A Mathematics Research of a Project Case under the Conditions of MCL

Zhao Tao, Sun Yuanxun, Yang Xiaoling
zhaotao85@gmail.com
Hainan Overseas Chineses Middle School
China

Abstract: *This paper expounds the process of setting foot on a chemistry problem to reflect the application value of mathematics research project by deliberation under the conditions of MCL. It also shows the process of students' applying mathematics thoughts to solve problems under the conditions of MCL. This paper indicates the handheld technology's great effect in cultivating students' application awareness and creative consciousness in teaching. The change from mathematics learning to practicing has come out in the new curriculum.*

1. Introduction

Academician Zhang Jingzhong has made an interesting metaphor：learning math is like eating a walnut．As is known, the walnut is tasty and healthy, but to enjoy it we need to break it open first, which not only costs great strength but also needs a suitable tool[1]. For a long time, while in studying math, most students fall into the circle of understanding concepts，memorizing formulas，working on exercises but neglecting the value of application as well as the instrumental role of math.

How can the present math teaching to break away the mode of working by exercises, and how we can to seek a road developing math thinking meanwhile upgrading students' consciousness of application? It has been the common inquiry among the mathematics teaching staff that has a foresight.

Compared with the deciplines of physics and chemistry, the traditional math teaching model, fails to provide students with a kind of technology platform to analyse the experiment result in theory. However, the MCL is supposed to solve such a problem.

MCL is short for Mobile Calculating Laboratory, it consists of graph calculator (computer), data collector, and various sensors. In practice, data is collected through sensors, then it is displayed to computer instantly and the computer does the further data analysis. In this process, we can analyze data with mathematics tools more freely and more universally.

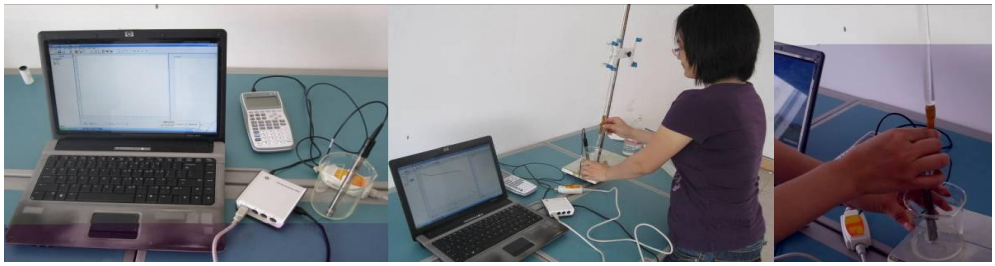
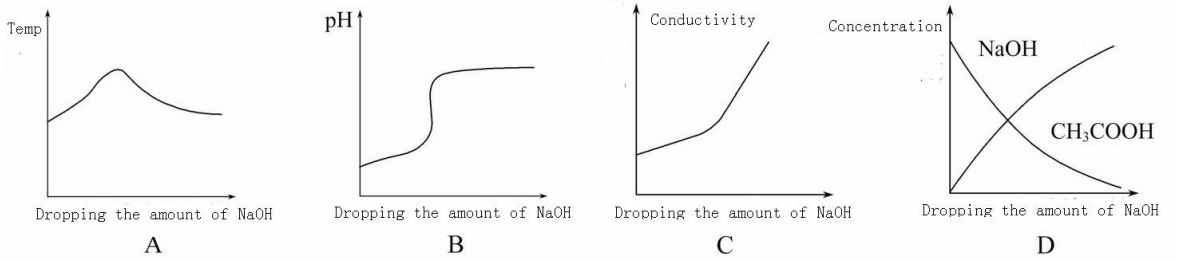


Figure 1: Mobile Calculating Laboratory (MCL)

2. Questions

(2009. NEMT, Liaoning Province) Titrate dilute solution sodium hydroxide into dilute solution ethylic acid, in the follwing charts showing the changing trend of the mixed liquid's quantity or character, which one is false?( )



This is a question from the chemistry National College Entrance Examination in Liaoning Province, 2009. This question, set in acid-base neutralization titration, tries to inspect students' understanding of the change of temperature，pH value, and concentration. There are lots of disagreements among the students who work on it, especially in Options A and B. And the MCL has the temperature and pH value sensors. So, with students' proposal and a chemistry teacher's instruction, we got the graph of titrated hydrochloric acid by sodium hydroxide

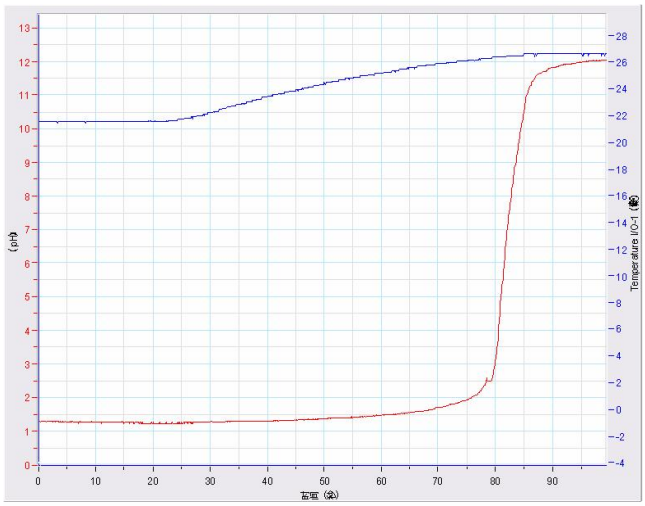


Figure 2: Temperature curve in red and pH curve in blue

We can see directly from this graph, the rising temperature shows that the neutralization reaction is an exothermic reaction. And then in the process of neutralization titration pH will jump remarkable. Aroused by this, we design and guide students to finish two experiments, and try to analyze the result using math as a tool. In this process, students not only gain a profound understanding of neutralization reaction between acid and alkali, but also acquaint the math applying directly, and know the importance of mathematics tool. We can see the improvement of students' mathematics applying ability from their calm thinking and fiery-hot enthusiasm.

3. Experiment1: The impact of concentration on the pH

3.1 The process of experiment

Apparatus:

Data collector and pH sensor, acid burette, breaker,
2mol/L liquor NaOH 2mol/L liquor hydrochloric acid, distilled water
Aim:
Drip distilled water into liquor hydrochloric acid, observe the change of pH,
acquaintance how to use the data collector.
Method:
Package the experimental equipment.
Put 1ml HCL into the beaker.
Collect data and drip distilled water into liquor hydrochloric acid.
Output the collected data into computer and analyze it[2].

3.2 Result and discussion

3.2.1 Experiment phenomenon:

Liquor hydrochloric acid's ph value will sharply rise from 2 to 6, showing the hydrogen ion concentration come down when the liquor hydrochloric acid has been diluted.

3.2.2 Chemical analyses of the result:

At the beginning 40s, the pH value curve doesn't change sharply and erratically. It may be due to the imperfect experimental equipment, asymmetric liquor hydrochloric acid and non-standard experiment operation.[2]

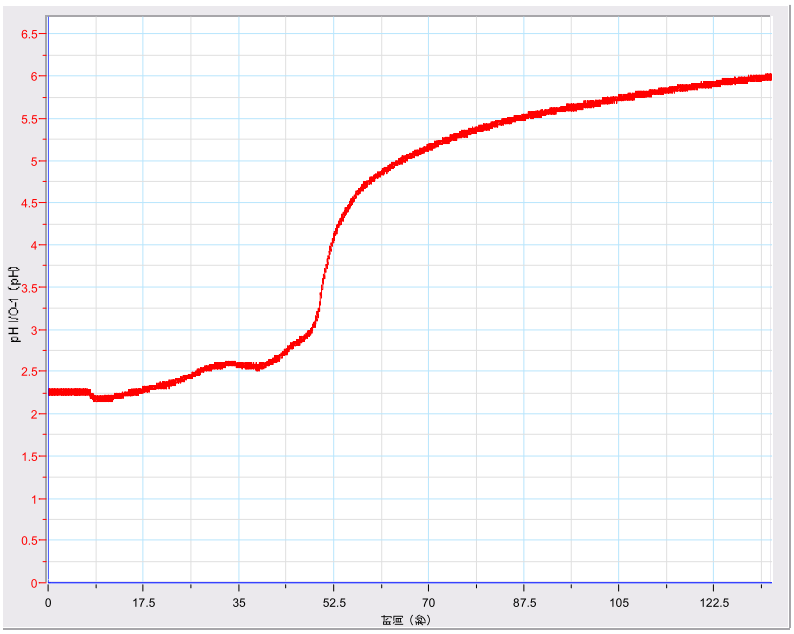


Figure 3: Dilute hydrochloric acid' pH—Time'

3.2.3 Mathematics analyses of the result:

We analyze the curve, ignoring the erratically part in the curve. From 49s to the end of the ending part, the pH value goes up continuingly. And the pH value is proportional to time. So we guide students to find out the pH value's approximate logarithm function image.

How can students explore the relationship between time and pH value, and go a step further to the relationship between concentration and pH value? After students' discussion, they chose following data from the experiment to do regression analysis.

Table 1 : Dilute hydrochloric acid' pH—Time'

time	48	53	58	63	68	73	78	83	88	93	98	103	108	113	118	123
pH	2.95	4.21	4.71	4.91	5.09	5.25	5.34	5.44	5.53	5.59	5.64	5.70	5.78	5.82	5.88	5.91

Output the data into EXCEL and do a scatter diagram as below.

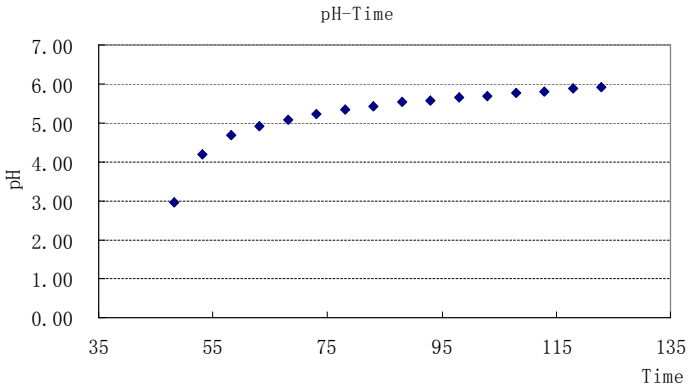


Figure 4: Dilute hydrochloric acid' pH—Time'

Do the linear regression for data.

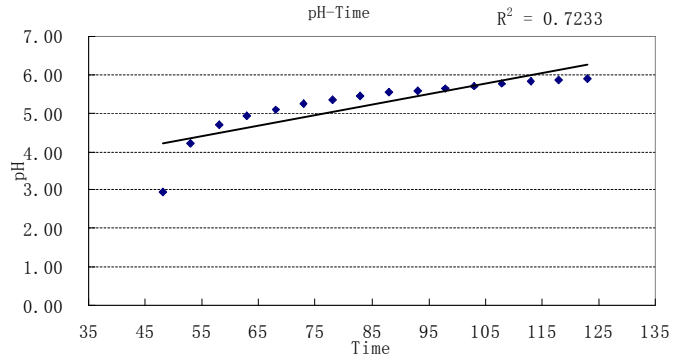


Figure 5: Linear regression

Add trend line and fit the data with logarithmic function.

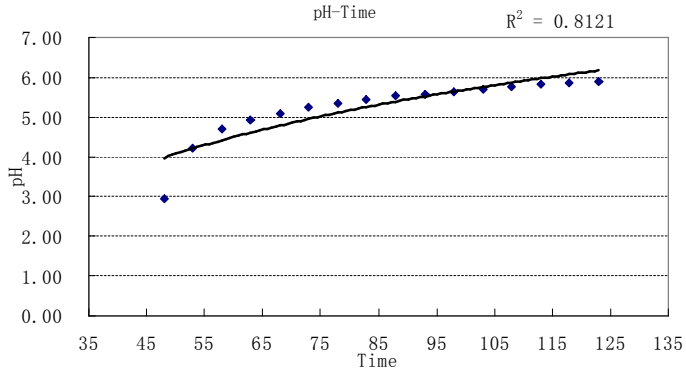


Figure 6: Result of fitting the logarithmic function

Do the data fitting with 5 factorial Polynomial:

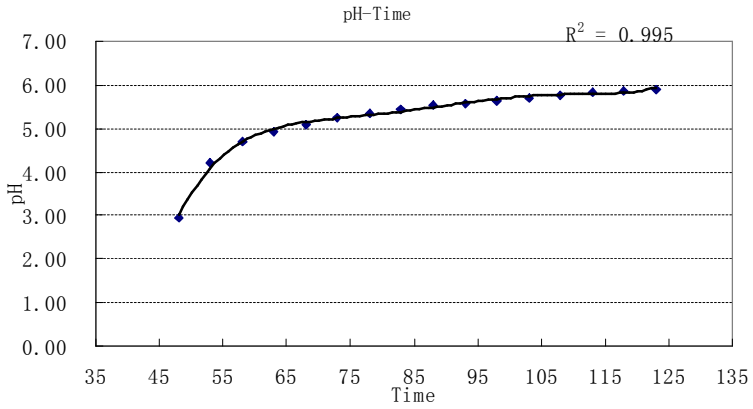


Figure 7: Result of fitting the 5.factorial Polynomial

Obviously, the fitting effects of above 3 regression models are quite different. To compare the fitting effects, we work out these three models' correlation coefficients: R^2=0.7233，R^2=0.8121，R^2=0.995. We can see logarithmic function fitting is better than linear extraction fitting. But the 5.factorial Polynomial fitting is much more accurate, so we couldn't decide the curve is a logarithmic curve.

PEP High School mathematics text books (Compulsory3 and Optional 2-3) talk about regression analysis. But because of the huge calculated amount, it is hard for students to finish handwork, and doesn't contribute to students' understanding of regression analysis. In the above experiment, students go through the whole process of collecting, sampling, analyzing and fitting with tool-ware. They achieve a deeper understanding of regression analysis and gain the preliminary regression analysis ability.

3.3 Prolongation and transference

In this experiment we also choose the same node time by repeated experiments, record the liquor's cubage at the moment, calculate concentration according to HCL's molar mass, then do the relation image between concentration and liquor's pH value.

Table 2: Dilute hydrochloric acid' pH—Concentration'

No.	Time	pH	Volume	Concentration	No.	Time	pH	Volume	Concentration
1	48	2.95	8.45	0.000237	9	88	5.53	682.30	2.93E-06
2	53	4.21	27.10	7.38E-05	10	93	5.59	769.10	2.6E-06
3	58	4.71	110.35	1.81E-05	11	98	5.64	880.60	2.27E-06
4	63	4.91	173.25	1.15E-05	12	103	5.70	1009.55	1.98E-06
5	68	5.09	254.00	7.87E-06	13	108	5.78	1232.85	1.62E-06
6	73	5.25	349.45	5.72E-06	14	113	5.82	1325.20	1.51E-06
7	78	5.34	441.30	4.53E-06	15	118	5.88	1510.55	1.32E-06
8	83	5.44	557.25	3.59E-06	16	123	5.91	1611.35	1.24E-06

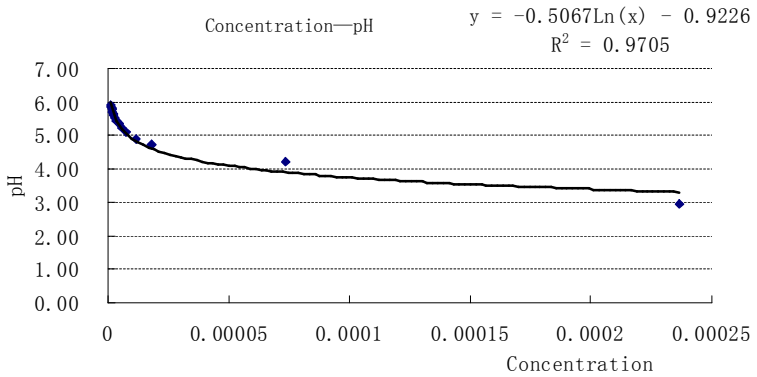


Figure 8: Dilute hydrochloric acid' pH—Concentration'

HCL is completely ionized by strong electrolyte, so the hydrogen ion concentration is close to hydrochloric acid concentration. Because pH=-lgC(H^+), the liquor's pH value and concentration are negative log functions.[3]

Regression analysis is done to scatter diagram, the logarithmic function model employed, R^2=0.9705. It indicates that we do a good job in data fitting. It also proves the relationship between hydrogen ion concentration and pH.

To help students to gain a profundity experience of linear regression thoughts and operational method, we guide them to do the following analysis by using graphing calculator to simulate the processing method in experiment 1.

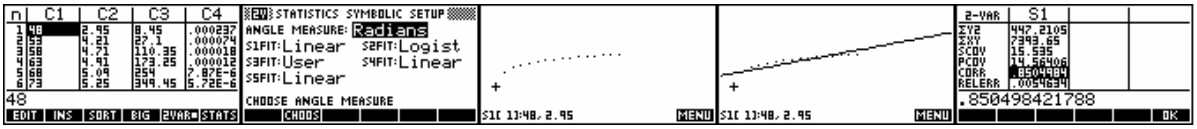


Figure 9: Students use graphing calculator to analyze the data of experiment 1

Linear regression, phase relationship for 0.8504984, and numerical computing results are consistent with Excel. However, due to the only use of the graphing calculator, only the correlation coefficient of linear regression model is attained. So the question, that how to compare linear regression model and the logarithmic model fitting effect, arises.

After discussions, students think regression analysis of an important role to play in the accurate forecast, predict whether or not a fitting model can compare the advantages and disadvantages.

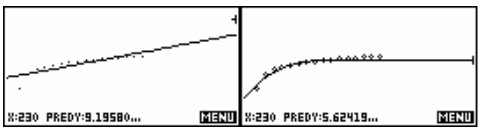


Figure 10: Students gain compare linear regression model and the logarithmic model fitting effect by applying the graphing calculator

Therefore, from the diagram above, we can see when 230s, if linear regression model is used, it is already alkalization, and it is absolutely wrong. As a consequence, in comparison, logarithmic model is more accurate. Through this process, students can have a profound understanding of the model choice of regression analysis, the analysis of the fitting effect.

Graphing calculators fail to provide high order polynomial fitting model, thus more than third-order fitting models can not come true in a calculator. For the relationship between solution concentration and pH , the direct use of logarithm model of fitting result appear not ideal. Since the negative logarithmic relationship between known pH and hydrogen ion concentration has been shown, it's possible to customize fitting models $f(x) = -\ln(x)/\ln(10)$ in the graphing calculator custom, as shown in figure, which verifies the relationship between pH and hydrogen ion concentration.

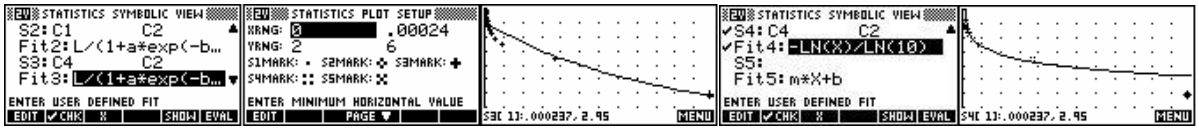


Figure 11: Fitted model $f(x) = -\ln(x)/\ln(10)$'s impression drawing

4. Experiment2: Liquor sodium hydroxide titrate liquor hydrochloric acid

4.1 The process of experiment

Apparatus:

liquor hydrochloric acid （pH=1）, liquor NaOH (pH=12)

base burette ,beaker, iron support, titration, data collector and pH value sensor, glass rod

Aim:

Titrate liquor hydrochloric acid （pH=1）by liquor NaOH (pH=12).

Make use of data collector to get acid-base neutralization titration curve.

Try to analyze the experiment and understand titration jump.

Method:

1. Package the experimental equipment.
2. Put liquor NaOH (pH=12) into base burette; put 1ml liquor HCL(pH=1) into 50ml beaker.
3. Connect the data collector to computer; connect pH sensor to data collector; turn on the "World Explore" software; collect data.
4. Put pH sensor into liquor lightly, then collect data.
5. Drip liquor NaOH, and observe the data change in data collector

4.2 Result and discussion

4.2.1 Experiment phenomenon:

In this experiment, from the beginning to 80s, liquor's pH value doesn't change sharply; it stabilizes in 1-2,. The liquor presents acidity. But in 80s to 85s, the liquor's pH value goes up quickly, from 2 to 11. The liquor presents alkalescency.

4.2.2 Chemical analyses of the result:

At the beginning of the experiment, sodium hydroxide is neutralized by hydrochloric acid quickly, the liquor is still acidic. From 80s to 82s, hydrochloric acid almost completely reacts, the liquor is neutral. Once we drip into sodium hydroxide, the liquor shows alkalization immediately. In this 5s, students describe the experiment as pH value revulsion. After referring to relevant material and consulting to the chemistry teacher, students know this process is called pH jump.[4]

4.2.3 Mathematics analyses of the result

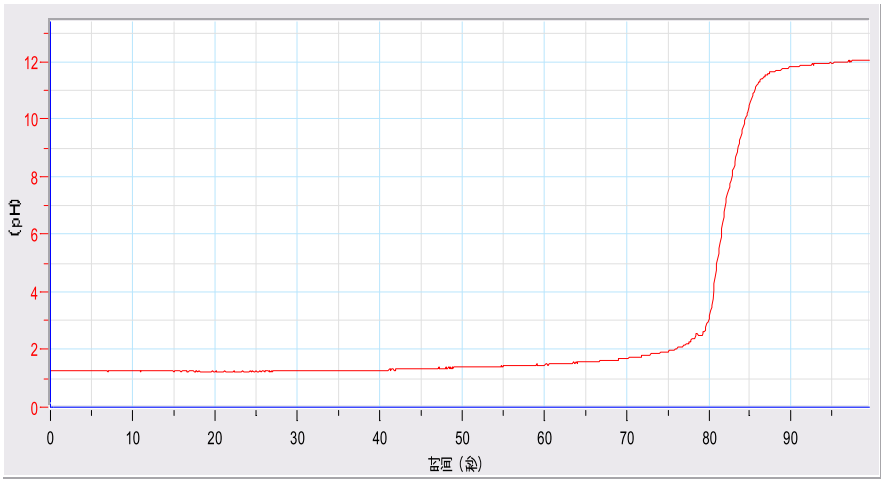


Figure 12: Liquor sodium hydroxide titrate liquor hydrochloric acid

In this process, the chemistry teacher asks students a question: "When is the end of neutralization reaction between acid and alkali?

After observing the pH value curve, students find that, at the beginning of the experiment, pH value curve slope is gentle. And then, the pH value jumps, pH value curve slope becomes cliffy. In the curve slope, it changes greatly firstly and then becomes gentle. That is to say, the slope reflects pH changing of the liquor. So, how can we describe the slope of curve?

Students bring forward that we can use derivative as a tool to differentiate the pH value curve. The curve is as follows:

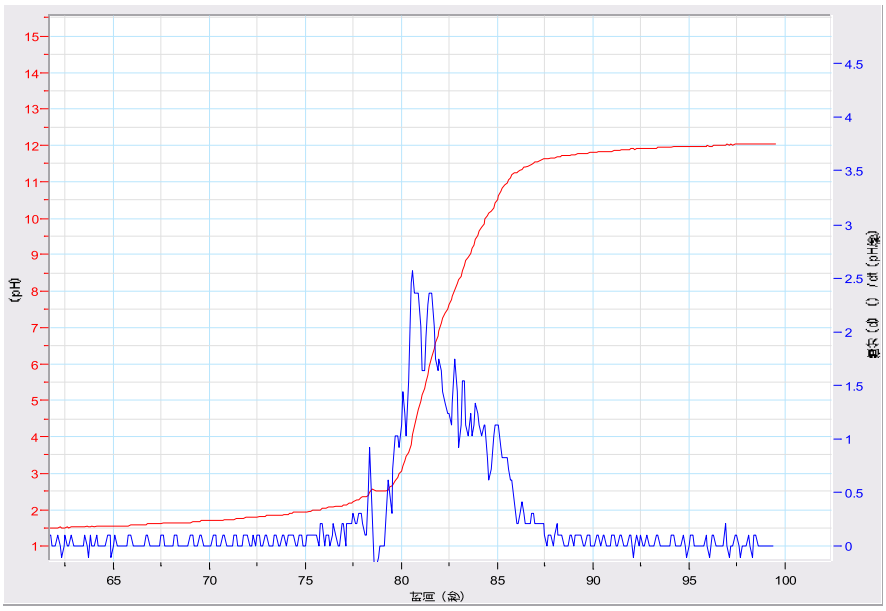


Figure13: Derivative curve

The steepest point in the pH value curve is the end of neutralization reaction. And when it reflects to the derived curve, it locates in its extreme point.

In this process, students go a further step to understand the geometric meaning of derivative. And students can use derivative as a mathematics tool to analyze and solve problems consciously, showing strong awareness of mathematics applying.

5. Conclusion

The difference between mathematical thinking and scientific thinking is that the mathematical thinking is totally abstract and non-experimental. That is also what most students think of. But it does not mean that mathematics is far from reality and application. On the contrary, it is precisely because the mathematics thought is highly abstract that it can be applied in the chemistry, physics and real life. So, as a mathematics teacher, we should not only teach students mathematical knowledge, but also mathematical thinking, and help them develop the skills to solve problem drawing upon mathematical thinking.

Mobile Calculating Laboratory (MCL) provides every student with such a technology platform. On this platform, every student uses mathematical tools to study the problems of the real world here and there. In Professor Wang Chang pei's words, it can make all students gain the opportunity to obtain an e-mathematical experience[5].

In the process of exploring this experiment, teachers and students decide the direction of research together. Drawing upon students' nearby examples, choosing a difficult example from chemistry discipline, raising the questions, the design of solution, observation of experimental phenomena and the analysis of experimental results, etc., students are deeply involved in. In the process of discussion, analysis and exploration, the nature of mathematics as a tool reflects very obviously, especially after students experienced the whole process of putting forward the problems and solving them. It plays a great role in improving learning confidence and developing the mathematics thinking.

In this experiment, without MCL's technical support, the chemistry teacher can only use the traditional indicator to study acid &alkali neutralization reaction qualitatively, while the mathematics teacher can only to lecture thoughts of regression analysis strenuously, so students can only to memorize geometrical meaning of derivative mechanically. Thanks to MCL, chemistry teachers have a new way of the experimental teaching, mathematics teachers can lead students to use mathematical thinking to analyze and solve the problem. What' more, students could actually find mathematics interesting, useful and natural.

Of course, this also gives the teachers work in the front line a further research direction, such as, whether mathematics teaching can pay more attention to the intersection disciplines and practical life problems, close to students' development areas, apply all kinds of technology, design research topics, give full license to students to do study by themselves. During this process, students' understanding of mathematical concepts, acquaintance of connection between mathematics and daily life will be sublimated. The transformation from "learn mathematics" to "use mathematics" will be realized.

References:

[1] **Zhang Jingzhong**. *Entering into Mathematics Education* [M] **Science Press**

[2] **Qian Yangyi**. **(2006)***Handheld Technology in the Application of Research-based Study and Psychological Foundation* [M], **Beijing: Science Press**

[3] **Qian Yangyi**. **(2003)** *Handheld Technology in Science Experiment Research on the Application* [M], **Beijing: Press of Higher Education**

[4] **Li Jinzhu, Xie Shaoli, Li Hong, Zhong Minghua**. *Handheld Technology in the Research on the Application of Acid-base Titration*, Jiangxi Chemical Industry, 4, 2010

[5] **Wang Changpei, A report in 2011**, http://202.112.84.61/~caoym/bbs/viewthread.php?tid=166&extra=page%3D1