# Solar energy investigation activities for primary pupils: Experience sharing from a teacher of a solar energy school in Hong Kong

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Received 22 June, 2005
Revised 25 June, 2005

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## The School

CCC Kei Wai Primary School (Ma Wan) is a 30-classroom 7-storey primary school located at Ma Wan Island. The campus was completed in 2003. There are three arrays of photovoltaic modules installed on the roof with an expected annual yield of 5600 kWh a.c. electricity. This system is supported by a research project called "Building Integrated Photovoltaic (BIPV) School Design" funded by the Innovation and Technology Commissions of the Hong Kong Government with matching sponsorship from the China Light and Power Research Institute (HK). The Faculty of Architecture of the University of Hong Kong is responsible for the system design. Real-time data of the BIPV system and the neighboring weather parameters can be accessed at the HKU Centre on Renewable Energy homepage. Information of the infrastructures can be found at:

http://www.arch.hku.hk/research/schoolsBIPV/SchoolsMAWAN/BIPVmawan1.htm

## Solar Energy Activities

Soon after moving into the new solar energy campus in September 2003, I started to plan with my colleagues some solar energy activities for our pupils. It is easy to find plenty of information about the Sun, solar rays and their effects (e.g. climate, greenhouse effect etc.), energy sources and related environmental issues from the libraries or the internet. Hence, information searching and book report were two activities we planned for our pupils. However, when we explored the possibilities of any hands-on activities, we encountered some problems with the following considerations.

1. Resources: Budget is always a very serious constraint. The most ideal activities are those only require simple and cheap materials and tools. Of course, the availabilities of worksheets of some feasible activities and external support are helpful.
2. Abilities of pupils: The activities should not require any sophisticated skills, such as electrical wiring. Safety is also another important issue.
3. Relevance to curriculum: The topic "Resources and Environment" in the Primary 5 General Studies curriculum was identified to infuse the solar energy activities. As a new General Studies curriculum would be implemented in the coming year, we hoped that the activities could achieve some learning outcomes recommended in the new curriculum, such as:
    - to develop motivation and skills to explore, investigate and generate solutions for scientific problems emerging from the study of the material world, use of energy, living things and the Earth and beyond;
    - to develop an interest in exploring the technological world and perform technology activities creatively to solve simple problems in daily life.

    (Curriculum Development Council, 2002)

After surfing the web, three possible pupil activities for the studies of energies "generated" by sun rays were found.

1. The first one coming to our mind was what activities could be done with ***solar cells*** because our school had the largest photovoltaic array in Hong Kong. One

possibility was to study what factors affecting the output of a solar cell. The variables could be the light intensity, the incident angle or the colour of the light. Another possibility was to ask pupils to construct something, say a small car or a small boat, powered by solar cells. However, we found the cells were not cheap at all. A small sized 1 W peak value solar cell costs around HK$100 in Apliu Street in Shamshuipo. Finally, we gave up these ideas because of the limited budget.

2. The second possible activity was to make a solar energy reflector which was a curved reflecting surface focusing the sun rays at a small region. There are a lot of interesting and delicate designs at the Solar Cooker Review homepage. However, we decided not to choose this activity because we did not think our pupils could handle those tools to construct the reflector.
3. The activity we finally chose was the construction of a "greenhouse heater". An agricultural greenhouse is a house which has its roof and some or all of its walls made of transparent materials. The transparent roof and walls allow visible light into the greenhouse and the re-emitted heat radiation is partially "trapped" inside the greenhouse. This causes the inside warmer than the outside. Our atmosphere behaves similarly to trap solar energy and this is called the greenhouse effect. The theory of greenhouse effect can be found elsewhere, such as:
    - "What's Green House Effect?" by Hong Kong Observatory: http://www.hko.gov.hk/wxinfo/climat/greenhs/c_grnhse.htm?
    - "Global Warming Kids Site - Greenhouse Effect" by U.S. Environmental Protection Agency: http://www.epa.gov/globalwarming/kids/greenhouse.html

Actually a greenhouse is not necessary really a house. Any transparent closed containers illuminated by sun rays would have its internal temperature increased. This principle has been used for many years in many rural areas to warm water (Cookers in Use Around the World). Any transparent vessels, such as a transparent plastic water bottle, can warm water under the Sun without any cost.

Another important reason that we chose the construction of greenhouse heater to be our pupils' activity was a similar activity with worksheets already available on the web. It was an activity of the Young Scientists Award Scheme jointly organized by the Hong Kong Institute of Education, the Curriculum Development Institute and the Hong Kong Association of Science and Mathematics Education. And luckily, the project leader of the Young Scientists Award Scheme, Dr. NG Pun Hon, kindly agreed

to give us advices in our preparation stage.

## The Greenhouse Construction Activity

After discussing with Dr. Ng, we decided to run the activity as a project-based competition for all Primary 5 classes with 3 to 4 pupils per group. Each group was asked to construct a small greenhouse with a container inside. During the competition, 10 ml of water was poured into the container. Then the greenhouse was placed under the Sun for 20 minutes. The rise in the temperature of the water was the indication of the performance of their greenhouse. Then pupils would present and explain their designs. We encouraged them to change at least one variable and test its effect(s) during their construction. The construction activity was to give a chance for the pupils to apply various investigation skills, rather than to teach them those skills. So, we needed to let them learn the required skills through some other activities. All these activities took 9 periods as summarized below:

Activity 1 (One double period)

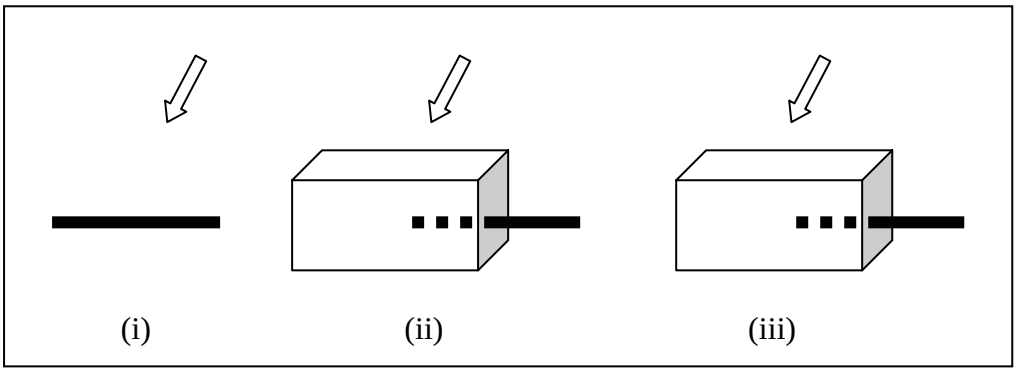
Pupils were guided to perform one of the activities of the Young Scientists Award Scheme called "流汗全面睇 (the study of sweating on body temperature)". It is a close-ended investigation studying the effect of the rate of evaporation on the decrease of temperature. After the experiments, concepts of making hypothesis, defining variable, testing hypothesis, data analysis and making conclusions were introduced. This activity also served the purpose to provide pupils with practice of setting up controlled experiments, reading data and interpreting their findings.

Activity 2 (One single period)

This was a case study activity. The main objective of this activity was to consolidate those investigation skills the pupils had learned in the previous lesson. They were given a short story called "Dr. Ross and Malaria". They were asked to identify which parts of the story were corresponding to making hypothesis, defining variable, testing hypothesis, data analysis and making conclusions.

Activity 3 (three double periods)

In the first double period, the worksheet "陽光真溫暖 (the sun light is so warm)" of the Young Scientists Award Scheme was distributed. The experiment below was demonstrated to show the action of a greenhouse. In a sunny day, (iii) takes less than 5 minutes to be several degrees warmer than the other two.




(i) a thermometer under the Sun. (ii) a thermometer measuring the internal temperature of a closed paper box. (iii) a thermometer measuring the internal temperature of a closed paper box with a transparent "roof".

After the demonstration, the details of the competition were explained. We encouraged pupils to use simple and cheap materials to make their greenhouses as well as the water containers. We also encouraged them to test their products for at least one variable, such as the size, the number of transparent sides, the colours of the greenhouse and the container etc. Each greenhouse would then be tested in the next lesson for whether it could produce a preset temperature rise which depended on the weather condition.

In the second double period, pupils brought their semi-finished greenhouse to the school and finished their products in the first period. Teachers walked around, asked questions and evaluated pupils' performances during that period.

Three girls were finishing their greenhouse

In the second half of the double period, the pupils brought their greenhouses to the playground and tested with 10 ml of water. The activity was carried out in late November. We found that it was not difficult to have the temperature of 10 ml of water increased by 8 to 10 degrees Celsius in 20 minutes in a sunny afternoon. Hence, the standard was set at 5 degrees Celsius. In the mean time, all pupils were asked to study and grade their classmates' designs.

This group found silvery internal walls could give a better warming effect.

In the third double period, each group presented their design and suggested possible improvements. Over 30 pupil products were displaced and voted by all primary 5 pupils for the best appearance (最佳外型獎), the “warmest” (熱力澎湃獎), the most environmental friendly (環保設計獎) and the most creative prizes (最具創意獎).

## Observations and Comments

1. Most of the pupils were highly motivated and excited to construct their small greenhouses. They worked collaboratively with some small "conflicts" happening occasionally. These "conflicts" were constructive and just showed that the pupils were actively presenting their own ideas. It was unexpected and encouraging that some "slow" learners were also highly motivated. This group of pupils, who was usually not asking questions in normal lessons, was very eager to ask their teachers concerning about technical problems and possible solutions of their work.
2. The greenhouse construction activity seemed to create an environment for active learning. I had one group of pupils who searched a lot of questions concerning solar energy from an encyclopedia. Since there was a service provided by local public library for schools to borrow books of a particular topic, a "Science Corner" was set up in our school library with books about energy resources borrowed from the Tsuen Wan Central Library. From our records, the loan rates of these books were tremendously high.
3. As a consolidation of various investigation skills for the pupils, case study was found to have two advantages over actual hands-on experiments.
    - Case study saves time and resources. It can be finished within a single period. It is not difficult to find stories about scientific discoveries. In the Secondary 1-3 Science curriculum, the first topic is "What is Science". It is easy to find stories of this kind in many Secondary 1 Science textbooks, such as "Dr. Jenner and Smallpox" and "Fleming and Penicillin" (Tao et. al., 2000).
    - The case study provided a real context to demonstrate the applications of scientific investigation. In Activity 1, all pupils were very excited in doing experiments but very few could give sensible answers to why learning the processes of investigation was important. After finishing the case study, pupils understood the sequence of the various steps they did in Activity 1 was actually the common practice done by many scientists.

4. Most of the General Studies teachers in my school, including me, were having little experience in scientific investigation. We worried about the greenhouse activity at first because it was quite open-ended. We are used to give pupils a task and then expect them to give same standard answer. We really worried that each group might give very different designs that we did not know how to comment. Actually, this situation did happen but we found this experience very interesting. We found that our pupils were more creative than us. The role of teachers is to equip pupils with the basic skills, such as what we did in Activities 1 and 2, and raise questions for them to solve. Our pupils have the ability to generate a lot of ideas and interesting solutions by their own if appropriate motivation has been given. There is no need for the teachers to know everything and answer all questions. Last year, we organized scientific investigation project described in this paper only for our Primary 5 classes. This year, we have the confidence to organize science projects for Primary 4 to 6 classes with some parts being open-ended in nature. For example, the project for Primary 5 this year is the production of traditional salted seafood on Ma Wan Island. Our pupils have visited some local fishermen there and have practiced the processes of making salted fishes and shrimps. They will later try various factors, such as amount of salt, sun light, wind condition etc., on the preservation of seafood.

# References

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