Implementing Problem Based Learning in Mathematical Studies using Graphing Calculator and Real Time Data Streamer

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Abstract: *Problem based learning is a focus in student center approach, which can be practically adopted into different learning styles, objectives, and subjects. However, creating of scenario appears to be the greatest challenge, especially in mathematical studies. The HP graphing Calculator with plug and play Stream Smart data streamer that we tested might be a supplement in scenario designs for mathematical studies. The parameters that can be captured by the data streamer are varied from humidity, temperature, to the pressure, or even level of oxygen. The real time data then can be stored and processed through graphing calculator. The vast measurable parameters can virtually bring students to the fields that closer to their future working environments, where their mathematical knowledge can be applied. This paper shows the utilization of the calculator with the data streamer, as well as some samples of scenario created.*

1. Introduction

As a part of constructive learning, problem-based learning (PBL) is one of the widely used approaches to train and develop the skills such as critical thinking, creative thinking, problem solving, and analyzing of the learners through the problem-based scenarios. PBL, since being developed early 1970's, being well adopted in medical sciences [6], business schools [5], certain levels of engineering studies [7], and even some high schools [1].

Although the background of learners might affect the effectiveness of PBL, the roles of the teacher in designing the problem-based scenarios remain the key to the successfulness of PBL. In mathematical study, teacher's instructional ability is critical to engage students in gathering information and apply their knowledge in their respective fields [10]. Students, through mathematical PBL, have greater opportunity to learn mathematical processes associated with communication, presentation, modeling, and reasoning [8, 2, 4].

Instead of pre-designed scenario with pre-set data, real time data collecting might be a supplement for PBL. As graphing calculator is a widely used in classroom activities, a real time data streamer can be coupled with graphing calculator in data collecting. The graphing calculator and the data streamer we used in this paper are *HP 39gs* and *HP Stream Smart 400*. The sensors used are supplied by Fourier.

The *HP Stream Smart 400* data streamer can be connected to more than 70 different Fourier electronic sensors, with the parameters of detection ranged from height, distance, temperature, humidity, to the concentration of gases (such as CO_2 and O_2), wind speed, chemical concentrations

(Na^{+}, Ca^{2+}, Cl^{-}, and NO_2^{-}), and even force, frequency, acceleration, light intensity, conductivity, current, voltage, and electricity charges [3]. Whilst in this paper, *HP 39gs* processes the data using Statistics Aplets.

What is aplet? Aplet is a combination of several programs to work on a particular mathematics topic, e.g. functions, statistics, inference, polar, parametric, sequence etc. According to [11], the simplest way to visualize an aplet is to think of it as a specialize room in which to work. Each aplet provides tools and views that are particularly suited to its purpose. For example, Statistics Aplet provides statistical graphs and also summary statistics.

2. Scenario Design

In this paper, two scenarios are designed to touch on the topics in finding best-fit line and linearization.

2.1 Finding Best-Fit Line

A scenario designed by Wong and Betty [9] was conducted using temperature and humidity sensors. Students were requested to collect the real time data for the temperature and humidity inside and outside their house of residence for seven continuous days. The setup of the sensor is explained in Part 3. The results are shown in Figure 1.

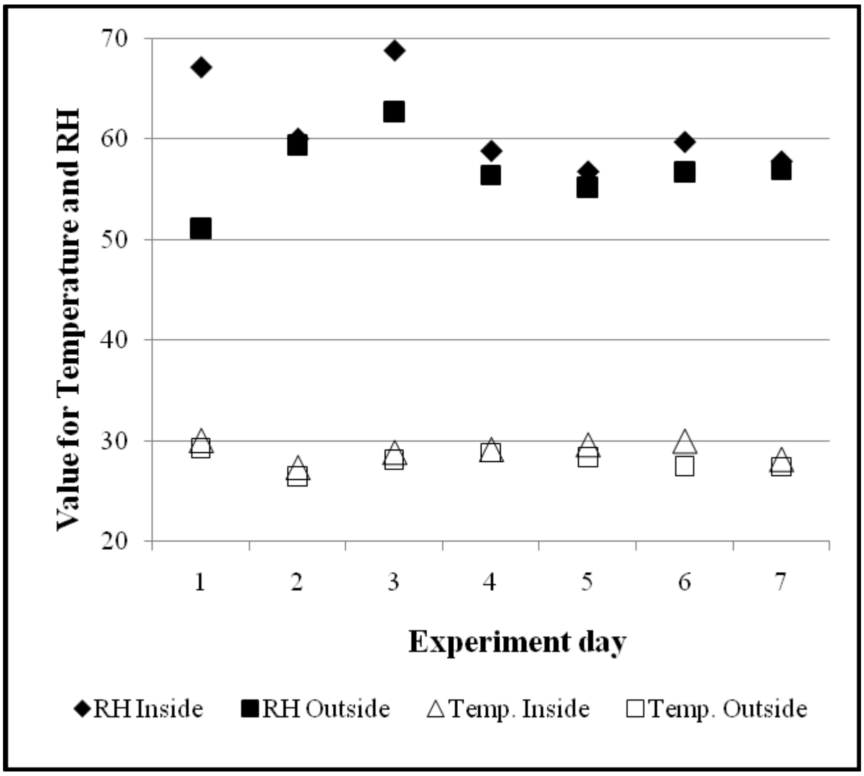

Figure 1 Relative humidity and temperature inside and outside of a house in Kajang, Selangor for 7 days.

From the data collected, students were required to find the correlation between temperature and relative humidity (RH) inside and outside the house using Statistics Aplet in *HP 39gs*. Some of the results are shown in Figure 2. The objective of this activity is to introduce the concept of correlation through data collected from familiar surroundings, indirectly to evoke their interest in learning mathematics from a real problem.

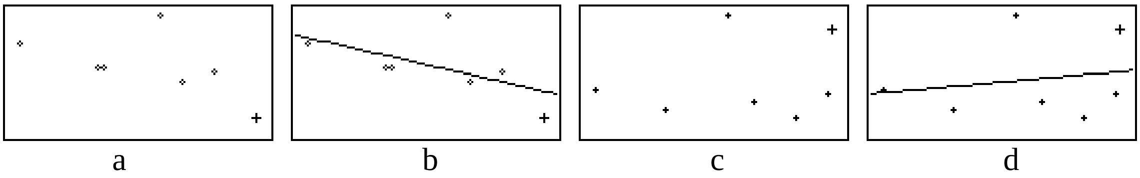

Figure 2 (a) Graph of RH(%) outside houses versus temperature outside houses. (b) Best-fit of RH(%) outside houses versus temperature outside houses. (c) Graph of RH(%) inside houses versus temperature inside houses. (d) Best-fit of RH(%) inside houses versus temperature inside houses.

2.2 Linearization

During the teaching on linearization, the next scenario maybe considered. First, collect data of air pressure in syringe versus volume using the sensor mentioned in Part 3 (Figure 3a). After plotting the graph, a reciprocal curve appears in Figure 3b. For students to predict the pressure at certain volume, they will have to learn how to obtain a best-fit equation and how does that equation work to solve their problem. In order to carry out this activity in class, students need to re-plot the graph using the relation $\frac{1}{y}$ versus x (Figure 3c and 3d). Then, a straight line is obtained and the students will need to use the gradient and y-intercept (Figure 3e) to find out the actual equation for the reciprocal curve or just using the straight line to predict the air pressure at certain volume (Figure 3f).

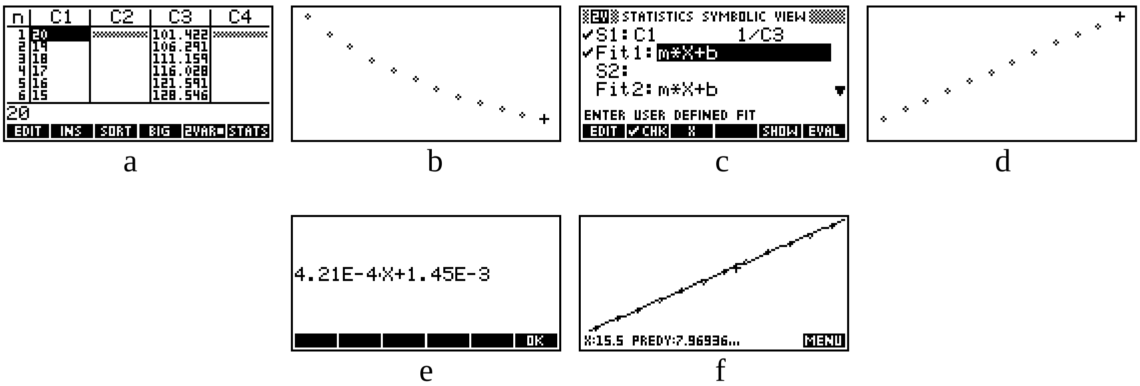

Figure 3 (a) Data of volume in column C1 and data of pressure in column C3. (b) Graph of air pressure versus volume. (c) Setting x values and $\frac{1}{y}$ values. (d) Graph of $\frac{1}{y}$ versus x. (e)

The function of $Y = \frac{1}{y} = 4.21 \times 10^{-4}x + 1.45 \times 10^{-3}$. (f) Best-fit of the line $Y = \frac{1}{y} = 4.21 \times 10^{-4}x + 1.45 \times 10^{-3}$.

More mathematical PBL can be blended into physics, chemistry, biology, environment, even engineering to help students in visualizing, hence appreciating the mathematics knowledge that they learnt.

3. Operation of the Sensors

Figure 4 shows the setup of the sensor. Both the sensors chosen and graphing calculators need be plugged to the data streamer. Turn on the graphing calculator, then go to Aplet Menu and choose Stream Smart Application. The sensor will be automatically detected by the application, and the data acquired will be displayed. The adapter can support up to four different sensors and take four different sets of reading simultaneously.

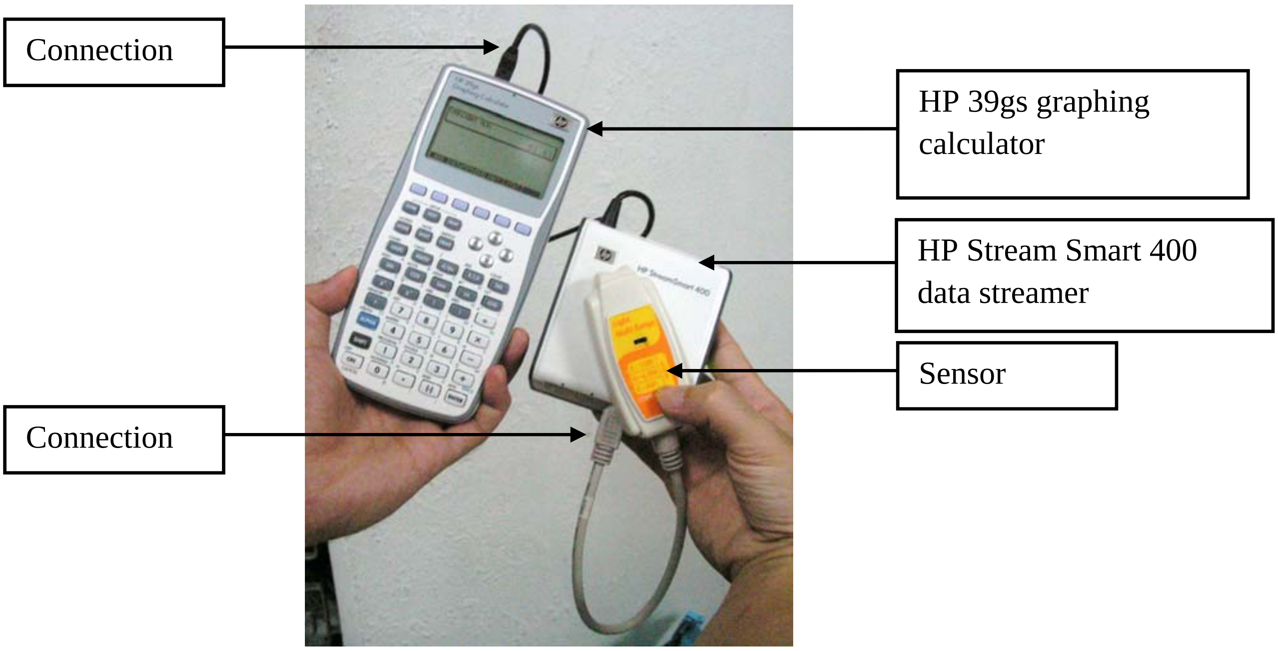

Figure 4 Complete set of electronic sensor, adaptor, and graphing calculator.

The sensors are simple to setup and easy to operate, teachers can concentrate more on guiding their students than dealing with the messy technical problems. The sensors, together with the graphing calculator and data streamer are batteries-powered, hence have high mobility in field works.

Figure 5 shows the data captured from the electronic sensor can be shown in graph form, e.g. relative humidity vs. time (Figure 5a), and numerical form that shows the reading at a particular time (Figure 5b). A series of data captured can be exported to “Statistics Aplet” (Figure 5c) for statistical analysis (Figure 5d).

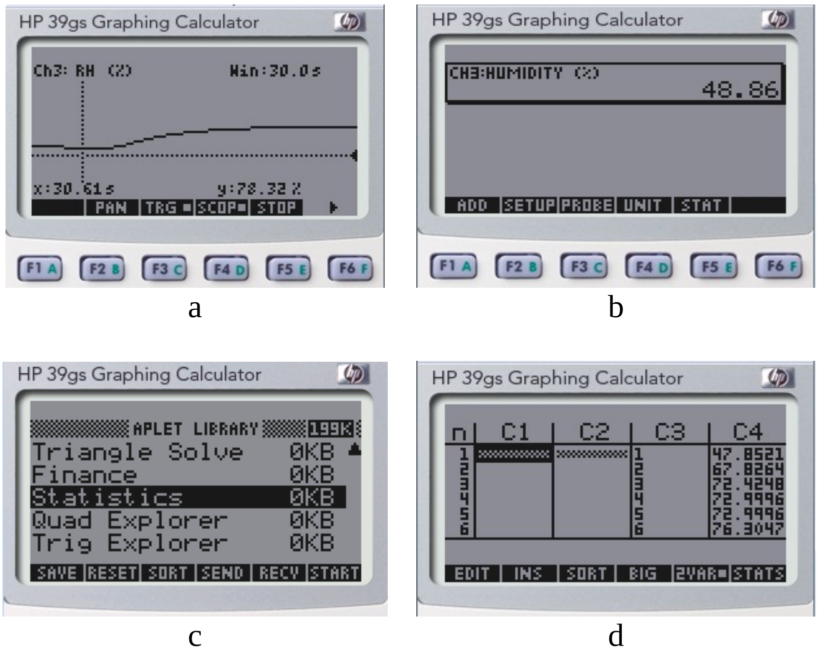

Figure 5 (a) Graph form of result showed the changes in RH (%) in 30 seconds. (b) Numerical form of result showed the RH (%) of that particular moment. (c) Choosing Statistics Aplet. (d) The reading for continuous exposure of the sensor can be recorded and showed in table form [9].

4. A Step and Beyond

The need of the environment with vast spectrum of disciplines nurtures the different pedagogical approach, to prepare the students not only for better adaptation to their future environment, but to foster their capability to learn constructively in many years beyond the formal education can reach. In traditional mathematical studies, students are taught how to follow instructions, how to use equations, how to obey the steps and how to score high in their exam, but yet lost their creativity and ability to apply their knowledge, or even the enthusiasm to understand the nature and concept behind a simple mathematic equation.

As one of the most widely used constructive approach in recent pedagogical activities, PBL can be a solution to expose students to learn mathematical processes in holistically (integrate with other interpersonal skills).

Graphing calculator-based electronic sensors is an answer in creating some PBL scenarios and projects, which can help our students to visualize and materialize the measurable parameters that seem to be abstract to them. Through these scenarios and projects, students are expected to relate mathematical studies to other fields, as well as to fill up the deficiency of the application part of the knowledge that they learnt.

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