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# Enlightening Chinese Science Education with American Educational Technology

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## Abstract

Chinese science education has achieved significant goals, but it can be improved by introducing appropriate technology. IBM's Personal Science Laboratory (PSL) is a promising new system that is enthusiastically supported by American science instructors. The instructional <u>method</u> of Chinese science education and the PSL's instructional <u>mode</u>l are introduced. Elements of the Chinese method are analyzed against American educators experience using the PSL system. Finally, the historical and cultural framework surrounding Chinese education and suggestions for introducing the PSL are presented.

## INTRODUCTION

China has accomplished significant achievements in science education, especially in basic research. The Chinese students continued success in the Youth Academic Olympics demonstrates their theoretical expertise. However these awards only reflect their academic prowess; they do not attest to their technical skills, which, in fact, are lacking. This deficiency is a formidable barrier to the country's continued development because the practical skills necessary to perform technical experiments are also required to invent and pursue innovative technologies.

As a result, Chinese investigators of United States science education heed the role of educational technology in the curriculum. Advanced technology can significantly enhance Chinese primary and secondary school science education.

The authors investigated primary and secondary science education in the United States in the past half year. They interviewed teachers and scholars, visited elementary and high schools, and performed a detailed study of the IBM Personal Science Laboratory (PSL) system, which is a technology designed to supplement primary and secondary school science education.

The Chinese science education method is presented. The PSL system is discussed. Shortcomings of the Chinese method and how the PSL can fill these deficiencies are discussed.

## I. CHINESE SCIENCE EDUCATION INSTRUCTIONAL METHOD

The basic Chinese scientific instructional method follows:

***Observation***
|
***Summarization***
|
***Experimentation***
|
***Exercise***

In the OBSERVATION step, teachers demonstrate experiments and use heuristic methods to guide students and motivate their interest. These steps include listing physical phenomena in their daily life, what they have seen, what they have done and ask questions. Teachers use this step to introduce the theory behind the scientific concepts.

In SUMMARIZATION, teachers perform theoretical analysis and derive the relevant scientific laws and theorems.

In the third, EXPERIMENTATION, students start their own scientific experiments under the teachers' instruction and try to verify the theory introduced in the second step.

Students use the theories taught in the preceding steps to perform EXERCISES (homework), which further reinforces their understanding.

Chinese scientific education strongly emphasizes the use of textbooks, and centers on teacher explanations, examination, exercises and uniform experiments. They do not use advanced education technology in their courses and Chinese educators nationwide rigorously adhere to this method.

## II. IBM's PSL AND ITS INSTRUCTIONAL MODEL

The PSL's structure and function are shown in the Appendix. The system is a microcomputer–based laboratory (MBL) that is capable of conducting physics, chemistry, and biology experiments to students from high school through university freshmen levels. IBM has designed 40 experiments for this system covering temperature (8), light (8), pH (10) and motion/kinematics (10). Furthermore, the PSL software has provisions for teachers and students to design their own experiments.

The PSL features straightforward operation, research grade components, and advanced software. The system simultaneously acquires, processes, and graphs data on the computer screen in real time. This capability enhances the experiment and makes abstract scientific concepts more tangible. It also encourages curiosity and exploration. Both are critical to the scientific investigation process and comprise the central design feature of the PSL system.

The PSL's instructional model is based on the learning cycle proposed by J. M. Atkin and R. Karplus. This model can be summarized as the five "E"s:

***Engagement***
***Exploration***
***Explanation***
***Elaboration***
***Evaluation***

The process starts with students ***engagement*** of the problem. They then use the PSL to ***explore*** the phenomena, present an explanation, following the teacher's ***elaboration*** , and finally both students and teachers form an evaluation of the experiment and the concepts conveyed.

Comparing the Chinese method with that of American educators using the PSL reveals deficiencies in the Chinese approach. This comparison also highlights the PSL's benefits to students and educators.

## III. CHINESE SCIENCE EDUCATION METHOD vs. AMERICAN METHOD USING THE PSL

*A. Explanation vs. Exploration*

Chinese education emphasizes the introduction of scientific conclusions, but methods using the PSL places more emphasis on the discovery process behind the laws.

The Chinese method uses established experiments and procedures to teach concepts. Teachers concentrate on the introduction of existing scientific theories and assign heavy homework loads to reinforce students basic understanding prior to experiments. Most of the students never question the accuracy of the information presented. Even though some students wish to explore new phenomena, they do not have the time nor the environment to seek the answers. This is due to the rigidly structured nature of primary, secondary and university science education.

This type of methodology allows students to establish a solid base of physical theories early in their education, which helps them solve more complicated problems when they reach an advanced level. However, it also encourages students to accept others' conclusions with minimal questioning and reduces their natural curiosity.

In contrast, American teachers using the PSL guide the students' investigations and helps them to formulate relationships and conclusions. For example, when explaining the relationship between distance, velocity, and acceleration of a pendulum, students observe three different curves on the computer screen. The students assignment is to explain the phenomenon and formulate their own physical model.

*B. Uniformity vs. Creativity*

The Chinese education method emphasizes uniform training while methods using the PSL promote individuality and creativity.

Currently all Chinese textbooks in a given subject are identical; the education methodology is uniform and the examinations are standardized. In terms of physics experiments, all teachers rigorously abide by the same procedures. Education proceeds in incremental steps. This training approach and the emphasis on conclusions bury the student's individuality and creative spirit.

In the United States, although the textbooks are very similar, the system encourages students and teachers to design their own experiments, reach their own conclusions, and evaluate their own experiments. The PSL instructional model shows the way: in a pH experiment, some students may like to use chemical solutions while others find it more informative to measure the acidity of various fruits. Students are not restricted by the apparatus or the model. Experiments and teaching can be individualized, which promotes active student participation and learning.

*C. Text Books vs. Reality*

Chinese education places its emphasis on textbooks while the PSL methodology balances both theoretical concepts and practical skills.

Chinese education emphasizes textbooks as self-contained knowledge sources; a principle goal is for students to complete the difficult exercises. This tendency of stressing theory over practice is a long existing problem. The principle reason is that teachers are trained at normal universities, where the instruction is almost completely unified and theoretical. Furthermore, the nation's textbooks are edited by professors from these same normal universities. While this approach is effective in training educators versed in teaching physical theories and concepts, it fails to address the practical use of these theories. Consequently high school teachers and textbooks cannot teach students to address their knowledge to real world physical problems.

The PSL system promotes intellectual and practical skills simultaneously. Textbooks are a reference, not the sole source of education in a particular area. Hands-on training is a principle part of the curriculum. Students can use the PSL system to perform standard textbook experiments or use it to design their own experiments. For example, one educator gave his students a problem in harmonic motion. His students used their theoretical training and the PSL to design and run a set of independent experiments that together provided the desired information. The PSL was central in this exercise, and as in most explorations with the system, enlarged the students conceptual knowledge while demonstrating the concepts practical application.

The previous analysis suggests the PSL can augment Chinese Science education. An investigation of the social constraints surrounding the process will explain the structure of the Chinese method the applicability of the PSL system.

## IV. SOCIAL CONSTRAINTS AND SUGGESTIONS FOR IMPROVEMENT

Economic, cultural, and practical constraints have shaped Chinese education. The main differences between American and Chinese science education and suggestions for using the PSL to improve Chinese science education are discussed below.

### *1. Education Technology Mirrors a Nations Development*

Students in the United States have opportunities to explore. This opportunity is related to the high social productivity and the wealth of the nation. The PSL instructional model is a good summarization in terms of the use of technology in the classroom. It reflects the willingness of society to apply advanced technology towards education and improved practical experience.

Chinese schools concentrate their science and technology efforts around texts because they have insufficient funding. Government support has been directed at perfecting technology that can help solve pressing problems such as food shortages, diseases etc.

The question facing Chinese policy makers is "Should China wait for further economic growth before improving its education system?" The answer from education professionals is a resounding "No!" A nations educational quality is a key factor in economic development. On the basis of research by Chinese educational economists, the growth rate of education investment should be faster than the growth rate of GDP in a developing country[1]. It is necessary to give education a priority position in the government agenda in order to promote further modernization. For instance, it is feasible to allocate at least one complete PSL system to key Chinese schools which would allow the students to begin practical training using an advanced, technological education "tool." As this process consistently continues, the application of the new technology will improve the quality of the students, and thus have a positive effect for the future development of the nation.

### *2. Education is Related to Cultural Background*

The United States is a relatively new country. Exploration is central to the nation's history. American students freely question their teachers and the

[1] Li, I Ning, *Zhongguo De Jing Ji Gai Ge Yu Fa Zhan*, 1984

curriculum addresses intellectual and social skills. However, it has been severely criticized for not adequately stressing mastery of academic skills[2]. In fact, American students are sometimes characterized as being academically undisciplined.

In contrast, China is a nation with an extensive culture and history. Pursuing intelligence is seen as an intellectual and respectable behavior. Books are central to the pursuit of knowledge and they are an important, inexpensive information carrier to understand the outside world and newer technology. Textbooks and publications by top scholars are seen as the most accurate sources of information. These scholars define the current intellectual view. In this cultural context, educators can use books to their fullest potential and have little reason to adopt changes in the curriculum. In addition, for thousands of years questioning teachers, and hence the books, was not acceptable.

Chinese science education can be improved by motivating students to play an active role in learning, developing their abilities and encouraging their creativity while improving their fundamental academic skills. Incorporating the strengths of United States science education with the Chinese structure will offer a new scientific education future. From a practical point of view introducing advanced education equipment, such as the PSL, and appropriate teaching methods to China will be a start of this change.

*3. Meritocratic Education System*

China is a developing country with highest population in the world. The success in academic subjects is the principal route to further education and high status employment. Chinese education uses a strict merit system.

The United States has ten times more universities than China, but only one-fifth the population. Thus, it is understandable that the system in China is conducive to strenuous intellectual achievements. However, it greatly shortens the students' time to explore and obtain hands on training. Only the most competent students who have the ability to complete their curriculum task, win international academic competitions, or obtain admission to the top American universities are rewarded. There are few benefits or opportunities to pursue activities beyond the curriculum, such as improving practical and technical skills.

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[2]Ranson, Baldwin, "Education For Modernization: Meritocratic Myths in China, Mexico, The United States, and Japan" *Journal of Economic Issues,*, Vol. XXII, No. 3, September 1988

Unfortunately this single pursuit of excellence in the curriculum subjects compromises China's ability to broaden the education experience.

Chinese educators and policy makers recognize the limitations inherent to the existing science education method. Fortunately they have begun investigations to determine the appropriate changes for improving science education.

## V. CONCLUSION

There are many differences between science education in China and the United States. China should try to absorb the United States strengths by learning their use of technology, encouraging exploration, creativity and closely relation among theory, experiments and reality. For this purpose, it is suggested that China should introduce advanced educational equipment such as PSL system, reset the relation between economy and education, for example, increase the educational investment, renew the perception of intellectuals, consistently continue the educational reform. Chinese educators need to conduct further in depth study and investigation of the education in the United States and other developed countries.

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# Appendix

## Table 1: PSL Hardware Components

| **Computer <–>** | **Base Unit <–>** | **Module <–>** | **Probe –<–** |
|---|---|---|---|
| The software is PSL explorer. It provides a friendly interface for the user, using menus to control PSL. | It is the control center of the PSL, linking the computer to the data acquisition probes. It processes signals and relays them to the computer over a cable. A single PSL base unit can accommodate up to four modules at once–of different types, if desired. | Provide command and control electronics specific to each type of probe. | Collect information through a sensing device: Temperature Light, pH Distance, etc. |

# Figure 1: The PSL System

## 2. The IBM Personal Science Laboratory

The IBM Personal Science Laboratory (PSL) is a flexible, and powerful microcomputer-based laboratory (MBL). PSL consists of hardware and software, working together to provide the optimal science learning experience.

### The Names of PSL Components

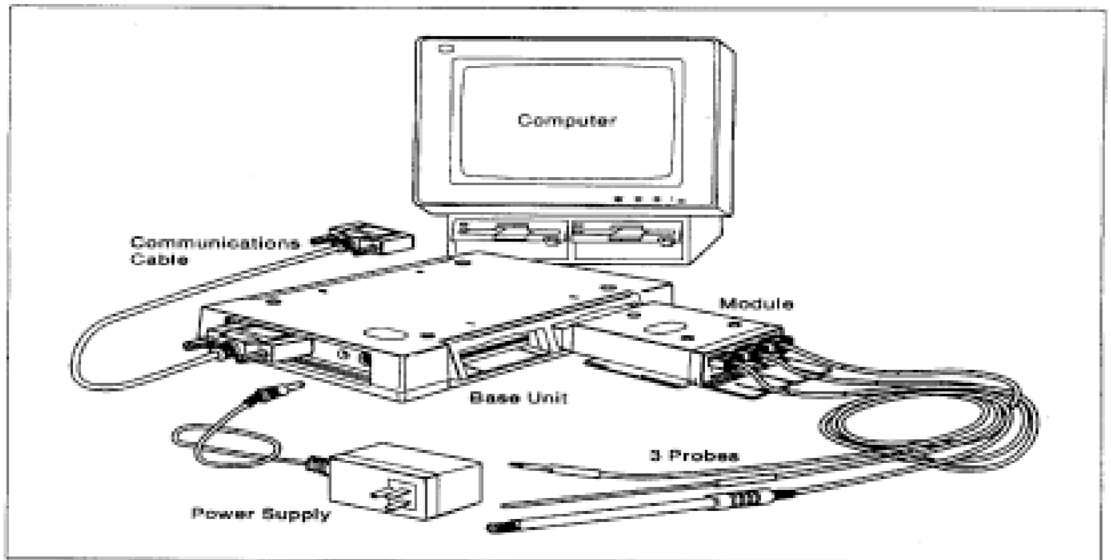


*Figure 1. IBM Personal Science Laboratory*

### The Hardware Components

The hardware for PSL consists of a *base unit* with *modules* and *probes*, plus the power supply and communications cable.

**Probe** Contains the sensing device.

**Module** Provides electronics specific to each type of probe. (To extend a PSL's capability, only another module or probe is required.)

**Base unit** Is the control center of a IBM Personal Science Laboratory, performing commands from the computer, collecting data from the probes, and sending that data back to the computer over the communications cable.