Applying electromagnetism for enhancing Thai high-school students' understanding in force and motion

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Abstract

The In this study, we present the sets of demonstration that we developed and used in a physics class for Thai high-school students. The demonstration sets comprise two main parts: (1) simple motion demonstration (2) complicated motion demonstration. In the second part, tools that required knowledge in electromagnetism were used for teaching non-uniform forces. We brought a magnet and a solenoid to create and show forces between them. We carry out the demonstrations with microcomputer-based laboratory (MBL) measurements. The results could be immediately displayed on the screen in front of the class using an LCD projector. This teaching method is called the interactive lecture demonstration (ILD) and is aimed to engage students to learn as well as to help them integrate their knowledge to new situations. The demonstration sets were planned to use with high-school students who have already learned basic topics on force and motions.

Introduction

The environment of physics instruction has two main types that are a traditional instructor-centered environment and an active-engagement student-centered environment (Redish, 2003). The traditional physics instruction consists of lecture, recitation and laboratory that the students are passive while the teacher is active during the class. One of step toward improving the traditional instruction is to modify the lecture to create a more interactive environment (Knight, 2003; Steinburg, 2001). Many researchers offered methods for increasing students' engagement in lecture such as Peer Instruction, Just-in-Time Teaching, Physics by Inquiry and Interactive Lecture demonstrations (Mazur, 1997; McDermott, 1995; Novak, 1999; Thornton & Sokoloff, 1998).

In this study, we focused to engage students' learning in Newton's laws of motion by using Interactive Lecture demonstration or called ILDs approach. This approach used computer-assisted data acquisition to quickly collect and display data. One of the advantages of real-time microcomputer-based laboratory (MBL) tools is that students can compare the differences between their observations and their beliefs in real situations (Thornton, 1990).

Purpose of study

1. To enhance students' understanding in Newton's laws conceptions.
2. To develop the demonstrations sets for teaching in interactive lecture demonstrations approach.

Methodology

Participants

In 2007, 71 tenth-grade high school students who had learnt mechanics before they learned with ILDs approach.

Tools

The data acquisition and the sensors

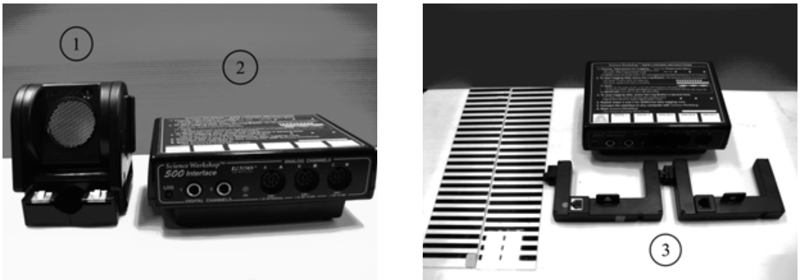

Figure 1. (1) Motion sensor, (2) Science Workshop 500 interface, (3) Photogates

The crucial tool is an interface box (SW500) for data acquisition. It is used to connect the motion sensor and the photogates (Mosca & Ertel, 1989) to the computer connected to the SW500. The computer probes live-time plots of velocity, acceleration and force. The SW500 and the sensors from Pasco are shown in Figure 1.

The sets of demonstration involve to magnetic interactions

Our ideas for designing the demonstration sets were divided into two main parts: (1) the demonstration set for teaching about a uniform force, and (2) the demonstration set for teaching about a non-uniform force (Peters, 1982). All demonstration sets were designed for one dimensional motion. The knowledge of Electromagnetism was used to create demonstration tools. The demonstration sets are:

Set # 1: The demonstration set of Newton's first law consists of
Demonstration #1: An object moves away from motion sensor at a constant velocity.
Demonstration #2: An object moves toward from motion sensor at a constant velocity.

Demonstration #3: An object is at rest when the equal forces act on it in both sides.

Set # 2: The demonstration set of Newton's second law consists of

Demonstration #4: An object moves away from motion sensor with an increasing velocity at a steady rate.
Demonstration #5: An object moves toward from motion sensor with an increasing velocity at a constant rate.
Demonstration #6: An object move away from motion sensor with a decreasing velocity at a steady rate.
Demonstration #7: An object is attached with a magnet at one end. Push and release the object to move towards a solenoid. When the object gets closer to the solenoid there will be a repulsive force between the solenoid and the magnet. the example is given in Figure 3.

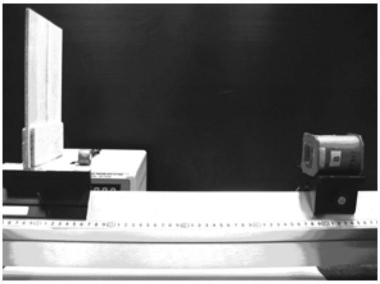

Figure 2. An example of the demonstration #7

The demonstration 7 is somewhat richer and more complex than those of the demonstrations in the set of Newton's second law, and particularly suitable for students who have learnt the basic mechanics before.

Set # 3: The demonstration set of Newton's third law consists of

Demonstration #8: A glider is heavier than the other one. Magnets of the same polar are attached on each of the glider. The gliders are then pushed with the same initial speed then they will collide without contact. The demonstration set up is shown in Figure 3.

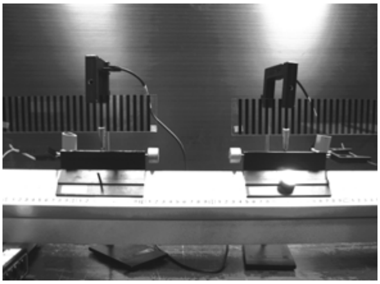

Figure 3. An example of demonstration #8

This set of demonstration is used to teach the third law of motion. The magnitude and the direction of the action-reaction forces are displayed immediately to make students belief in this law.

The conceptual test

We evaluated students' understanding in two parts; the uniform force and non-uniform force. For the first part, we chose 20 items from the Force and Motion Conceptual Evaluation (FMCE) that was translated into Thai by Emarat et al (2002).

The prediction sheets

In the teaching process, we display the results of the demonstration by using graphs. The prediction sheets are separated into 3 main parts. The first part describes the detail of the demonstration. The second part contains empty graphs consisting of velocity-time, acceleration-time and net force-time graphs. Each graph will be sketched (or predicted) by students after they observe an experiment. In the last part students will explain the graphs which they draw. Figure 4 shows an example of the prediction sheet.

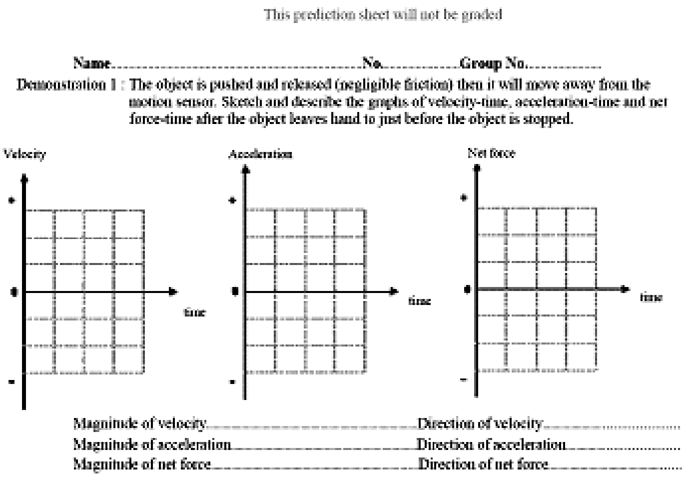

Figure 4. An example of prediction sheet

Results and discussions

The results using the FMCE as a pre- and post-test are shown in Table1 and Table2. A class average normalized gain is 0.47. The results of P-value in all items indicate that the average post-test score of students who has participated in the Interactive Lecture Demonstration is better than the average pre-test score of students who has participated in the traditional instruction at significant 0.05.

In addition, the average normalized gain in part of the graphical evaluation is greater than the natural language part. This may be due to ILDs approach that displays the results of the demonstration by graphical mode.

According to table 2, the highest gain was in the Newton's third law that was 0.91. This result suggests that the demonstration set for Newton's third law had more effective than the others. This also leads to the assertion that the real-time display of the action-reaction forces had much effect to the students' learning of Newton's third law.

Table 1. Pre- and Post-Results for Results on FMCE questions in this study.

	Full score	average pre-test score	average post-test score	P-value
Newton's laws	**20**	**3.59**	**11.28**	**0.00**
Newton 1st &2nd(Nat.Lang,)	**7**	**0.61**	**2.18**	**0.00**
Newton 1st &2nd(Graph,)	**7**	**1.34**	**4.51**	**0.00**
Newton 3rd	**5**	**1.64**	**4.59**	**0.00**

Table 2. Normalized gain [g] for Results on FMCE questions in this study.

Items	<g>
Newton's laws	0.47
Newton 1st &2nd laws (Nat.Lang.)	0.25
Newton 1st &2nd laws (Graph.)	0.48
Newton 3rd laws	0.91

Moreover, the normalized gains of different groups of students of traditional instruction and ILDs instruction are presented in figure 5.

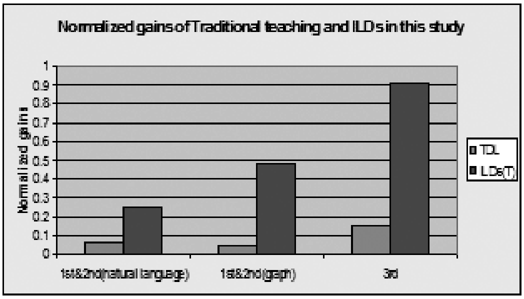

Figure 5. The normalized gains of traditional instruction and the ILDs of this study

The graphs are grouped by each conceptual area of Newton's laws according to Jairuk (2007). The average normalized gains of traditional instruction was from the research of Jairuk that he did the research about use of Interactive Lecture Demonstrations to develop Thai high-school students' understanding in force and motion. It can be seen that the normalized gains of ILDs instruction in this study are higher than the normalized gains of the traditional instruction. Moreover, we considered the average normalized gains of our ILDs and Jairuk's ILDs for comparing the effective of demonstrations. The results shown that our demonstration sets were more effective than Jairuk's one. Jairuk used only simple demonstration sets to teach students while our demonstration sets applied the electromagnet to construct the complicated demonstrations. The advantages of our demonstrations are that they can engage students learn in basic and rich concepts and can enhance students' thinking skills.

Conclusions

The ILD is an effective instruction for improving Thai students' conception in Newton's laws of motion. The success of this work is to develop the demonstration set which consists of the basic demonstrations that solidify the students' conception and the advance demonstrations that help them integrate their knowledge to new situations. According to the complicated demonstration set, the knowledge of electromagnet is used for construction this tools. Furthermore, ILD can increase the concepts of students especially in Newton's third law. In addition to the normalized gain of Newton's first and second laws, the graphical part has higher gain than the natural language part.

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References

Redish, E. F. (1991). *Teaching physics with the physics suite*. United state of America: John Wiley & Sons.

Knight, D. R. (2003). *Five Easy Lessons: Strategies for successful physics teaching*. San Francisco: Addison Wesley.

Steinberg, R. N. and Donnelly, K. (2001). PER-based reform at a multicultural institution. *The Physics Teacher*, **40**, 108-114.

Mazur, E. (1997). *Peer instruction: A User's Manual*. Prentice Hall.

McDermott, L. C. (1995). *Physics by Inquiry*. New York: Wiley.

Novak, G. M., Patterson, E. T., Gavrin, A. D. and Christian (1999). *Just-In-Time Teaching: Blending Active Learning with Web Technology* . Prentice Hall.

Thornton, K. R. and Sokoloff, R. D. (1998). Assessing student learning of Newton's laws: The force and motion conceptual evaluation and the evaluation of active learning laboratory and lecture curricular. *American Journal of Physics,* **66(4)**, 338-352.

Thornton, K. R. and Sokoloff, R. D. (1990). Learning motion concepts using real-time microcomputer-based laboratory tools. *American Journal of Physics*, **58(9)**, 858-867.

Mosca, E. P. and Ertel, J. K. (1989). Photogates: An instrument evaluation. *American Journal of Physics*, **57(9)**, 840-844.

Emarat, N., Arayathanitkul, K., Soankwan, C., Chitaree, R., & Johnston, I. (2002). The effectiveness of the Thai traditional teaching in the introductory physics course: A comparison with the US and Australian approaches. CALLab5.