online, using the Quizziz application, 5 consolidation / generalization questions, following the following link: <https://quizizz.com/admin/quiz/66e94d14bd81f31810654496?at=64009c5824ffb0001d9fd345> Through the quiz, students answer pleasantly the questions that appear to them by earning points. The aim is to consolidate and generalize what they learned and observed from the initial stimuli, images, videos and simulations.

The multiple-choice questions summarize what was said about the movement of bodies, constant velocity as well as analysis of speed – time and position – time diagrams. The aim is not to consolidate what they have learned, but to understand and apply it in their daily lives.

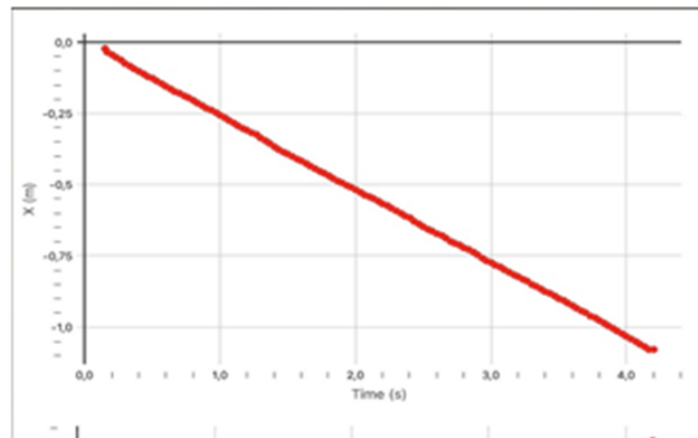


Fig. 4. Screenshot of the x-t graph of the Video Physics application.

3 Teaching Scenario Application-Results

This educational scenario was applied to 2nd year students of the Department of Education Sciences and Social Work of the University of Patras. The sample consisted of seventy (70) students. The completion of this scenario required one (1) teaching hour at the laboratory of the Compulsory Course "Basic Concepts of Physics". They distributed to the students the Worksheets which they completed. They were then analyzed and gave the following results: In the first Phase of the teaching scenario in the 1st Worksheet and specifically in the question: "Cars A and B are in the same position. Do you think they have the same speed?" is observed from Fig. 5, where a large percentage of students (90%) answered that they do not have the same speed while 10% believe that they have the same speed. The purpose of this question was to determine whether students can distinguish and identify the vector character of velocity. That is, to focus on the fact that velocity is a vector quantity that depends also on the direction of the mobile body. It was observed that, although a large percentage of students answered that cars do not have the same speed, they focused on other elements to justify their answer by citing unnecessary information from observing the images. From this question, we conclude that the students did not dwell on the fact that velocity is a vector quantity. After watching the video of the movement of the bubble, followed the true-false question "In rectilinear smooth motion, the mobile body travels at equal times at equal intervals". The students had to choose whether this sentence was right or wrong. It is observed from Fig. 6, that the largest percentage of students (90%) chose the correct answer. A small percentage (10%) answered incorrectly, suggesting that they do not understand how a body's position changes over time in rectilinear smooth motion and that speed remains constant.

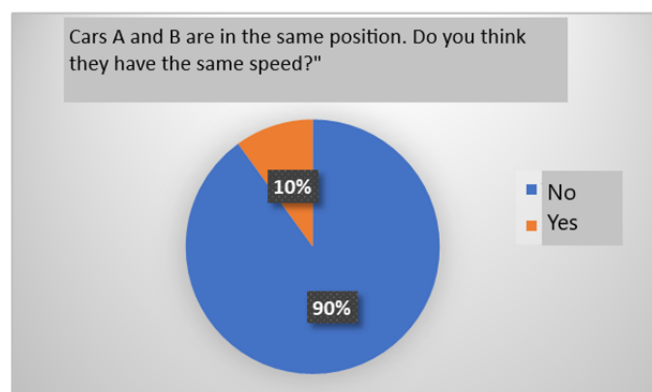


Fig. 5. Percentage of students answering the question "Cars A and B are in the same position. Do you think they have the same speed?" after observing a relevant picture.

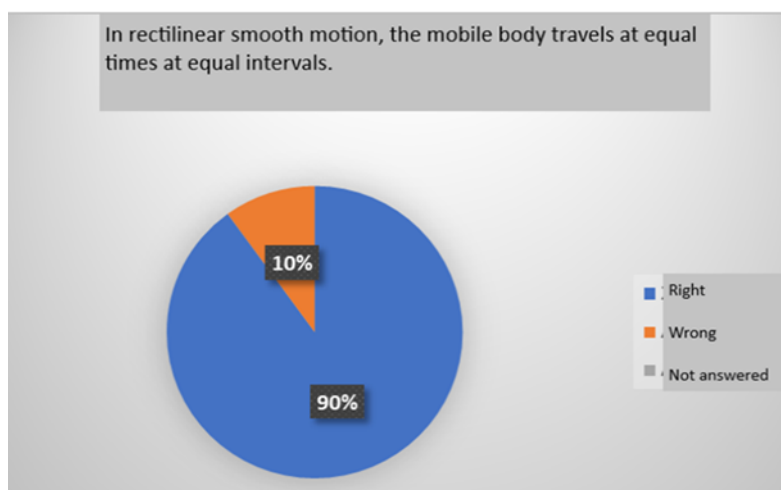


Fig. 6. Percentage of students answering if the sentence “In rectilinear smooth motion, the mobile body travels at equal times at equal intervals”, is right or wrong.

After the completion of the 1st Worksheet, the second phase of the teaching scenario begins, where students were initially explained the concept of speed, its role in rectilinear smooth motion as well as what quantities need to be known in order to be calculated. Then the 2nd Worksheet was distributed to the students with the two activities aimed at experimentally addressing the phenomenon of speed in rectilinear smooth motion. The 1st activity, which involved the use of simulation, went quite well with students observing and understanding both the concept of speed and the relationship of displacement and time interval sizes between them as well as the construction of speed-time and displacement-time diagrams. They recorded and calculated the speed in various positions where the motorbike was located and were asked to answer questions that puzzled them about the rectilinear smooth motion. The 2nd activity, which involved recording the movement of a train on a straight track using the Video Physics application, was carried out by the students using their mobile devices, as shown in Fig. 7. It is worth mentioning that because the difficulty of students in understanding the vector character of velocity was observed in the 1st Worksheet, it was chosen the train to move to the left. The aim was for the students to reflect and observe that the speed when calculated came out with a negative sign, thus understanding that it is a vector and therefore depends on direction of the train.



Fig. 7. Screenshot from the recording of the train movement with the help of the Video Physics application.

After the experimental treatment and the completion of the 2nd Worksheet, the 3rd phase of the teaching scenario followed, which concerns the consolidation and generalization of the knowledge. This phase consisted of a quiz of 5 points questions in which students had to choose the correct answer based on what was said and understood throughout the workshop. Of the 5 questions, the following is indicatively mentioned: "When the speed of a body moving in a straight line is constant, the motion is called":

- A. rectilinear smooth.
- B. rectilinear smoothly accelerated at initial speed.
- C. rectilinear smoothly accelerated without initial speed.

D. rectilinear smoothly decelerated.

From Fig. 8 it is observed that the largest percentage of students (97%) understood the concept of speed in rectilinear smooth motion, marking an improvement after the realization of the 2nd Worksheet and the experimental procedure. Certainly, even before the 2nd phase we had a fairly good percentage that had answered correctly, but with this question we saw that the correct answers increased even more.

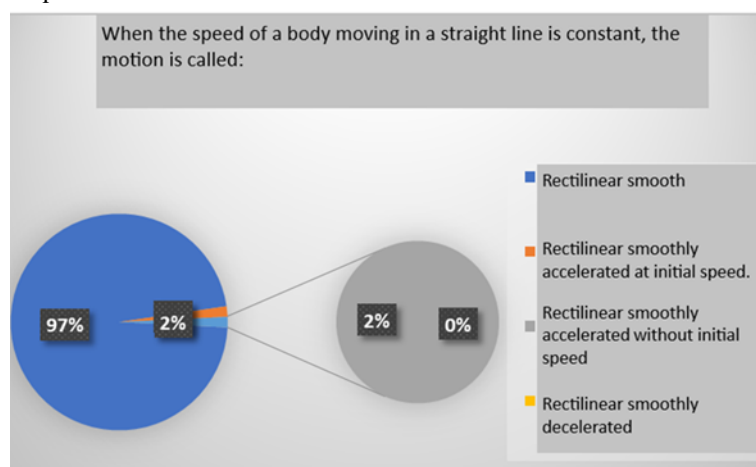


Fig. 8. Percentage of students answering the question: “When the speed of a body moving in a straight line is constant, the motion is called:”

In conclusion, after the implementation of the teaching scenario, students managed to understand the rectilinear smooth movement of bodies. They understood when they can characterize a movement as straight and smooth and through the experimental process, they found out the relationship between time and displacement. The difficulty of the students was identified in understanding the direction of the speed. They were also able to explain position-time graphs and use them in the study of rectilinear smooth motion. They gradually established that the slope of the line in the position-time graph helps to calculate the measure and direction of speed. Furthermore, we believe that this educational scenario could also be applied to high school students, where according to the curriculum they should be able to comprehend the rectilinear smooth motion before the introduction to the acceleration.

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