Mobile Calculating Lab (MCL) based Mathematics Application

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Abstract: *Since 2007, Beijing Education carried out curriculum reform. Mathematics education was performed according to newly revised curriculum standards and adopted new text books. In our fresh curriculum standards, we emphasize "Develop the students' mathematics application consciousness" and propose "The connection between mathematics application and practice need in our senior school mathematics education needs to be strengthened", and try to turn mathematics application teaching into practical operating process. Mobile Calculating Lab is one of many various mathematics application approaches. While I was teaching mathematics application, I adopted this teaching model and got some experiences. I summarized the general formula of this teaching model should contain the following four parts: question raising; experiment designing and data collecting; data analysis; data obtaining. The value behind this teaching model is that it helps the students foster their abilities on data collecting, data sorting and data processing; enhance their consciousness of mathematics application; deepen their understanding of the intrinsic side of the mathematics knowledge.*

1. Introduction

Since 2007, Beijing Education Commission has made the decision to launch a new round of curriculum reform of senior high school. Mathematics education was performed according to the newly revised curriculum standards and adopted the new text books. In our fresh curriculum standards, we emphasize "Develop the students' mathematics application consciousness" and propose "The connection between mathematics application and practice need in our senior school mathematics education needs to be strengthened", and try to turn mathematics application teaching into practical operating process. Among various mathematics application approaches we see today, Mobile Calculating Lab provides us a good choice.

Mobile Calculating Lab (abbreviated for MCL) is a set of hardware system including Graphing Calculator, Sensor and Signal Converter (Figure 1).

Figure 1 Mobile Calculating Lab

Those components are Graphing Calculator, Signal Converter (middle square box, Figure 1) and Sensor respectively from left to the right side (Figure 1). The Sensor is used to collect information such as sound, temperature, light waves, distance, **ph** value, pressure and so forth. We use different sensor in view of different object. Signal Converter helps to turn analog signal collected by sensor into digital signal. Graphing calculator functions here as data display and data processing. This system has characteristics like deft, easy operation and accuracy of data collection. Meanwhile, it covers nearly all the physics, chemistry and biology experiments in senior school curriculum standards we are using now, so it is suitable for the high school students. They can adopt this MCL to conduct their experiments, whenever they have puzzles, to solve their curriculum problems. The data processing on Graphing Calculator and the later on data analysis can help them reach a conclusion.

What's the general model of MCL's mathematical application? What's the value of using MCL in mathematics application teaching? To find answers, my colleagues (Lili-Sui and Lihua-wang) and I encouraged our students to conduct micro – research on Mathematics Application in their spare time. Many students adopted MCL. Here are two typical examples we would like to share. In the process, students firstly proposed the question, secondly students together with us discuss to obtain the question and made experiment design. Next students did it.

2. Cases of using MCL in Mathematics Application Teaching

Case 1: Illumination curves of different kinds of bulbs and their impacts on reading

Tester: Hao-cheng Yang (First year high school student)

Question: Since our human kinds set foot on "Electric Age", desk lamp has become an indispensable stuff in each household. The essential part of a lamp is the bulb. With the development of technology, bulb categories are now getting more and more colorful, from early times Incandescent Lamp to Fluorescent Lamp person use nowadays, all dazzling persons' eyes. Now the problems arrive: How can person choose a bulb in a scientific way when facing different kinds of bulbs and what type is more suitable for person to use?

Experiment Design:
Set up a simple indoor reading scene: Put the lamp in the direction of left front 45 degrees from the tester and leaving a 55 centimeters distance between the bottom of the bulb and the book. To mimic the eye position while reading, set the probe of the Illuminance Meter 30 centimeters from the book. The other end of the Illuminance Meter is connected to Graphing Calculator (Figure 2).

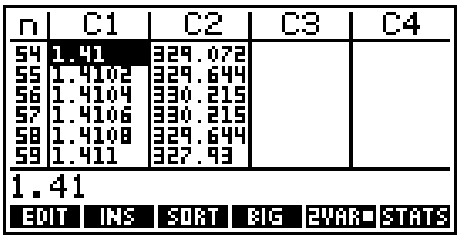
Figure 2 Illumination curves experiment

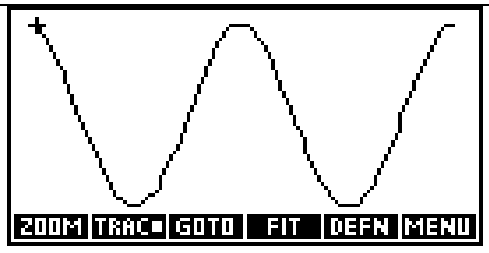
In order to guarantee the scientific experimental results, the three bulbs his used here are: 40 Watts Incandescent Lamp, 8 Watts Energy Saving Lamp (equivalent to 40 Watts Incandescent Lamp) and 18 Watts double H type Eye-protection Lamp.

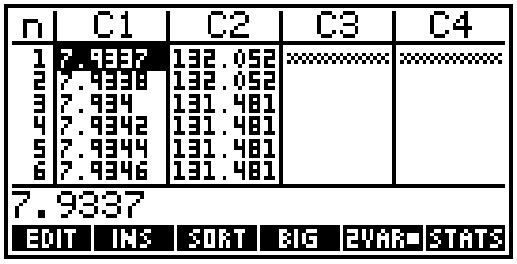
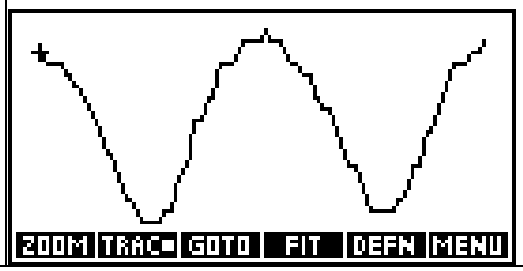
Experiment Procedure:
He start the Lamp, Graphing Calculator and Illuminance Meter one by one. The illumination curve will be processed into Graphing Calculator automatically. Then he changed another bulb, finishing another round of data collection.

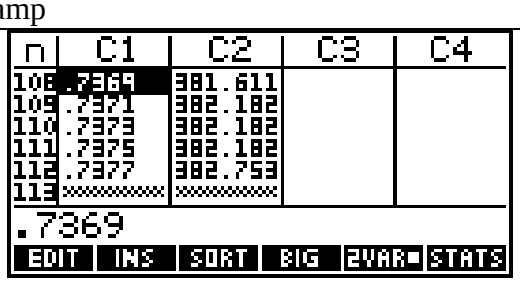
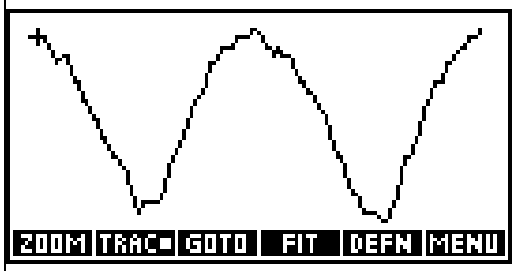
Experiment Results:
After statistical analysis, the illumination variation versus time of three different bulbs are plotted as shown in Chart 1:

Chart 1 Data and graphs of three bulbs (illumination versus time)

<table>
<tr><td colspan="2">Incandescent Lamp</td></tr>
<tr><td>Part of the data</td><td> 

Note: C1is the time; C2 is the Lux.</td></tr>
<tr><td>Part of the graph</td><td> 
</td></tr>
</table>

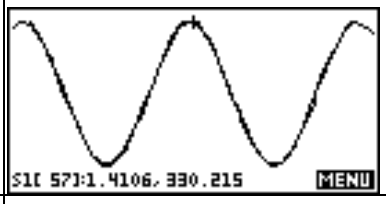
Energy Saving Lamp	
Part of the data	 Note: C1 is the time; C2 is the Lux.
Part of the graph	

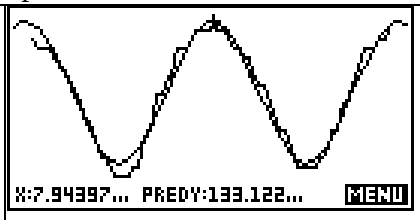
Eye-protection Lamp	
Part of the data	 Note: C1 is the time; C2 is the Lux.
Part of the graph	

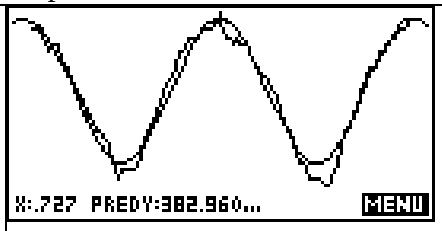
Data Processing:

It is obviously the above three Illumination-Time curves carry trigonometric function characteristics, so he decided to fit the data with trigonometric function formula (Chart 2).

Chart 2 Graphs and trigonometric function analytical formula of Illumination-Time curves of three bulbs

Incandescent Lamp	
Fitting Image	
Analytical Formula	L=35.9sin(564.6t-9.3)+293.5

Energy Saving Lamp	
Fitting Image	
Analytical Formula	L=4.4sin(593.4t+176.3)+128.8

Eye-protection Lamp	
Fitting Image	
Analytical Formula	L=5.3sin(568.2t+22.1)+377.7

Note: All the coefficients and constant numbers shown in Chart 2 are corrected to 0.1

Conclusion: The analytical formulas data from Chart 2 can be presented as data shown in Chart 3

Chart 3 Relative data of three bulbs

	Incandescent Lamp	**Energy Saving Lamp**	**Eye-protection Lamp**
Maximum Illumination	329.4	133.2	383
Minimum Illumination	257.6	124.4	372.4
Difference of extreme value	71.8	8.8	10.6
frequency	89.9	94.4	90.4

Note: The frequency shown in Chart 3 is corrected to 0.1

It is reported the appropriate illumination frame for reading is between 250 Lx and 300 Lx. Based on this information and the above collected data from our experiments, he drew the following conclusions:

1. The Incandescent Lamp has a sufficient illumination which satisfies our reading needs. However, it can easily lead to visual fatigue due to its extremely unstable characteristic. The waves of incandescent lamp fluctuate more frequently than the other two alternatives.

2. Energy Saving Lamp is the most stable one among the three tested bulbs, but the far lower illumination impedes its application in reading.

3. Eye-protection Lamp has similar drawbacks as Energy Saving Lamp has. It is stable but not suit for use while reading due to its relatively higher illumination.

4. For the three tested bulbs, Incandescent Lamp can be used for short term reading; both of the rest two have their obvious negative effects, therefore not recommend for using while reading.

5. Eye-protection Lamp with lower Watts is considered most suits for reading; In addition, Energy Saving Lamp can be used for indoor illumination; Furthermore, the Incandescent Lamp will eventually becomes relic of history due to its native unstable, high-energy consuming characteristics.

Case 2 Effects of common seen beverage's pH value on human health

Tester : Xiao Zhang and An-ye Zhou (First year students in high school)

Question: Nowadays, people turns to pay more attention to the idea of "acidic body" and its corresponding effect on our health. Many food specialties had provided some suggestions on our daily diet. Beverages also plays an important part in students' life, therefore they were attempted to find which beverage(s) gives beneficial for people through investigation and experiments.

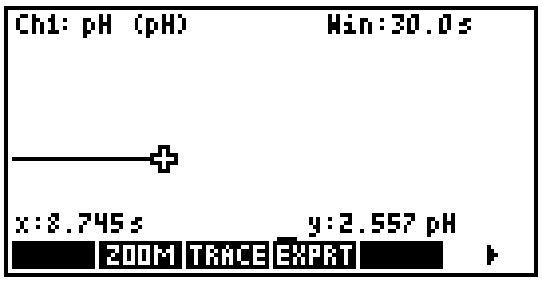
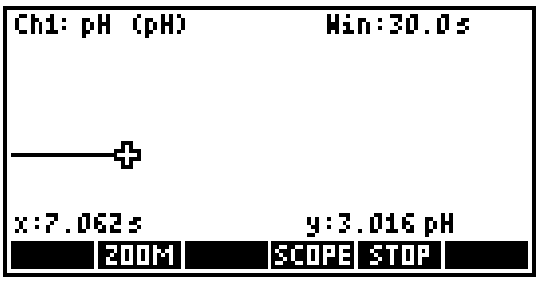
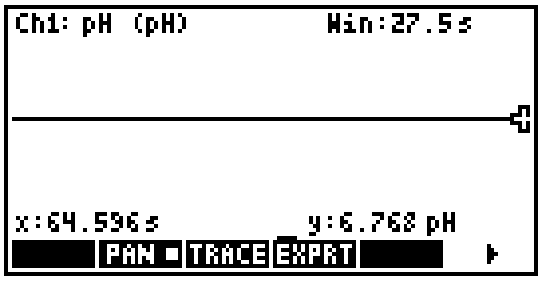
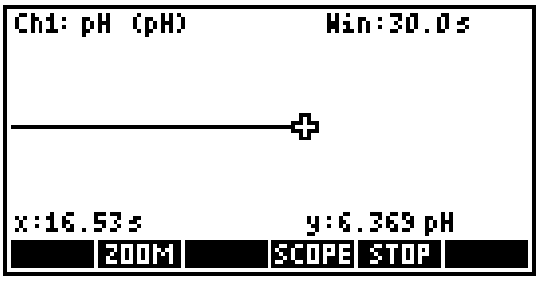
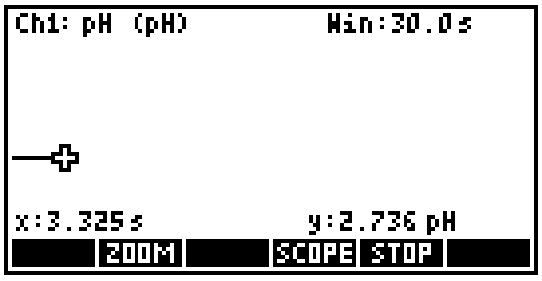
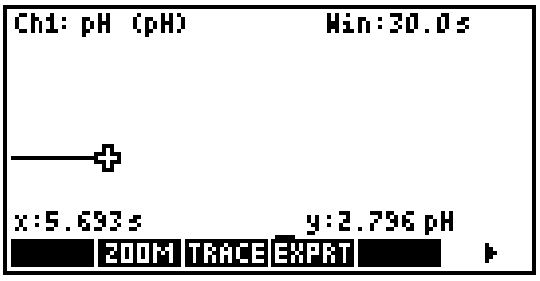
Experiment Design:
Dumped the beverage into our instrument and then started the Processor and Graphing Calculator. The instrument can input the pH value of the beverage into Graphing Calculator automatically. Then switch to next beverage and collect data with the same operation procedure until gathered all data. This procedure is shown in Figure 3.

Figure 3 Impact of beverage's pH value on human health

Test results: Through statistical collection, the pH values of twelve different beverages are shown on Chart 4.

Chart 4 pH values of twelve different beverages commercially from market

pH value of Jasmine Tea	pH value of Beer
pH value of Tea	pH value of Fanta
pH value of Red Guava	pH value of Red Wine

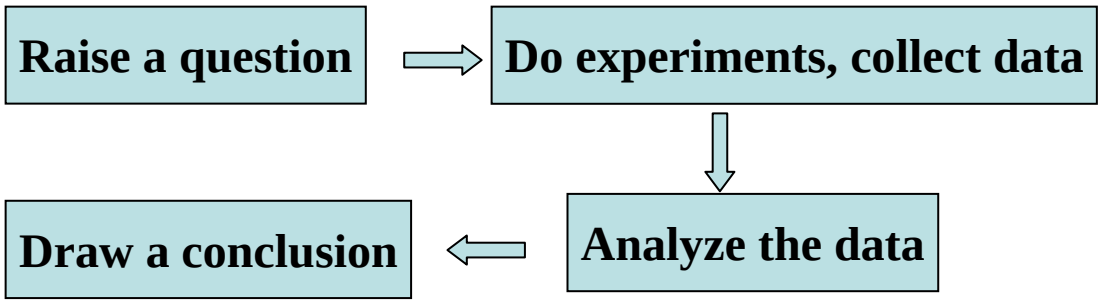
pH value of Cola 	pH value of Sprite 
pH value of Water 	pH value of Coffee 
pH value of Mizone 	pH value of Plum Juice 

Conclusion:

According to reported literature, the pH value of human body fluid maintains between 7.35 and 7.45 and shows slightly basic properties. The balance point is 7.41 which is also the optimal condition of normal physiological metabolic processes of human. When environment pollution and bad diet habit are considered, it is possible that our human body might reveal regulation problem owing to extra acid accumulated inside and that might leads to acidosis. What was worse, it can even threaten our life if that issue is not handled properly. Keeping acid-base balance of our human body fluids has a significant meaning to us and we need to do something to keep that pH value stays within the normal range by paying attention to healthy diet and avoiding body fluids get acified. The data in Chart 1 indicates that among the twelve beverages they chose in the experiment, fruit juice has a pH frame between 2.9 and 3.4, the corresponding value for carbonated drinks are 2.0 to 4.0. Hence, they suggest drinking plain water, if possible, instead of taking carbonated beverages like Cola, Sprite, etc.

3. General model of MCL's mathematical application

Based on the above two cases, we can summarize a general model of utilizing MCL in mathematics application.



3.1 Raise a question:

In this part, the student raised a question, then the teachers get involved in discussing and help the students turn the raised question to be more meaningful. The question raised by the students directly reflect their interests and deserves adequate respect from the teachers. Sometimes the question raised by the students are not that fanscinating or seems trivial as they are liminated by their knowledge and life experience. At this time, the teachers needs to communicate with them and bring them in line.

3.2 Do experiments, collect data

In this part, the students need to design an experiment, then do the experiment in the lab and finally collect data, all by their own. MCL based experiments are different from those physics or chemistry counterparts as the former are simpler, the experiment devises are easier to operate. For MCL, in some easy experiment, one can finish all the parts on their own. Take Case 1 as an example, MCL system directly turns analog signal into digital signal with real-time input into Graphing Calculator realized at the same time.

3.3 Analyze the data

In this part, we first collect data, then put them into analysis. We used various mathematical knowledge we learned in class to analyze all the data. That knowledge contains functions, inequalities, equation, regressive analysis and so forth.

3.4 Draw a conclusion

We obtain our conclusion based on our mathematically analyzed data. We express our conclusion in many ways like mathematical language, mathematical model, some suggestions or some understandings.

4. Conclusion

4.1 Mathematical application based on MCL can enhance students' mathematics application consciousness and also can cultivate their mathematics application skill

MCL based Mathematical application differs from casual mathematics problem solving. In this case, the problem the students faced is not simply mathematical, but a general one. To solve this problem, the students need to design experiments, test their hypothesis through real experiments, collect data, plot the data in mathematical way, analyze the data and then reach a conclusion; all those procedures are carried out on their own. In the past, the students directly face to data or graphs; but now, not only do they need to process data, but also they have to master the skill of obtaining data, get know with the source of data and so on. While doing a project, they undergo a complete process from problem raising to problem solving. This teaching model (MCL) helps to foster students'

ability to solve the practical problems and also helps the students obtain skills in real life problem solving.

4.2 MCL based Mathematical application stimulate the students to think in mathematical way, deepen their understanding to the intrinsic of mathematics knowledge.

Doing experiments with MCL and then collecting data provides alternative practical model for mathematics study. Those real models are real presentations of abstract mathematics knowledge. In the process of studying from real to abstract and then go backwards, students' understanding towards mathematics knowledge get sublimized. Take the trigonometric function as an example: In the newly revised high school curriculum textbook, generally they only provide models of trigonometric function with angles as the independent variable. Some students narrowed their understanding of trigonometric function only to angle as the independent variable, this adversely affect theirs accurate understanding of trigonometric function. They need more real model to correct their inherent concept. Case 1 is another real model of trigonometric function. The plot of light illumination versus time is a typical trigonometric function. The students learned from their experiments that time, other than angle, can also be taken as an independent variable in trigonometric function. By this, their understanding of independent variable in trigonometric function was deepened.

4.3 Cultivating students the ability of proposing question though the teaching of MCL based mathematics application

Question is the key to mathematics. This applies as well on MCL based mathematics application. We need to guide the students to propose valuable problem while we conduct MCL based mathematics application in high school. From one side, we need to guarantee the raised problems are operational, close to the student's study life and interest-pique; On the other hand, we hope the raised problem can elicit students' thinking and meaningful in mathematics realm. Though the process, the students get to know how to propose the question,.

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