

## The Scientific Inquiry in the Standard of the Primary Science Curriculum in China - the Intended and the Reality

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### Abstract

This is an important article in providing a clear introduction to the standard of the primary science curriculum in China. The aim of a primary science curriculum is to cultivate scientific attainment among the youngest groups of students. In teaching and learning science, scientific inquiry should be made the most important part of the process, so that it will develop the attitude of making science, loving science and applying science. This will produce pupils who can master scientific knowledge and skills; possess positive scientific attitude, value and perception; and widen their understanding of the nature of science. As a result, this can promote and develop the scientific attainment and achieve the targets of science education. To ensure deeper understanding of the primary science curriculum in China, this article will present the aims of scientific inquiry, curriculum structure and contents, pedagogical recommendations and suggestions for evaluation. However, after seven years of implementation, have China achieved these intended new curriculum?

**Key words:** Science education, science curriculum, primary science, scientific inquiry, Chinese education.

## 1. Introduction

In June 2001, the Chinese government decided to drastically reform the Basic Education curriculum. This includes the changes in the system, structure and content of the curriculum to fulfill the needs of a new Basic Education System which includes the pre-school, compulsory school and ordinary senior high school education. Thus, the Ministry of Education of China (thereafter MoE) issued a circular entitled “The Guidelines for Curriculum Reform of Basic Education Curriculum” (thereafter “The Guideline”). It pointed out that “The previous system has over-emphasized on passive, rote and training-oriented learning. Hence the change should promote pupil’s active participation, heuristic inquiry, active learning; develop skills to master IT, to acquire new knowledge, to analysis & solve problems and to communicate & collaborate.” “The Guideline” also stated that science should be taught in primary school from Year 3 to 6 (age 9 to 12). In September 2001, the MoE distributed a booklet entitled “The Standard of Primary (Year 3-6) Science Curriculum” (thereafter “The Standard”) which clearly presented the aims, contents, teaching strategies, assessment, curriculum resource development, etc. of the primary science curriculum. This article will only focus on the scientific inquiry described in “The Standard”, the present achievement and explore the possibility to further research the success of the implementation of this new curriculum. It is hope that more readers will understand the science education reform scenario in China and further create collaboration and draw lesson from it.

## 2. The purposes of the science curriculum

“The Standard” stated that the new primary science curriculum is design to cultivate scientific attainment. The basic principle of the science curriculum is that: the curriculum should aim at the pupils as a whole; pupils should be the main subjects of the learning of science; scientific inquiry should be the core of science learning; the contents should fulfill the needs of both the society and pupils; the curriculum should be open-ended; the assessment should be able to promote the cultivation and development of scientific attainment.

“The Standard” has outlined the aim and objectives of the science curriculum. The aims are: through the science learning, pupils will be able to relate daily phenomenon with some surface scientific knowledge, thus enable them to apply it in their daily lives which will gradually develop scientific attitude and life style among them; pupils will understand the processes and methods of scientific inquiry, thus are willing to try some scientific investigation activities and learn how to see and think of problems scientifically; maintain and develop the sense of curiosity and desire to seek

knowledge in the surrounding environment of the pupils which will eventually shape more adventurous imagination, greater sense of respect to scientific evidence, cultivate innovative & scientific attitude, love of science and the country; appreciate and approach the natural environment, treasure lives, actively engage in protecting the environment and natural resources and aware of the new technological development. Among the objectives are to promote scientific inquiry, attainment and knowledge. These three objectives do not stand alone, rather they are inter-related.

## 3. The scientific inquiry

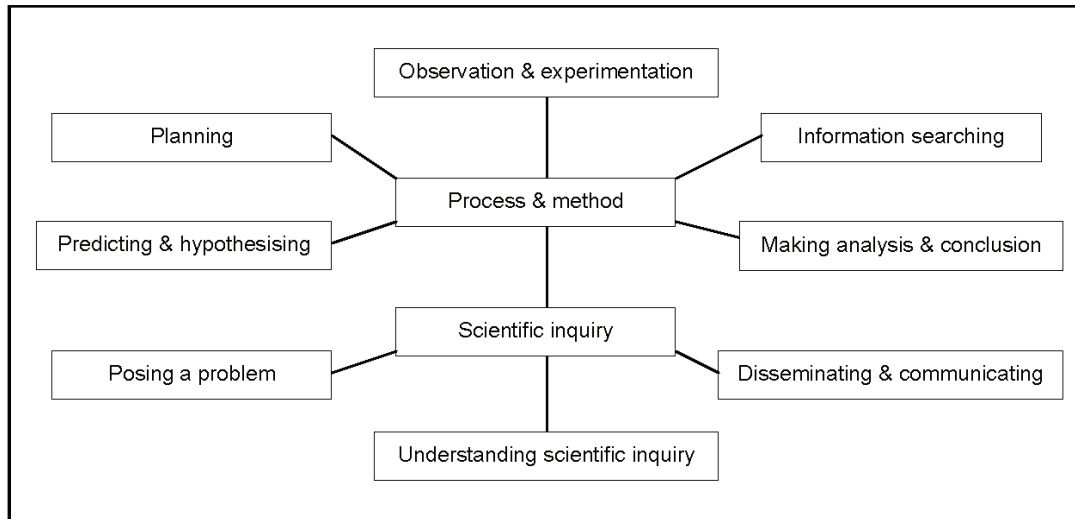
“The Standard” has explicitly stated that scientific inquiry is the core of the science curriculum which can achieve the below objectives:

- a. to know the main activities related to scientific inquiry and understand the basic features of scientific inquiry.
- b. to be able to pose problems/hypotheses through the observation of the surrounding environment.
- c. to apply knowledge available in attempt to generate hypotheses for the problems.
- d. to design simple plans for scientific inquiry activities according to the hypotheses.
- e. to carry out investigations through observations, experimentations, etc.
- f. to be able to refer to and organize scientific information obtained from external sources.
- g. to be able to explain and conclude results through simple analysis based on knowledge, experience and information at hand, and aware that the conclusion can be replicated through further experimentation.
- h. to be able to present results in a confident manner, engaging in communication and discussion, understand that criticizing and questioning others’ investigation results is a part of scientific inquiry.

### 3.1 The contents of scientific inquiry

As the core of science learning, scientific inquiry does not just let the pupils experience the joys of making investigation, to be confident and develop critical thinking, it also can help them to learn how to differentiate between what is science and what is not. Scientific inquiry involves posing problem, predicting, planning, observing, experimenting, collecting evidence, synthesizing, communicating and so on. To the higher level, it also involves the understanding of scientific inquiry such as the features of scientific inquiry.

The development of scientific inquiry ability is dependence on the learning activities and investigation of the pupils. The use of scientific



**Figure 1: The standard contents of scientific inquiry**

knowledge in hands-on activities will provide valuable experience in constructing meaningful learning which cannot be taught simply through conventional chalk-and-talk classroom teaching. At the primary school level, the standard of scientific inquiry ability should not be too high. It must take into the consideration of the pupils' young age, gradually from giving plenty of assistance until they can work independently. In practical, the scientific inquiry can involve one or a few parts of the teaching process, though ideally it should involve the whole process.

Referring to Figure 1, below is the description of each content as documented in "The Standard":

*a. Understanding scientific inquiry:*

- i .knowing that scientific inquiry involves posing problems, solving problems and comparing own results with the scientific discussions.
- ii .knowing that different problems require different methods of investigation.
- iii.knowing the reason for using an instrument is more effective than using only human senses.
- iv.experiencing the importance of evidence, logical thinking and use of imagination in making hypothesis in scientific inquiry.
- v .understand that the result of scientific inquiry can be replicated.
- vi.knowing that questioning the results of other scientific investigations is a part of scientific inquiry and by doing it appropriately is a source of scientific advancement.
- vii.knowing that communicating and discussion can lead to new thinking.
- viii.knowing that scientific inquiry can further obtain new experience, imagination, methods and skills.

*b. Posing a problem:*

- i . can pose problems about the surrounding matters from asking simple questions like "what is this?", "why is it like this?", etc.
- ii . can choose a problem that is suitable for own investigation.
- iii. can compare and evaluate the problems posed.

*c. Predicting and hypothesizing:*

- i .can employ knowledge and experience available to make inferences to phenomena observed.
- ii .can differentiate between hypothesis and reality.

*d. Planning:*

- i .can suggest a thinking framework of an activity for investigation.
- ii .can suggest workable plan for the problems in a small group or individually.

*e. Observation and experimentation:*

- i .can use senses to feel the natural phenomena and relate to the features as observed into drawing or writing.
- ii .can use simple instruments (hand magnifier, microscope, etc.) to make detail observation of objects and describe them using drawings or writing.
- iii .can use simple measuring instruments (ruler, balance, scale, measuring cylinder, thermometer, stopwatch, etc.) to make persistent observation, collect data and make simple record.
- iv .can use simple materials to make simple observational experiments and record the results.
- v .can manipulate the variables to make simple investigative experiments, design simple experiment reports and diagrams.

- vi. can create simple scientific models.
- vii. can create technological innovations through the use and combination of knowledge.

*f. Information searching:*

- i. can refer to magazines and other sources of information.
- ii. can use simple tables, diagrams, statistics, etc. to organize related information.

*g. Making analysis and conclusion:*

- i. can try different ways of analysis to make sense of the numbers and make logical explanation of the phenomena.
- ii. can suggest more than one explanation for the same phenomenon.
- iii. can reflect on own investigation procedures and make comparison between the results and the hypotheses.

*h. Disseminating and communicating*

- i. can choose a confident method (speech, writing, diagram, model, etc.) to disseminate the procedures and results of the investigation.
- ii. can listen and respect critiques and comments from others.
- iii. can make evaluation on the procedures and results of the investigation, and exchange ideas with others.

### 3.2 Pedagogical recommendations

It is suggested in “The Standard” that scientific inquiry should be the core teaching method. The scientific inquiry activity should follow the principle of moving from simple to complex, from imitation to semi-independent and then toward more independent learning process which should be done gradually. It can be implemented in the whole learning process or partially, e.g., in topics that only emphasis on the exercise of problem-posing, hypothesizing, predicting, inferring, planning or searching for information. It should not be too rigid. However, below are some suggestions for conducting teaching and learning of science using inquiry:

- a. attention should be given to problem-posing and brain-storming exercise as the beginning of the scientific inquiry activity.
- b. encourage imaginations and suggestions that may predict the result of a problem.
- c. before attempting to solve a problem, pupils should learn how to make planning, including determining the procedure, method and pre-caution.
- d. attention should be given to data collection which includes observation, measuring, experimenting, recording, making analysis and diagram.
- e. train the pupils to make their own conclusion and

teachers should avoid suggesting their own opinions.  
f. organize post-mortem discussion to invite the pupils to listen to other opinions.

### 3.3 Recommendations for assessment

Below are some recommendations to make assessment in this new curriculum.

#### 3.3.1 Identifying the purpose of assessment

According to the standard of Chinese primary science curriculum, the main purpose of assessment is to understand how the pupils study and develop, and to use the information to improve teaching and learning which will ultimately realize the aim of the curriculum, that is to develop scientific attainment in each pupil. This is different from the traditional kind of evaluation – streaming and dividing the pupils solely from how the teachers assessed pupils’ performance. The changes include the main structure, content, method, timing and so on:

- a. Expanding the main structure of the assessment - The pupils will participate in the teaching assessment, reflect on their own learning condition and give their own comments about the teaching. The parents, school management, technicians, local organizations and public will be invited to participate in the assessment of science curriculum in terms of the organization, implementation, method, efficiency, etc. Teachers will still play the main role in the assessment process but they will not be playing as judges, instead they are the companions and motivators of the pupils in their learning process, as well as the navigators of the teaching process.
- b. Comprehensive assessment contents – The assessment should follow the curriculum standard of the primary science which covers all aspects of science, takes into the account of the pupils’ understanding of scientific ideas, attitude, nature, passion and value, also the ability and skills in scientific inquiry, scientific awareness, advancement in science, etc.
- c. Variety of assessment methods – Paper-and-pencil test by itself is no longer sufficient for the science curriculum assessment. Different purposes and contents need different types of assessment methods. This can be learnt from the experience of other successful examples or created by the collaboration of teachers, pupils and related groups of people. Any assessment method that can help cultivate the scientific attainment should be encouraged.
- d. Continuous assessment – the aim of the assessment in science curriculum is to improve the pupils’ learning and progress, so the assessment should not only be taken place at the end of the learning process but should be during the teaching process. This requires the teachers to be aware and make

observation of the pupils' performance in the classroom, provide necessary assistance and appropriate supportive and instructive assessment.

### 3.3.2 Mastering the assessment contents accurately

The key contents of the assessment of scientific inquiry is to assess pupils' interest and technique in 'making' science, thinking and manipulative skills. Practically they can be assessed on their participation in the learning activities, if they are active, perseverance, empirical; is their observation holistic, is the problem appropriately posed, is the measurement accurate, is the design logical, is the presentation clear, is the communication promote two-way interactions; how are their skills in collecting data, organizing information, making explanation and doing experiment; and how do they work together with each other. For primary pupils, attention should be given to encourage them to carry out scientific inquiry activities, understand the process, gain the joys of making scientific investigation, and then gradually improve their scientific attitude. It should not be emphasized on the results and standard.

### 3.3.3 Using the assessment methods flexibly

According to "The Standard", the assessment should take the everyday teaching as the basis so that every opportunity to assess the pupils, in and out of the classroom, can be fully used. This can reflect the actual learning condition of the pupils. The below are a few assessment methods to be considered:

- a. Teachers' observation – the science teacher should observe the performance of the pupils in their learning and referring to the results to plan their lessons, depth of teaching, improve their teaching methods and design an individual instruction when necessary. All these continuous long-term assessment results and treatments should be recorded.
- b. Talking to the pupils – the science teachers, administrators and parents can act as peers and ask some open-ended questions to the pupils to explore their thinking and perception.
- c. Attainment record – any special or valuable information in the learning process for both the teachers and the pupils (e.g. pupils' outstanding performance, unique opinions, creative innovations, etc.) should be recorded immediately for future reference especially during summative assessment.
- d. Examinations – there are two applications of assessment in science curriculum: first, it is a form of background information for teachers to grasp the prior knowledge and experience of the pupils before lessons are planned; second, it is to summarize the learning process after a period of time. Instead of testing the rote memorization of scientific concepts in the examinations, the new form of assessment will pay attention in varying the examinations format for

various needs. For example, the use of oral examinations, pen-and-pencil test, practical examinations, etc. are suitable for assessing the pupils' ability in analyzing and solving practical problems.

- e. Projects/portfolio assessment – any product from the pupils' science activities can be assessed. For examples, science notes, diagrams, writings, models, experiment reports, investigation records, hand-copied reports, and so on. These types of self-assessment and peer-assessment can help the pupils to analyze and understand the talent and uniqueness of each individual.
- f. Learning journal – this can be done by the teachers or the pupils themselves by recording the pupils' learning outcomes such as scientific observation diary, science project, scientific report, etc. This is a way to monitor the progress of the pupils.
- g. Assessment chart – teachers can make direct assessment from one particular performance of the pupil on the chart. The chart can be presented in descriptions, degrees, grades and numbers.
- h. Exercise – teachers can assess the quality and ability of the pupils by giving them exercise which can be completed in a long-term or short-term. The short-term exercise needs to be completed by the pupils immediately in the classroom. Direct observation on how the pupils complete the exercise can be a form of assessment. The long-term exercise can be a complicated task which involves planning, implementing and reporting that can be completed in a period of time (from a few days to few months). Teachers can provide some instructions during the period to assess which aspects the pupils depend and need more on.
- i. Reviews – This is useful to assess the scientific attitude and value. The pupils are asked to make self-reviews according to the standard, then form groups to conduct peer-reviews, and finally the teachers can make assessment through the discussions of the self- and peer-reviews supported by the records of observations, examinations and exercises.

## 4. Main expected outcomes of the new curriculum

It is anticipated that through this reform of primary science education which emphasizes on scientific inquiry can bring changes to the below main aspects:

- a. Teachers' perspective and attitude – It is hoped that the Chinese science teachers will change their perspective and attitude considerably toward the teaching of science, especially when scientific inquiry approach is practiced.
- b. Teaching approach – There will be an overall but gradual transformation from the traditional teaching approach to student-orientated approach where

teachers are the navigators, instructors and participants while the pupils are the active participants and researchers.

c. Learning approach – It is hoped that pupils will become more independent in their own inquiry and vary their learning approach. The opportunity for the pupils to learn via scientific inquiry can significantly develop the scientific attainment and further cultivate interest in science learning among the pupils.

d. Scientific attainment – The aim of the curriculum is to cultivate scientific attainment among pupils. However, it is a long-term process. After a few years, teachers are able to incorporate the knowledge of the latest development in science and technology into the teaching. Teachers will be able to organize a variety of inquiry-based learning activities and take part in the scientific investigation. This can help the pupils to actively learn new scientific knowledge, master scientific skills and embody the scientific attitude and value.

## 5. Current state of the implementation of the curriculum

After 7 years of reform and implementation of this new curriculum, the impact is not as positive as it has been expected. This is due to many factors, such as the difficulty to accept and flexibly carry out scientific inquiry in the Chinese educational system, the provision of facilities, the quality of the teachers, the ability of the students, etc. Below are some results of the performance reported by Hu, et al. (2007). This descriptive research was carried out in a province in China, Shanxi, involving 92 primary science teachers using questionnaires.

a. There is a need to increase teachers' understanding of the requirements and standard of the science curriculum. This is because only 53.33% of the teachers recognized that “the aim of the primary science curriculum is to cultivate scientific attainment”. There are only 36.96% of the teachers claimed to have understood “The Standard” while 58.69% of the teachers did not have deep understanding and review of “The Standard”. Another 4.35% of the teachers did not understand “The Standard” totally.

b. There is a need to increase the scientific attainment of the teachers. Surprisingly, 80.43% of the science teachers did not have any specialization in science study and only 41.30% of them claimed to be able to teach any topic in the science curriculum.

c. A number of schools did not have sufficient facilities to fulfill the requirements of the new science curriculum. There were 71.74% of the teachers complained that their schools did not have enough teaching materials, 63.04% agreed that there was not sufficient materials to carry out experiments, 52.17% said that the IT facilities were not up-to-date and

17.39% claimed that the hardware was out-of-date.

d. There is insufficient scientific resources. About 43.48% of the teachers tried to use available resources to conduct teaching even though they were facing the problem of lack of scientific teaching resources at the schools. In facing the same problem, 56.52% preferred to use video and lecture but only 15.22% took the initiative to build their own resources. When it comes to topics that involved experiments, 8.70% of them substituted experiments with lectures and demonstration while 4.35% of them explained the experiments followed by exercise to substitute the experiments. Nearly half of them told that there is no opportunity to explore the resource for out-door activities.

e. Both the teachers and the pupils need to change their perspective on teaching and learning. According to the research, only 47.83% of the teachers were able to pay attention to all the pupils. Those who gave attention to the weak pupils are only 2.17% while 19.57% of the teachers paid attention to outstanding pupils and 30.43% to average pupils.

f. The teaching approach has yet reached the targets of the curriculum to push for a change in the learning approach of the pupils. There were 41.30% of the teachers had the opinion that scientific inquiry-based teaching and learning approach gave the best result. About 62.22% of the teachers encouraged pupils to read extra materials and do self-study, 48.89% of them organized hands-on activities to observe and investigate, 86.93% of them agreed that the pupils had strong interest in learning science. The most interesting finding in their research is that 51.85% of the teachers were reluctant to implement scientific inquiry simply because it was too difficult. 18.51% of the teachers thought that scientific inquiry was far too foreign for the pupils and 14.81% of the teachers believed that the approach did not benefit the pupils at all.

g. Teachers need to focus more on the scientific attainment of the pupils though several efforts have been put into the teaching. It is good to have 83.61% of the teachers tried to deliver the latest development in science and technology in the science classes and 76.09% of the teachers, in addition, initiated related activities to help the understanding of the pupils. It is also encouraging to find out that 40% of the teachers always tried to prompt the pupils to do their own scientific investigation.

h. The assessment method needs to be improved to reach the purposes as explained in section 3.3 of this paper. However, only 17.78% of the teachers were confidence that the assessment that they carried out served the purposes outlined by “The Standard” and sometimes even more. Nonetheless, there were 31.11% of them who said that it was not possible to achieve at the moment and 6.67% who were believed that it was impossible.

## 6. Discussion

Thus far, Hu, et al. (2007) is the only research paper that is done empirically to investigate the implementation of the new primary science curriculum in China which we managed to find. These findings, unfortunately, do not necessary represent the whole Chinese population because it was carried out only with a small number of teachers in a province of China which only represents 1.62% of the national share out of 33 provinces in China (Wikipedia, 2008). The shortcomings of the implementation of the new curriculum reported in their paper maybe true to many other teachers across the country because some discussions regarding these problems can be found of a website which is dedicated to the Chinese primary science education – <http://www.xkx.cn/>.

On this website, there are active discussions among teachers and academicians regarding the problems and solutions in conducting the new curriculum. Some teachers shared their experience and thoughts on the website. It is interesting to find that until recently, teachers are still facing the dilemma to understand the meaning of scientific inquiry and question the credibility of this approach in primary science classrooms (Du & Xu, 2006). Some teachers even tried to point out the misconception among teachers about scientific inquiry (Wu, 2006).

However, there are a few good articles on this website that try to explain in detail using teachers' own experience in the classrooms to encourage other teachers to implement this new approach (Lee, 2006, Gao, 2006). It is still a new approach for many even though it has been introduced since 2001 (Qian, 2006) but teachers who are active on this website are determine to use this approach as far as they can (Lu, 2004).

Scientific inquiry can be traced back as far as the time of John Dewey in 1910 (Metz, 1998) yet, it is only now that we can see the implementation of the approach in science education. China has just started less than a decade ago, it needs time to re-conceptualize the meaning of scientific inquiry in the Chinese context and translate it into a powerful approach that can finally increase the scientific attainment among the pupils in China, starting from primary schools. From the report of Hu, et al. (2007), it is clear that more efforts are needed in increasing the resources and facilities in the schools and in training the teachers to familiarize themselves with the new approach.

## 7. Conclusion

The introduction of the primary science curriculum in the Chinese Basic Education system is a crucial step in beginning the reform of the education system in China, while the initiative to install scientific inquiry across the science curriculum is yet another

breakthrough in this reform. Although there are many problems and shortcomings in the attempt to implement this new approach in the Chinese primary science curriculum, it is hoped that this will plant the seed of new thinking in science education, either in the aspect of learning or teaching. With the supports from a community of primary science teachers and academics like those on the website mentioned in the previous section, it may be possible to achieve better scientific attainment among the new generation of Chinese scientists.

This reform brings plenty of opportunity for educators and researchers to further investigate the implementation of this new approach and explore the possibility to conduct this approach in the context of modern China. It is hope that this paper will invite further research in this new approach specifically and the curriculum in general. The findings will further reform the teaching and learning of science, improve the quality of science education in China and cement a strong foundation to escalate the scientific attainment of the Chinese population.

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