Title: Kinematics Model

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Highlights: One of the aims for Physics subject under the topic Force and Motion is to provide an understanding of movement. Students needs to learn about its application. An interview has been conducted among physics teachers and physics tutors and it was found that students have difficulties in understanding motion graphs. In order to solve this problem, Kinematics Model was developed to help students understanding and plotting the motion graph.

Key words: Teaching and Learning; Physics; Kinematics Graph

Introduction

Kinematics is one of the first topics taught in traditional high-school physics courses. In them, concepts such as position, velocity, and acceleration are commonly taught based on graphs since they offer a valuable alternative to verbal and algebraic descriptions, while also providing a clear way of representing relationships among variables (Arons, 1990; Ates & Truman, 2003). Among the many skills developed in the study of physics, the ability to draw and interpret graphs is one of the most important (McDermott, Rosenquist, & van Zee, 1987; McKenzie & Padilla, 1986). There are so many challenges related to teaching/learning kinematics as stated by past researches over the last three decades (Dyskra and Sweet 2009; Elby 2000; Halloun and Hestenes 1985). Students encounter conceptual difficulties in different stages of learning. For example, many students have difficulty when explaining the formal mathematical relationships of speed, distance, acceleration and time which is explained in how they interpret and explain these physical concepts represented by the graphical representations of distance versus time as well as speed versus time (Mcdermott et al. 1987).

Moreover, student's difficulties with graphing are not always related to inadequate mathematical knowledge (Mcdermottet al. 1987). Whenever the students are provided with representations that involve the movement of objects in the same form, they usually have difficulty to differentiate between speed and average speed. (Halloun and Hestenes 1985). (Brungardt and Zollman, 1995) explain the problem the students have with graphing and relate it to students understanding of vectors and how they are related to physical quantities.
In order to solve the problems, we come out with the idea to develop a cart with time-sensor pathway which will help a student to understand the kinematics graph quickly.

The student having a problem in plotting the kinematics graph which involved 2 variables which are time and distance travelled. By using the kinematics model, learners will easily plot the graph of distance vs. time. Learner will see and feel the motion of the cart, and from there, they will be more understand the pattern of the graph (with help of guidance). This is a time-tested method to identify every young student's creative abilities and encourage creative contributions. It will also encourage different teaching and learning techniques as well as the freedom to explore for both teacher and students.

Description of Product

This product will show the values of time and velocity of the object when touching each point. Each distance from one point to other point is 18cm. From there, student can use these values to plot the Kinematics Graph and they can calculate velocity for each point and compare the value of velocity from the product.

Innovation Background

Past studies have indicated that the understanding of kinematics among students depends on properties and misconceptions in some circumstances. Kinematics is a subdivision of classical mechanics and a branch of physics concerned with the geometrically possible motion of a body or system of bodies without consideration of the forces involved, which include causes and effects of the motions. Kinematics aims to provide a description of the spatial position of bodies or system of a material particles, the rate at which the particles are moving, and the rate at which their velocity is changing. When the causative forces are disregarded, motion descriptions are possible only for particles having constrained motion. There are some restrictions in research on student's understanding on kinematics problems related to spatial ability (Zavala, Tejeda, Barniol, & Beichner, 2017).

Understanding of kinematics concepts requires students to have a sufficient understanding of graphs of position, acceleration versus time in one dimension and velocity. Several researchers have shown students difficulties with understanding kinematics graphs. In 1994, Beichner comes up with the Test of Understanding of Graphs in Kinematics (TUG-K), the most widely used test to date which is designed to evaluate students understanding in this subject (Zavala et al., 2017). Student conceptions solely depends on practical experiences, which is usually not always being generalized to a scientific or theoretical setting. When students try to solve a complex problem, they often over-generalize a particular principle in order to solve the problem (Monk,1990; Hale, 1996).

There are so many challenges related to teaching/learning kinematics as stated by past researches over the last three decades (Dyskra and Sweet 2009; Elby 2000; Halloun and Hestenes 1985). Students encounter conceptual difficulties in different stages of learning. For example, many students have difficulty when explaining the formal mathematical relationships of speed, distance, acceleration and time which is explained in how they interpret and explain these physical concepts represented by the graphical representations of distance versus time as well as speed versus time (Mcdermott et al. 1987). Moreover, student's difficulties with graphing are not always related to inadequate mathematical knowledge (Mcdermottet al. 1987). Whenever the students are provided with representations that involve the movement of objects in the same form, they usually have difficulty to differentiate between speed and average speed. (Halloun and Hestenes 1985). Brungardt and Zollman (1995) explain the problem the students have with graphing and relate it to students understanding of vectors and how they are related to physical quantities.

Innovation Value

1. Students are engaged in learning when they are using the model.
2. Create positive emotional class environment.
3. Students can plot Kinematics Graph using value of time and distance that from the model.

Methodology and Findings

We conducted qualitative approach to find if the product has reached the objective of this innovation. To get the data, we conducted a demonstration and interview to the 3 physics secondary school teachers. The demonstration and interview were conducted at the Universiti Teknologi Malaysia. Firstly, we explained the purpose and objective of our innovation which is to help students to learn Kinematics Graph. Before we developing the product, we had an interview to the same teachers regarding the problems in teaching and learning of Physics subject. Two of the teachers had mentioned that the students have difficulties in understanding and making the Kinematics Graph. After explain the purpose and objective of this innovation, we conducted a demonstration to all three teachers on how to use the product. They tried the product and give positive feedback about the product. Below is the feedback by the three teachers:
Teacher 1: This product is very innovative. It can be used to replace the ticker-tape experiment in the school.
Teacher 2: This product also can be used during Form 5. This is because in Form 5 syllabus, we have topic electronic. For this product, I saw resistor and also microcontroller. It can motivate the students to use the knowledge of electronic to innovate something new. I can used it to show the students the real component of electronic by using this product.
Teacher 3: I never imagine that you come out with this idea. I am sure this product is good for students learning on plotting the graph. The students can get the data from here, and they can use the data for plotting the graph. It would be interactive for the in-learning Kinematics Graph.

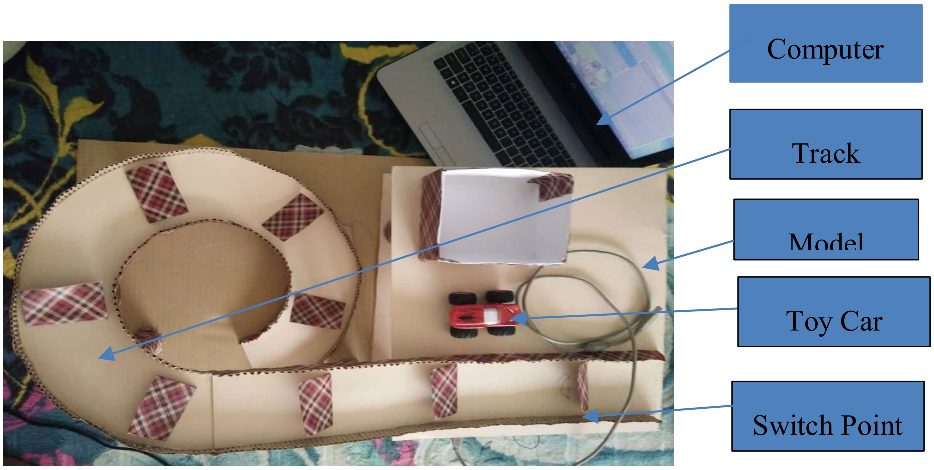

Figure 1: Kinematics Model

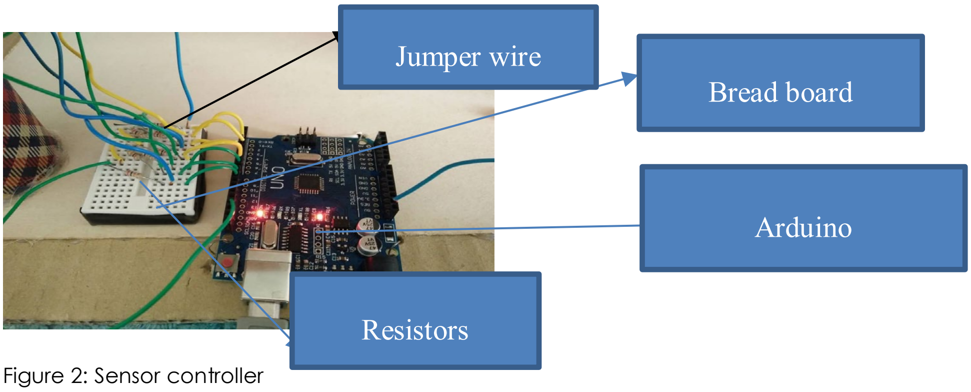

Figure 2: Sensor controller

References

Brungardt JB, Zollman D (1995). Influence of interactive videodiscinstruction using simultaneous-time analysis on kinematicsgraphing skills of high school physics students. J Res Sci Teach 32(8):855–869. doi:10.1002/tea.3660320808

Dyskra DI Jr, Sweet DR (2009) Conceptual development about motion and force in elementary and middle school students. Am J Phys 77(5):468–476. doi:10.1119/1.3090824

Elby A (2000) What students learning of representations tells us aboutconstructivism. J Math Behav 19:481–502. doi:10.1016/s0732-3123(01)00054-2

Halloun IA, Hestenes D (1985) The initial knowledge state of collegephysics students. Am J Phys 53(11):1043–1055. doi:10.1119/1.14030

Hale, P. L. (1996). Building Conceptions and Repairing Misconceptions in Student Understanding of Kinematic Graphs Based Laboratories. Ph.D. Thesis. https://doi.org/10.1038/nclimate2554

Mcdermott LC, Rosenquist ML, Vanzee EH (1987) Student difficultiesin connecting graphs and physics: examples from kinematics. Am J Phys 55(6):503–513. doi:10.1119/1.15104

Monk, S. (1990). Students' understanding of a function given by a physical model. In proc. Purdue University conference on the learning and teaching of the concept of function, 1990.

NRC (2011) Simulations and games in the classroom. NationalAcadamies Press, Washington D.C.

Zavala, G., Tejeda, S., Barniol, P., & Beichner, R. J. (2017). Modifying the test of understanding graphs in kinematics. Physical Review Physics Education Research, 13(020111), 1–16. https://doi.org/10.1103/PhysRevPhysEducRes.13.020111