PHYSLETS – EFFECTIVE WAY OF LEARNING PHYSICS

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Abstract

In this article, we are going to introduce a very useful ICT tool - Java Physics Applets (Physlets) for physics instructional purpose. Physlets have the capability of user-interactive visualization of results and hence enable students to experience a more interesting and effective way of learning physics which is never implement in traditional physics teaching method. Limitations in teaching and learning physics using traditional way will be discussed and this article will show you how to use Physlets to overcome the problems. Pedagogical issues on using Physlets will be discussed so that the benefits of Physlets are fully utilized.

Introduction

Many physics teachers in schools deeply dismayed with how little the majority of their students have learned. From students’ view of points, physics is considered as one of the hardest subject. For most of the students, learning physics is not more than memorizing plenty of formulas.

What is physics? Do all the formulas make sense?

Physics is a search for order in our observation of the world around us (Giancoli, 1998). It is a subject that gives people some control over their lives, so that they do not feel at the mercy of a wild and unpredictable natural world.
The course of physics at secondary level should be characterized by

- Conceptual organization of subject matter
- An emphasis on manipulative activities
- A problem solving mode

The use of Physlets have opened new vistas in physics education by taking full advantage of our basic “senses” of learning such as visualizing 3D objects and nonlinear nature of thought processes. Visual presentations in Physlets encourage experimentation and discovery learning, allowing students to construct their own knowledge. Questions from a pedagogical viewpoint are “How and where can Physlets be used?” and “What issues should be considered before and during such a use?”

This article aims to introduce Physlets and explain its integration with teaching and learning Form 4 and Form 5 physics in the schools. In order to achieve our goals, we will first go through the limitation of traditional educational practice for physics.

**Learning Difficulties in Traditional Educational Practice in Physics**

Lecture, using textbook and laboratories are categorized as traditional instruction. However we found that traditional instruction itself is insufficient in delivery the physics content in secondary level. Some problems and limitations regarding traditional way of teaching and learning physics are common and occurred frequently. They include:
(i) **Time and Space Limitation**

Within traditional instructional techniques, teacher and students are constrained to involve in the teaching and learning process at a specific time (according to timetable) in a fixed classroom. In the present educational system, teaching hours are often insufficient for students. Moreover, when students are absent to the class, they may have missed material that is particularly difficult. Perhaps a laboratory activity took place, which is difficult to make up. Students may also copy the lecture notes their peers took, which may not be reliable.

(ii) **Multiple Types of Information**

There are various concepts and phenomena in physics that inherently involve, dynamic, multimedia, and interactive information. Such information can usually not be represented, distributed and communicated in paper form (and even using a blackboard or overhead-projector with transparencies) due to various limitations. Even though animations can be created using other techniques (for example, GIF animation tool), they lack interaction. The "mental picture" that a teacher has is better conveyed to a learner if the information is presented in its appropriate form. **

(iii) **Students’ Difference Learning Styles**

Some students are auditory learners while others require tactile experiences. Others may learn best from reading text and viewing pictures (Distance learning, 98). Traditional instruction techniques are unable provide a medium for students with different learning styles.
(iv) **Students’ misconception**

Students often hold ideas about scientific concepts that conflicts with scientifically acceptable ideas (Pfundt & Duit, 1991). Research into children’s scientific conception reviews that these ideas are deeply rooted and are not easily changed (Osborne, 1983). Tradition instructional techniques often fail to facilitate a process whereby students can change their conception in order to make them consonant with scientific concepts.

(v) **Laboratory Limitation**

The nature of school physics apparatus is designed to illustrate general principles, not the apparatus of the research physicist looking for accuracy and reliability. While conducting the experiment, students learn how to perform experiment and not the answer which is “Why does it behave this way?” Moreover, experiment that fail to demonstrate students’ purported intentions make them confuse. This is because of most of the physics’ experiments need to be conducted in the approximately ideal condition to get the reliable results. In addition, practical in laboratory is not accessible to the students all the time for reason of safety or equipment availability. This will be an obstacle to develop constructional learning which is essential in physics education.

**What are Physlets?**

*Physlets* — “Physics applets” — are small, flexible Java applets that can be used in a wide variety of WWW applications. Many other Physics-related Java applets are being produced around the world — some of them very useful for education. However, the class
of applets we call “Physlets” has some attributes that make it valuable for the educational enterprise.

- **Physlets are simple.** The graphics are simple; each Physlets is designed to deal with only one facet of physical phenomena, and does not incorporate very much in the way of data analysis. This keeps Physlets relatively small —easing downloading problems over slow network connections—and removes details that could be more distracting than helpful.

- **Physlet-based pedagogy is agnostic.** Physlets can be used as an element of almost any curriculum with almost any teaching style. Although we believe that interactive engagement methods such as Just-in-Time Teaching, Peer Instruction, or Tutorials can improve pedagogy, Physlets can be used as traditional lecture demonstrations and can be given as end-of-chapter homework.

- **Physlets technology is flexible.** All Physlets can be set up and controlled with JavaScript, meaning Animator can be used for almost any subject in mechanics and EField for almost any topic in electrostatics with small changes in the JavaScript—and not the Java—associated with each exercise. Data taking and data analysis can be added when needed using inter-applet communication.

- **Physlets are written for the Web.** They can run on (almost) any platform and be embedded in almost any type of html document, whether it be a homework assignment, a personal website, or an extensive science out-reach site.

- **Physlets are freely distributable for noncommercial use.** Physlets archives, that is, compressed archives containing compiled Java programs, can be downloaded from the Davidson College WebPhysics server:
Instructions to Physlets

All Java applets in the lab are organized like in this screen snapshot. The screen snapshot is divided into three areas, there is the animation area where the motion of the wagons shown. On the right-hand side in the parameter area, various parameters can be changed. In the measurement area, the arrow and specific field for showing the result is available to measure certain properties of the system.
The Parameter Area

The parameter area shows control panels for several parameters. Each panel shows its verbal name (not the mathematical one!) together with its physical units. Its actual value is shown in a text field. It can be changed either by manipulating the scrollbar or by putting some numbers directly into the text field. Note, that parameters with fixed values are not shown.

After the mass and the initial velocity for both wagons in specific situation had been decided, click on the start bottom, both of the wagons will start moving and collided each other. User also can choose the slow motion for clearer observation by click on the box beside ‘slow motion’. The Physlets will show the direction after the collision for both wagons.
The measurement area

After the collision had occurred, the measurement area will show the direction of wagons by using the arrow. Beside that, the direction for the wagons also can be observed clearly at the animation area. Velocities or the result of the virtual experiment after the collision will be given at this area.

There are at least four ways that Physlets can be used in education:

- **Informational Applets.** These applets are similar to the Help files in Windows-based programs where by clicking on a tab or choosing an item from a pull-down menu, the user can obtain more information on the topic. These applets may have minimal interactivity on part of the user.

- **Concept Illustrating Applets.** Such applets illustrate concepts underlying the subject, for example, the notion of limit in Calculus. These applets should have maximum possible interactivity on part of the user.

- **Computational Applets.** These applets can serve as examples of concepts being learnt as well as illustrating a phenomena. They can have the capability of user-interactive visualization of results and with a built-in graphical user interface (GUI) to facilitate experimentation by manipulating various parameters which can be "hard-wired". For example, given the linear equation f(x) = (1/2)x, the applet
finds its fixed point iteration, that is, 0. These applets should have maximum possible interactivity on part of the user.

- **Assessment Applets.** Assessment is fundamental to every learning process. To assess student learning, quiz applets with multiple-choice questions can be designed and implemented. A quiz can present the user with a set of problems, each with multiple choices that he/she could select from. Such a presentation can even be "randomly" generated (using Java's random number generator) from a database of questions. Once selected, the choice can be processed and appropriate response message with explanations can be displayed. These applets may have minimal interactivity on part of the user. (Pankaj Kamthan, 7th March 1999)

**Advantages of Physlets**

a) **Integration Physlets in Teaching and learning Form 4 and Form 5 Physics**

An Example

Above shows an example of Physlets about Elastic and Inelastic Collision. As most of the design of Physlets, we have the parameters and action buttons (on the right-hand
This *Physlets* is very suitable to be used for instructional purpose due to a few reasons. Firstly, the graphics is big and clear enough for teacher to show to the students. It presents the concept in a clear simple way. Only the relevant information is given and there is no disturbing animated graphics.

As we can see, *Physlets* provide a high interactivity between the user and the page. We can determine the parameters we want such as *elastic* or *inelastic*. Besides, we are able to insert the value of valuables (for example the masses of the wagons). We also have the action buttons to begin, stop or reset the graphical actions.

This *Physlets* actually enable a virtual experiment to be carrying out. Students are expected to construct two important concepts in physics - *conservation of momentum* and *conservation of energy* from their observation on the page. By changing the valuables, repeating the motion, observation, recording the data in tables, and draw the graphs, students would be able to find out the relationship between the masses and the velocities of the wagons. Hence they would be able to built up the rules of concept, which make sense and meaningful to them.

Of course teachers play importance role to make sure the students learned in the lesson. Preparation of the teachers is essentially importance. Before the lesson are carried out,
teachers have to make sure that the chosen *Physlets* is appropriate to the students' level and not running out of the syllabus. Teachers also have to go through the whole learning process, which the students will experience to predict the miserable that may occur among, the students while interact with the page. Other than that, a hierarchy learning task need to be prepared to help the students to build up their knowledge and also to assess the learning process. Lastly, teachers are responsible to minimize the technical problems as well.

**The main purposes of *Physlets* are to:**

- Make the learning experience more interactive.
- Provide a greater variety of learning experiences within the classroom.
- Permit ‘virtual physics’ experiments to be carried out in interactive internet sessions.
- Show reactions not possible in school lab.
- Dynamic images/animation aid understanding.
- Enables visualization of process that are too small, too fast, too slow or too dangerous to be seen in real life.
- Visual impact/attractive.
- A new way to present difficult ideas.
- Deliver the concept in a more intelligible, plausible, and fruitful.
- Allow physics teachers everywhere to freely share resources with colleagues and students at other establishments.
- Create wider opportunities for students to learn independently, either from home or in school.
- Make course documentation freely available to students and their parents.
- Direct students to web pages closely related to their course requirements.
- Make teaching resources available to students outside lessons to facilitate independent catch-up and/or review.

1) Pedagogical issues

*In theory, there is no difference between theory and practice. But, in practice,*

*there is.* ~Jan L. A. van de Snepscheut

There are various pedagogical issues that should be considered before making the decision of using *Physlets* for educational purposes.

b) Appropriateness

One of the most important questions is: “*Where is the use of Java applets most appropriate, and why?*” *Physlets* can be based on carefully chosen topics from the syllabus of a course. It is not necessary that all topics automatically lend themselves to illustration by a Java applet; in many cases, traditional methods (such as a blackboard or overhead-projector with transparencies) of explaining a concept may be sufficient. For example, it could be argued that the concept of measurement does not require any special use of *Physlets* for illustration. Topic of choice could be ones that pose special difficulties in learning or require a
much-needed illustration, for example, the concept of waves-interference. The *Physlets* can complement the lecture and the sessions with physics information which is difficult to convey in traditional manner.

b) **Effectiveness**

The results and effectiveness of educational use of Java applets can be evaluated from the following:

- **Students' Response.** An interactive feedback form for this purpose can be made available on the WWW site with Java applets.

- **Tutor's Feedback.** The tutor could provide feedback based on students' performance in computer laboratories.

- **WWW Site Statistics.** Collection of statistical data and subsequent analysis based on visits to the WWW site with Java applets.

(Pankaj Kamthan, 7th March 1999)

c) **Syllabus**

People with different culture background and education create *Physlets* all around the world. Not every ready make *Physlets* is match to our instructional goal. A careful selection of *Physlets* need to be done so that it meets our need and optimize the learning process.
d) **No Silver Bullet**

As with the use of any other technology, it should be accepted that use of *Physlets* will not by itself solve all the problems faced during teaching and learning process, and may even create some problems of its own. Identifying and addressing these problems can help avoid potential bottlenecks during their use.

6) **Conclusion**

In education field, identification and analysis of students difficulties is essential so that instructional can be designed to address those difficulties. Utilizing the technologies of Information and Communication in education somehow provide an efficient medium for teaching and learning.

In physics, there are some aspects that help and show the learning with understanding. Students show their understanding only when they can answer the questions that require quantitative reasoning and verbal explanations. In order to do that, they need to participate in the process of constructing qualitative models that help them understand the relationships and differences among concepts. Besides, persistent conceptual difficulties of students must be explicitly addressed by multiple challenges in different context. They also must be intellectually active to develop a functional understanding. As teachers, we should be given the opportunity to learn the content that we will be expected to teach.

Without the development of ICT, all of the stated requirements above sound difficult and even impossible to achieve. But now they are not far from us anymore. What we
have to do is just equip ourselves with the skills and knowledge of technologies, which connect us to the world of ICT.

*I hear, I forget; I see, I remember; I do, I understand.*

~ (Paul R. Halmos)

The significance of education in any evolving society is paramount. Physlets can help an interactive environment of 'learning by doing' in the study of physics. Beyond their ability to better convey certain concept, the Physlets can increase and instill greater interest among the students, and encourage them to be more actively involved in the class. Consequently, their understanding of the course content can further improve. Such an endeavor can also be useful to a teacher during instruction and otherwise in their course work.

References