Chapter 14
Learning Nature of Science Through Socio-scientific Issues

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School Science Curriculum Reform in Hong Kong

A series of reforms in science education in Hong Kong started at the turn of the twenty-first century. In line with international trends, science education in Hong Kong has undergone considerable changes in the last decade since the implementation of the revised junior secondary science curriculum (grades 7–9) (Curriculum Development Council [CDC], 1998). The new curriculum encourages teachers to conduct scientific investigations in their classes, advocates scientific investigation as a desired means of learning scientific knowledge, and highlights the development of inquiry practices and generic skills such as collaboration and communication. Most importantly, it was the first local science curriculum that embraced understanding of nature of science (NOS), for example, being “able to appreciate and understand the evolutionary nature of scientific knowledge” (CDC, 1998, p. 3) was stated as one of its broad curriculum aims. In the first topic, “What is science?”, teachers are expected to discuss with students some features about science, for example, its scope and limitations, some typical features about scientific investigations, for example, fair testing, control of variables, predictions, hypothesis, inferences, and conclusions. Such an emphasis on NOS was further supported in the revised secondary 4 and 5 (grade 10 and 11) physics, chemistry, and biology curricula (CDC, 2002). Scientific investigation continued to be an important component while the scope of NOS was slightly extended to include recognition of the usefulness and limitations of science as well as the interactions between science, technology, and society (STS).

In preparation for the implementation of a new curriculum structure (from a 7-year secondary education system to a 6-year one) in September 2009, a new set
of Curriculum and Assessment Guides was devised for senior secondary level science subjects (CDC-HKEAA, 2007). We note a further leap forward along the direction of earlier curriculum reforms in the curriculum and assessment guides. The importance of promoting students’ understanding of NOS is more explicitly spelt out. To put greater emphasis on environmental issues, students’ appreciation of STS is extended to STSE, where “E” stands for environment. For example, in the physics curriculum, students are expected to “appreciate and understand the nature of science in physics-related contexts,” “develop skills for making scientific inquiries,” “be aware of the social, ethical, economic, environmental and technological implications of physics, and develop an attitude of responsible citizenship,” and “make informed decisions and judgments on physics-related issues” (CDC-HKEAA, 2007, p. 4). There is a clear intention to develop students’ awareness and understanding of issues associated with the interconnections among science, technology, society, and the environment. A separate subsection entitled STSE connections is embedded in each science topic of the Curriculum and Assessment Guides. It suggests examples of issues that teachers could make use of in developing students’ awareness and understanding of STSE connections. For example, in the topic mechanics, one of the issues suggested is a dilemma of choosing between convenience and environmental protection in modern transportation.

Preparing Teachers for the New Curriculum Goals

Based on the literature and our local context, we identified a host of problems and challenges we had to tackle in encouraging and training teachers to teach NOS. In particular, we have been cognizant of the disappointing conclusions that were consistently reached by various studies. That is, both students and science teachers have inadequate understanding of NOS (Lederman, 1992) and STSE (Rubba & Harkness, 1993). There is however emerging empirical evidence that can inform efforts to improve NOS and STSE understandings. Explicit and reflective approaches in teaching NOS can support learner development of sophisticated NOS ideas (Abd-El-Khalick & Lederman, 2000; Khishfe & Abd-El-Khalick, 2002). Teachers with good understanding in NOS still face many constraints including concerns for student abilities and motivation (Abd-El-Khalick, Bell, & Lederman, 1998; Brickhouse & Bodner, 1992), lack of pedagogical skills in teaching NOS (Schwartz & Lederman, 2002), and lack of teaching resources (Bianchini, Johnston, Oram, & Cavazos, 2003) particularly those in local contexts and language (Tsai, 2001). Effective NOS teaching also depends on teachers’ belief in the importance of teaching NOS (Lederman, 1999; Tobin & McRobbie, 1997) and their conception of appropriate learning goals and teaching role (Bartholomew, Osborne, & Ratcliffe, 2004).

In addition to the problems identified above, Hong Kong teachers very rarely have experienced learning of NOS or STSE during their own schooling. Noting teachers’ inadequate NOS understanding and hence their lack of appreciation and
less than effective use of the NOS instructional materials, we then restructured our teacher training programs to allow more time on these aspects. For example, in early 2000s, we proposed the use of science stories, such as on the discovery of penicillin, the development of cowpox, Newton’s proposition of Law of Universal Gravitation, and the treatment of stomach ulcers (Tao, 2002), as a medium through which NOS could be introduced to students. However, due to the lack of both understanding of NOS and experience in learning and teaching NOS, many teachers made use of them only for arousing students’ interest. Hence, the availability of teaching resources would not by itself result in teachers’ learning of NOS and an effective teaching of NOS. Unless teachers had the ability to understand and appreciate the rationales behind the design of the instructional materials, it was likely that they would overlook or miss the targeted learning objectives (learning NOS features) and gravitate toward the parts which were more appealing to them (dramatic stories which promote students’ interest). Such a situation was reflected in the comment made by a junior science teacher who had been telling the interesting science stories to his students. He came to realize his oversight of not having made good use of the stories for teaching NOS after he attended our NOS training workshop:

I found the story on stomach ulcers very interesting….Marshall tested his hypothesis by trialling out himself….Students all enjoyed the story… I only realised now that there are deeper meanings behind the story and other important learning outcomes to be achieved through it and other stories.

We also reckoned that there were some inadequacies of these relatively “old” stories. Teachers and students expressed that though these stories aroused their interests, they happened quite a while ago. Those who did not have the historical and cultural backgrounds of the scientific discoveries and inventions would fail to develop an in-depth understanding of, and hence appreciate, the thought processes of the scientists related to what they encountered at their time.

In summer 2003, when the crisis due to the Severe Acute Respiratory Syndrome (SARS) in Hong Kong was coming to an end, we saw a golden opportunity to turn the crisis into a set of meaningful instructional resources which might help address the issues raised above. The SARS incident was a unique experience that everyone in Hong Kong had lived through and the memories of which would stay for years to come. At the beginning of the outbreak, the causative agent was not known, the pattern of spread was not identified, mortality and morbidity seemed soaring, yet an effective treatment regimen was uncertain. It attracted the attention of the whole world as scientists worked indefatigably to understand the biology of the disease, develop new diagnostic tests, and design new treatments. Extensive media coverage kept people up-to-date on the latest development of scientific knowledge generated from the scientific inquiry about the disease. We believed that the incident would have much to reveal about NOS.

As anticipated we identified many interesting aspects of NOS based on our interviews with key scientists who played an active role in the SARS research, analysis of media reports, documentaries, and other literature published during and after the SARS epidemic. The SARS incident illustrated vividly some NOS
features advocated in the school science curriculum. They included the tentative nature of scientific knowledge, theory-laden observation and interpretation, multiplicity of approaches adopted in scientific inquiry, the inter-relationship between science and technology, and the nexus of science, politics, social, and cultural practices. The incident also provided some insights into a number of NOS features less emphasized in the school curriculum. These features included the need to combine and coordinate expertise in a number of scientific fields, the intense competition between research groups (suspended during the SARS crisis), the significance of affective issues relating to intellectual honesty, the courage to challenge authority, and the pressure of funding issues on the conduct of research.

The details on how we made use of the news reports and documentaries on SARS, together with episodes from the scientists’ interviews to explicitly teach the prominent features of NOS can be found in (Wong, Kwan, Hodson, & Yung, 2009). Since January 2005, we have been using the SARS story in the training of hundreds of preservice and in-service science teachers about NOS. The feedback has been encouraging. The SARS story was particularly successful in promoting teachers’ understanding of NOS in terms of (1) the realization of inseparable links between science and the social, cultural, and political environment, (2) deeper understanding of how science and technology impact on each other, and (3) a richer appreciation of the processes of authentic scientific inquiry and the humanistic character of scientists. The effectiveness was mainly attributed to immediacy, relevance, and familiarity of the SARS story which made the abstract tangible. Teachers’ personal experience of this unique piece of “history” of science and the powerful affective impact of the interviews with scientists also contributed to the favorable learning outcomes (Wong, Hodson, Kwan, & Yung, 2008).

The encouraging results of using the SARS story with teachers prompted us to produce NOS instructional materials that should also be grounded in the local contexts (and language) for school students. At the same time, we were fully aware that high quality curriculum materials do not automatically result in student learning. Such materials have to be mediated by teachers with necessary content knowledge, pedagogical skills, beliefs, and intention of meeting the curriculum goals (Bartholomew et al., 2004; Lumpe, Haney, & Czerniak 1998; Schwartz & Lederman, 2002). Thus, in September 2005, we embarked on a 2-year project which aimed to produce local NOS/STSE curriculum resources while preparing more teachers for NOS/STSE teaching. We also envisioned that the project was timely in view of the new science curricula to be implemented in 2009. Having made reference to the reminder by Hodson (2006) that,

> [a]ction research offers the most likely route to such far reaching curriculum changes, committed teachers work together in mutually supportive groups to address the theoretical and practical issues surrounding the implementation of a learning about science curriculum and to develop suitable and effective curriculum resources. Curriculum materials need to have a “street credibility” that can only be gained when they are developed by teachers, for teachers. (p. 305)

we deliberately involved teachers at the beginning stages of the design process of instructional materials. More than 50 senior secondary science teachers worked
together with the university team members to develop 12 sets\(^1\) of teaching resources which integrate NOS knowledge with subject knowledge of the new senior secondary biology, chemistry, and physics curricula. Efforts were made to include as many local examples as possible. The topics included development of the Disneyland in Hong Kong, consumption of shark fins, an abridged version of the SARS story, etc. In doing so, teachers would be more ready to make use of the materials in their own classrooms. This was important for our project as we wanted to collect data to refine the teaching materials as well as provide opportunities for the teachers to learn how to teach NOS with the support of the university team members. In brief, the teacher development project comprised the following key components:

1. A 6-h NOS session conducted by the first author using SARS and other contexts in illustrating various aspects of NOS.
2. Workshops on refinement of NOS instructional materials drafted by the university team members.
3. Prelesson discussion with the university team member(s) on the main ideas and fine adjustment of the instructional materials to be tried out in the teacher’s own classroom.
4. Teaching the lesson(s) using the instructional materials.
5. Reviewing the lesson video and reflecting on the trial lesson(s).
6. Meeting between the university team member(s) and the teacher to discuss critical incidents in the videotaped lesson (followed by written feedback from university team members) in preparation for a sharing session with other in-service teachers joining this project (teacher members).
7. Sharing of the trial-run experience with other in-service teachers of the project and receiving their comments.
8. Dissemination seminar: Over 500 teachers from other schools in Hong Kong attended. Sharing of teaching materials and trial-run experiences with a wide audience.

Due to the limited financial and human resources, seven of the teacher participants went through all the above training components. The rest participated only in components (1), (2), (7), and (8). The development of the seven teachers in the understanding of NOS, the pedagogical skills in teaching NOS, and the intention to teach about NOS were probed at various stages of the project. These teachers found learning through a contextual approach, as what they did in the NOS workshop, very effective in promoting, enriching, and consolidating their NOS understanding. They also treasured both the training materials and some activities in the teaching resources that they tried out in their classroom as they could modify or had modified them to incorporate teaching of NOS in their teaching of subject knowledge teaching. The actual classroom implementation and detailed review and discussion of the lesson video “worked best” and more importantly were “treasured most” by

\(^{1}\)12 sets of teaching resources can be accessed through the website: http://learningscience.edu.hku.hk
the teachers in enhancing their pedagogical skills in teaching NOS and intention to teach NOS. The review and analysis of the lesson videos facilitated teachers’ reflection on which areas needed improvement. It also allowed them to appreciate and value the teaching of NOS when they saw students’ ability and interest in learning NOS. The proof of workability of both teaching and learning NOS had prompted teachers who were reserved about teaching NOS to follow suit. Details of their development, their concerns, and their learning outcomes were reported in Wong, Yung and Cheng (2010).

While encouraged by the promising results in the project, we have been mindful that a lack of collegial support may lead to a decline of teachers’ commitment in achieving curriculum change. Thus in September 2008, we initiated another 2-year professional development project. It aimed to cultivate a mutually supportive environment where teachers would collaborate and develop their pedagogical content knowledge of NOS. A key feature of the new project was the formation of study groups among teachers of the same subject discipline from different schools (subject-based approach) and science teachers of the same school (school-based approach). We believe that putting like-minded teachers together in a study group is more likely to sustain and even enhance their commitment to teach NOS. While retaining the components that teachers who participated in the previous project valued and treasured most (such as the SARS case study, the detailed review and discussion on their lesson videos with the university team members and their peers, etc.), we also encouraged teachers not to simply modify and adapt the available teaching resources, but to proactively design their own instructional materials. This is indeed a goal that we wish teachers could ultimately achieve. Thus at the outset of the current project, we explained our intention to the teachers by a Chinese proverb, “Give a man a fish and you feed him for a day. Teach a man to fish and you feed him for a lifetime.” (In Chinese, it says 授人以魚,三餐之需; 授人以漁,終生之用。).

Two physics teachers, Wayne and Kyle, who were from the same school, participated in the school-based approach of the project (with three other colleagues teaching other science subjects). Inspired by the contextual approach in which they learned various NOS aspects through a series of socio-scientific issues (SSIs) in the SARS incident, they designed and implemented their own teaching materials in which NOS and SSIs were drawn upon. In the following sections, we expound on their learning and teaching experience in the current project by covering in detail three important components that they found most helpful in their development, namely (1) contextual learning of NOS through SSIs in the SARS crisis and other related contexts, (2) viewing and responding to videos of exemplary practice of NOS teaching; (3) their own practice of designing and implementing a NOS lesson. At appropriate places, we include views and comments expressed by Wayne and Kyle during our interaction with them in the following occasions: brainstorming sessions on how to incorporate NOS ideas in their physics lessons, pre- and post-lesson discussions, video workshops with the team of science teachers of their school in which we shared and reflected on video episodes of how the teachers instilled NOS in their respective subjects, and an exit interview near the end of the project.
We then compare the instructional materials and the teaching strategies of the NOS lesson collaboratively planned by Wayne and Kyle, and discuss the extent to which the SSI and NOS features demonstrated in the materials and the strategies are mediated by their learning experience.

Learning NOS Through SSI During the SARS Crisis

A detailed review of 17 experimental studies of context-based or STS-oriented approaches at secondary school level by Bennett, Lubben and Hogarth (2007) indicated that such approaches had positive impacts on students’ understanding of scientific concepts and attitudes to science and school science, especially when attention focuses on recent scientific research and innovations. Though none of these studies focused specifically on NOS understanding, we successfully demonstrated that the use of the SARS context with a number of remarkable SSIs was effective in enhancing NOS understanding (Wong et al., 2008). This provided support to the compelling arguments that critical consideration of SSIs offers an ideal forum for students to deploy and develop their NOS understanding (Sadler, 2004; Sadler & Zeidler, 2005; Zeidler, Sadler, Simmons, & Howe, 2005), especially when the issues are controversial (Kolstoe, 2000; Oulton, Dillon, & Grace, 2004) or have strong personal relevance (Ryder, 2002). Khishfe and Lederman (2006) remind us that although locating NOS teaching within controversial topics (in their case, discussion of global warming) can be effective, the essential requirement, as in internship and apprenticeship approaches, is that NOS teaching is both explicit and supportive of critical reflection. The case study of SARS contextualized in many examples of SSIs was intensely personal for our learners and had many controversial aspects. Moreover, the learning materials were designed to draw explicit attention to important NOS items and to encourage reflection.

To explicate the learning experience of Wayne and Kyle through these SSIs, we describe in detail four key SSIs during the SARS crisis, namely (1) the hunt for the causative agent of SARS (2) the tragic outbreak at Amoy Gardens and the subsequent quarantine of all residents in the severely infected block, (3) the disclosure of Dr. Jiang on the discrepancy of the number SARS cases announced by the mainland Chinese government, and (4) the ban on eating of civet cats to prevent reoccurrence of SARS infection. These SSIs were most cited by preservice and in-service teachers taking the teacher training programs as very effective in prompting their deeper understanding of how science and technology impact on each other, and their realization of the inseparable connection between science and society, in particular the influence of scientific findings about SARS on the actions of different bodies in society during and after the epidemic (Wong et al., 2008). The detailed historical development of each of the four SSIs with the NOS elements exemplified, and the learning and teaching activities included in the multimedia instructional materials are given in Tables 14.1–14.4.
Table 14.1  Details of hunting for the cause of SARS

| Time            | Historical development related to the SSI                                                                 | Multimedia items/teaching and learning activities                                                                                                                                                                                                 | Embedded elements of NOS                                                                                     |
|-----------------|----------------------------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------------------------------|
| Mid-Mar 2003    | Dr. Klaus Stohr, a scientist with the WHO, initiated the establishment of an international collaborative network among 11 laboratories, located in 10 countries. | A 60-s video showing Dr. Stohr making several phone calls and inviting different labs to form an international research consortium through telephone conferencing – thus enabling rapid sharing of data and information about SARS. Learners are asked to identify and describe the nature of collaboration shown in the video. They are also asked if they can see beyond collaboration (we were looking for students to identify competition, as reflected in the hidden message of the video narrative). | Technology can change the ways in which science is conducted and the speed with which it is completed. Without recent advances in telecommunications and availability of the Internet, the large-scale collaboration could not have been established so rapidly. |
|                 |                                                                                                         | A 40-s video edited from the interviews with Dr. LP and Dr. RC, in which they talk about how the pace of their research was accelerated by “competing” against time, resources, their own self-esteem, and social demands.                                                                 | Scientists are competitive by nature; they compete with each other, themselves, time, resources, etc.               |
| 18 Mar 2003     | CUHK first announced they had found evidence that paramyxovirus was the causative agent of SARS.         | Learners are shown a picture of a landscape with trees and rocks on the seaside. The picture also depicts a praying mother and son as an “embedded view” which is not immediately obvious to most observers. [It is anticipated that when the first learner sees the embedded view, more learners will start seeing it. Learners will then be explained about the possible subjectivity in observation which can be affected by one’s knowledge base.] | Scientists are not detached from society and they often work strenuously to meet social demands.                      |
|                 | Laboratories in Germany, Canada, and Singapore immediately announced that they had also found evidence of paramyxovirus in samples collected from patients. |                                                                                                                                                                                                                                               | Subjectivity of scientists and theory-laden observation. Scientists’ observations are influenced by their knowledge and the theoretical framework they employ – i.e., their observations may be affected by what they expect to see or prepare themselves to observe. |
22 Mar 2003  

HKU found evidence suggesting that the causative agent was coronavirus. A laboratory in Rotterdam and CDC in Atlanta quickly announced that they had also found evidence in favor of coronavirus. 

Learners are then asked to identify and describe examples of theory-laden observations from an 80-s video showing the progression from the agreement among different laboratories that a paramyxovirus was the causative agent of SARS to the agreement that a coronavirus was the real causative agent of SARS.

The video includes excerpts from the press conferences of both announcements and the characteristics of both types of virus.

Learners are explained that coronavirus was initially ignored as it is well known for causing mild common cold only.

[It is expected that some learners may even be able to identify that the virologists who identified the viruses from their characteristic appearance were basing their views on their own expert knowledge, whereas a lay person would be unable to recognize the patches on the microscopic slides as viruses.]

Subjectivity of scientists and theory-laden observation. Scientists’ observations are influenced by their knowledge and the theoretical framework they employ – i.e., their observations may be affected by what they expect to see or prepare themselves to observe.

Uncertainties and controversies in science.

Tentative nature of scientific knowledge (linked to the skepticism and open-mindedness of scientists.)
Table 14.2  Details of the tragic outbreak at Amoy Gardens and the subsequent quarantine of all residents of block E

| Time          | Historical development related to the SSI                                                                 | Multimedia items/teaching and learning activities                                                                 | Embedded elements of NOS                                      |
|---------------|------------------------------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------------------------------|-------------------------------------------------------------|
| 28–31 Mar 2003 | A residential building, Block E in Amoy Gardens, Hong Kong, was found to have an alarmingly high number of cases of SARS infection. | An animated graph showing the accumulated total number of infected cases in Amoy Gardens, rising from 7 to 185 within 4 days. | Science and political decisions are interrelated.           |
| 31 Mar–1 Apr 2003 | The Hong Kong Department of Health imposed quarantine on Block E of Amoy Gardens. An unprecedented order from the Hong Kong government to move all residents of Block E to isolation camps to allow a thorough investigation of the mysterious severe outbreak. | A 20-s video showing government health workers and residents of Amoy Gardens, all in masks, being sent to isolation camps in a rural area. It also shows the cross-disciplinary investigation team entering the building to find clues to the cause of the outbreak. Learners are prompted to consider the diverse sentiment of people living inside versus those living outside Amoy Gardens. |                                                                 |
| Early- to mid-Apr | Scientists identified the presence of SARS-coronavirus in rats, cockroaches around the residential area, sewage from the drainage system of the building. The pattern of infection (most of the infected residents lived in higher floors of Flat 7 and 8 which are connected to the same drainage system) suggested the causes of the outbreak was related to the drainage system. The model proposed by the local scientists explaining the infection was only accepted by the scientists of the WHO when they saw the over-packed conditions of the buildings. | Pictures showing the pattern of infection. Pictures illustrating the proposed explanation by scientists: The bathroom floor drains with dried-up U-traps opened a pathway for small droplets containing coronavirus into the bathroom. The exhaust fan in the bathroom then sucked the contaminated droplets to the light well where they were carried to higher levels by the warm humid air. | Modeling is a typical process in scientific research to provide explanation to fit the observations. Uncertainties and controversies in science. |

(continued)
Wayne indicated the hunt for the causative agent of SARS (Table 14.1) was most remarkable. He found many NOS aspects illustrated in this SSI rather new to him and even beyond his expectation. These included ideas about the theory-laden nature of observation and the related subjectivity of scientists.

Yes, the theory-laden one was really good. In the competition between CUHK [Chinese University of Hong Kong] and HKU [University of Hong Kong]…to be the first research team to identify the cause of SARS…when the professor [in CUHK] announced that he found it [paramyxovirus], other expert virologists quickly agreed with him…It’s a big surprise to me that these renowned scientists also made mistake…they’re also affected by their prior knowledge and belief…You know, SARS, it’s a big thing…it’s large-scale…but they’re still heavily affected by their background knowledge. [Coronavirus has been well known for causing mild common cold. The scientists only realized later that SARS-coronavirus can become deadly after gene shuffling due to cross-species transmission.]
Wayne also frankly admitted that he was not quite aware of the competition between research teams as he described above or even collaboration among scientists before he experienced the SARS instructional materials, as he put it:

The collaboration of those scientists was also memorable…the science we teach now was done in old days…we just know somehow the scientist got it…we don’t even exactly know how he got it…In SARS, we saw the collaboration of many scientists.

Apparently Wayne was recalling the video clip from the program, *SARS: The True Story*, produced by the British Broadcasting Company (Higgins and Learoyd, 2003)

| Time       | Historical development related to the SSI                                                                 | Multimedia items/teaching and learning activities                                                                 | Embedded elements of NOS                                                                 |
|------------|----------------------------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------------------------------|----------------------------------------------------------------------------------------|
| 23 May 2003| Researchers from Hong Kong and the CDC and Prevention of Shenzhen, mainland China, successfully isolated the coronavirus causing SARS from civet cats. | Photos of civet cats in cages in restaurants and newspaper headlines about research in Hong Kong and Shenzhen CDC revealing that many civet cats carried a coronavirus that was 99.8% genetically identical to the human coronavirus. | Scientific claims are based on logical deduction.                                      |
|            | They also found that some animal traders involved in slaughtering the animals had antibodies of the virus carried by civets. | Researchers commented that civets might have been infected from yet another unknown animal source in the markets, where many different animals are caged in close proximity. Such market practices could provide a venue for the spread of the virus. |                                                                                        |
|            | The unique dietary habits in Guangzhou might have caused the disease. |                                                                                                              |                                                                                        |
| Since late May 2003 | The sale of civet cats in mainland China and other exotic animals was banned when evidence identified civet cats as the origin of SARS. | A 18-s video of a scientist who commented on the livelihood of many people working in businesses related to the sale of civet cats and exotic animals was greatly impacted by this political decision. | The findings of science affect political decisions, which in turn affect social and cultural practice. |
| Oct 2005   | After SARS, newer evidence reported by scientists pointed to bats as the natural reservoir of SARS-coronavirus. | Learners were asked if they were aware of the most updated research findings in the search of the origin of SARS virus. | Not uncommon to have political decisions based on or inadequate scientific findings.   |
which described how Dr. Klaus Stohr, a scientist with the World Health Organization (WHO), initiated an international collaborative network, utilizing telephone conferencing, among 11 laboratories spread across 10 countries. The interview of Dr. Stohr and the narrator of the program gave a sense of urgency at that moment in time.

We knew that it was a race against time, so we had to find very quickly the pathogen, the causative agent for this disease… These scientists are competitive by nature but we called up 11 laboratories in 10 countries… (Dr. Klaus Stohr)

24 hours later, all the labs had agreed to forgo their rivalries and collaborate. For the first time in history, the full force of the world’s scientific might was united. (Jack Fortune – Narrator)

The SARS crisis also provided Wayne with an excellent example of how society impacts science in the STS connections:

This disease…very life-threatening…there was a huge societal demand…there was an immediate need to do research, to find out what caused it and how to cure it. I recalled in STS, society and science should be interrelated…but does science affect society or society affects science?…This one (SARS epidemic) is a good example of society driving the development of science…so many scientists thus worked together to tackle the problem.

The inclusion of an interview with Dr. RC conducted by a local television company gave Wayne a strong impression of the urgent societal need for scientists to find out more about SARS disease. It was filmed during the most serious and critical moment of the SARS crisis, when many doctors in her hospital were being infected. She was almost in tears as she shared her frustration and helplessness.

After the two colleagues passed away, some of our colleagues are in a life threatening situation. We are now receiving phone calls if our research can give immediate help. We need to work on urgent requests…hoping that we can help stop or reduce the rate of infection… We have become so stressed out…We also wish earnestly that we can lessen the harm and have been asking ourselves “how come our research still can’t be any help?”

The feelings expressed by Dr. RC reinforced the need for scientists to compete against time and highlighted the pressure on them to meet social demands. Her distress and expressions of concern demonstrated that scientists were not isolated from the social environment in which they worked.

**Tragic Outbreak at Amoy Gardens**

In the tragic outbreak at Amoy Gardens (Table 14.2), Wayne and Kyle saw a clear impact of scientific findings on political decisions. In response to the finding of the medical statisticians identifying an alarmingly high infection rate and peculiar infection patterns of a particular residential building, the Hong Kong government imposed an unprecedented order of quarantine. All residents of the building were moved to a rural campsite to permit a thorough and unimpeded examination of the building. In relation to the issue of whether the government should isolate the residential building and its residents, they appreciated that a decision could arouse very diverse sentiments among people of different roles.
Disclosure of Dr. Jiang About the Infection Situation in Beijing

In the disclosure of actual number of infected cases of SARS by Dr. Jiang Yanyong (Table 14.3), they saw the opposite relationship between science and political decisions. There were, sadly, some occasions when scientific research on SARS was impeded by political decisions. In mainland China, in a misguided effort to prevent widespread panic, strenuous efforts were made to conceal the true extent of the epidemic. When Dr. Jiang exposed the cover-up in a letter to a Beijing television station and *Time* magazine, he was put under house arrest. The comment made by Dr. AC, a Hong Kong medical researcher who played an active role in fighting the disease, reflected how political decisions could hugely exert negative impact on the advance of science:

In Mainland China, when the government said there were no cases of SARS at the beginning of the epidemic…how could the scientists in China do research on samples collected from the SARS patients there if there were no cases?…Certainly scientific research is oftentimes controlled by the will of the government.

Professor GZ, a mainland Chinese molecular biologist who played a key role in tracing the molecular evolution of the SARS-coronavirus during the course of the SARS epidemic in China, said that he could see “both sides of the coin” with regard to the delay in announcing details of the SARS infection in China. In an interview conducted 18 months after the SARS crisis was over, he commented:

We have learnt from SARS that if the government wants to keep this kind of thing secret, it’s not good… The government didn’t want to release information in the early stages because they were afraid that the media was going to make the situation worse…

Now the WHO doesn’t think SARS is a very severe disease. Even if SARS comes back, the WHO will treat it very calmly…Media may sometimes be dangerous in causing over-reaction among the people… and that probably would influence the research and also the medical treatment…It’s really not necessary to panic, but the media didn’t know that… I think we have to educate the government, the media and the people…

Clearly, Professor GZ held the view that irrational panic could be suppressed by educating the general public and promoting a better understanding of science and nature of science.

Ban of Sale of Civet Cats

In the ban on the sale of civet cats, Wayne and Kyle further consolidated the impact of science on political decisions and social practice. They also felt the helplessness on the immediate impact on livelihood of a particular group of people in the society due to the findings of scientific research as commented by Dr. RC about the data leading to the ban on eating of civet cats. She put particular emphasis on the social impact as a result of research findings.
The data [including early SARS patients were mostly restaurant workers who handle wild animals and serve exotic food like civet cats; civet cats carried a coronavirus almost identical to human coronavirus] directly affected the business of merchants selling exotic animals. These people may not even have learnt science at all in their life, but their lives have been heavily affected by science.

Her feeling of helplessness and sympathy for the merchants further deepened when she learnt that later compelling data pointed to bats instead of civet cats as the natural reservoir of SARS-coronavirus when the epidemic was over. Such an episode prompted Wayne and Kyle to recognize the intrinsic problems with the uncertainty of science and that decisions could only be made based on data available which at the time may turn out to be incorrect.

**Exposure to Good Practice of Teaching NOS**

Through the SARS story, as another component of the professional development project, Wayne and Kyle also reviewed and shared their thoughts on videos of exemplary NOS teaching integrated in the teaching of science. These exemplary lessons were conducted by teachers who adapted some instructional materials developed in our previous project (2005–2007). Thus teacher participants of the current project, including Wayne and Kyle, have been exposed to good examples of different ways of teaching NOS, for example, situating the scientific concepts being taught in a historical context, making use of teachers’ demonstrations or students’ inquiry experience to highlight NOS, and capturing critical incidents to elaborate on certain NOS aspects.

As demonstrated in the study by Wong, Yung, Cheng, Lam, and Hodson (2006), exposure to exemplary science teaching prior to the commencement of formal pre-service teacher training course is effective in getting prospective teachers “ready to ‘think like a teacher’ and to begin to be cognizant of the complex ways in which the actions of teachers impact on their students” (p. 17). Wong and her colleagues provide evidence that videos could reinforce and develop prospective teachers’ conceptions of good science teaching in one or more of the following ways: (1) recognizing exemplary practitioners in the videos as role models who can inspire them to formulate personal goals directed toward these practices; (2) broadening their awareness of alternative teaching methods and approaches not experienced in their own learning; (3) broadening their awareness of different classroom situations; (4) providing proof of existence of good practices; and (5) prompting them to reflect on their existing conceptions of good science teaching.

Teaching NOS was fairly new to Wayne and Kyle. There are many similarities in enculturating preservice teachers into good science teaching and in enculturating teachers into teaching NOS. For instance, Wayne and Kyle were very impressed by a physics teacher who demonstrated diverse teaching strategies in teaching
NOS while covering the topic ‘wave nature of light’. The lessons included the story-telling of how Fresnel tried to overcome the challenge by Poisson on his argument on the wave nature of light, the reconstruction of Fresnel’s demonstration of diffraction of light to simulate how Fresnel provided empirical evidence in convincing Poisson of his argument that wave nature of light, etc. The lesson series broadened Wayne and Kyle’s awareness of alternative teaching methods and approaches and provided them proof of existence of good NOS teaching. In another instance, after watching an early career physics teacher trying a different way (from the standard lesson sequence in local physics textbooks) of introducing the concept of momentum and its relevant NOS, Kyle commented with a pleasant surprise.

…less than one year of teaching experience? …he was so good…and his students got the ideas [both the concept of momentum and NOS aspects]!…Students also practised the skills in extracting data from the graphs [generated by the data-logging software] and data handling skills.

Apparently his comments reflected an initial doubt about students’ ability in discovering the conserving property of the total sum of the products of mass and velocity of each colliding object, (i.e. total momentum) before and after different types of collision, and students’ appreciation of pattern- or rule-seeking as a typical and important activity of scientific inquiry.

Making Use of a Timely SSI to Teach SSI

With the encouraging proofs of existence of successful teaching of NOS by other physics teachers, Wayne and Kyle decided to make their first collaborative attempt in teaching the interconnection of science, technology, and society. In August 2009, Kyle and Wayne had a meeting with the first author, Alice, to share their preliminary idea about making use of the recent controversial decision of FINA\(^2\) that the use of shark skin swimsuits\(^3\) would be banned in international swimming competitions after 1 January, 2010. Their intent to cover STS connections was guided by an apparent focus of the new physics curriculum guide. They felt that this SSI was a very suitable context to be integrated in the topic of mechanics. It was also timely and relevant to the interest of their students.

After Wayne and Kyle had introduced the fundamental physical quantities related to the motion of an object (time, distance, displacement, speed, velocity, 

\(^2\)The international governing body of swimming, diving, water polo, synchronized swimming, and open water swimming. FINA stands for Fédération Internationale de Natation, meaning International Swimming Federation.

\(^3\)Swimsuits made of technologically advanced fabrics biomimetically designed with a surface that mimics the shark denticles to reduce drag resistance through the water.
acceleration), they decided to conduct the lesson on the *Ban of Shark Skin Swimsuits* which was dedicated to promote students’ understanding of the STS connections. It was discernable that the choice of the context and their design of the instructional materials bore considerable similarities to the SSIs that they learnt in SARS. For example, the context chosen was immediate, contemporary, and familiar to students. The topic itself and the decision of the ban were controversial. It was a good example to illustrate the impact of science and technology on social practice (in sports). The contents of the 50-min lesson are shown in the first column of Table 14.5. The second and third columns are the teaching and learning activities and the embedded NOS aspects, respectively.

| Lesson sequence | Multimedia items/teaching and learning activities | Embedded elements of NOS |
|-----------------|---------------------------------------------------|--------------------------|
| Introduced the purpose of the lesson: STS connections. | Asked students (Ss) to recall how to calculate velocity and acceleration. Teacher (T) highlighted their relationship with time and hence need accurate measurement of time for calculation. T showed photo of a digital stop watch and an electronic timer which avoids errors due to reaction time. T elaborated improved technology can generally benefit sports competition, and timing device is one of them. | Society demands for more accurate timing devices. Technological advances may bring advantages to societal events (e.g. sports competitions). |
| Quick revision of quantities in describing motion of an object (t, s, v, a). | Highlight the need of accurate timing device for accurate measurement of these quantities. | |
| Highlight the need of accurate timing device for accurate measurement of these quantities. | Use of a highly-attended 110 m hurdle race to illustrate why accurate timing device (or technology in general) is important to the fairness in sports competitions. | Highlighted once more accurate device is needed for fairer judgment. |
| Use of a highly-attended 110 m hurdle race to illustrate why accurate timing device (or technology in general) is important to the fairness in sports competitions. | T capitalized on the first return of Liu Xiang on the field (the best Chinese 110 m hurdler) in an international hurdle match in Shanghai held just 2 days ago. Showed a video clip in which Liu Xiang and Terrence Trammell made the same time record of 13.15 by digital timer (difference <1/100 s). T then explained the use of ultra high-speed multiple photo shots in differentiating the position. | Linked the need of technologies to fairness of sports competitions. |

(continued)
Table 14.5 (continued)

| Lesson sequence                                           | Multimedia items/teaching and learning activities                                                                 | Embedded elements of NOS                                                                 |
|------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------|----------------------------------------------------------------------------------------|
| Drew Ss awareness to the use of other technologies beyond accurate timing. | Invited Ss to give examples of the use of technologies in sports for other purposes in sports competitions.         | Various technologies improve the performance of sports competitions and change the practice both during competition and during training which results in much improved world records. |
| Prompted students to reflect on the issues of fairness brought by the use of technology in sports. | Ss gave appropriate examples including: IR gun used in measuring distance of short put, sports shoes with air cushion, electronic scoring machine. T showed a series of video clips of technologies used within competitions and (e.g. set-running aid, shark skin swimming suit, man-made legs for running competition in Olympics for the handicapped), during training (swimming pool with resistive flow, video replay for identification of imperfect action for focused improvement) |                                                                                       |
| Focused on shark skin swimsuits – the technological product which just got banned. | T showed Ss the video of the recent swimming competition in July 2009 in Rome in which Michael Phelps of USA lost to Paul Biedermann of Germany in the 200 m-free style due to a considerable progress of the technology used in shark skin swimsuits. | Technological advances which result in a jump beyond social expectation can lead to controversy of its use. |
| Highlighted the impact of the shark skin swimsuits on the world records in swimming competitions. | Showed a table of the world records in swimming competitions to highlight that almost all events were broken in 2009 and then contrasted this situation with track events which were much less frequent. |                                                                                       |
### Immediate Reflection and Modification of Lesson Implementation

Wayne and Kyle conducted their own class on the same day. Wayne’s lesson with class 4F took place in the morning while that of Kyle with class 4E took place in the afternoon. Kyle and Alice joined Wayne’s morning lesson. Wayne and Kyle had put great effort in locating relevant videos, historical world records of swimming...
and track events, and other informative data for various lesson activities. During the lesson, videos like the return of Liu Xiang back on the track, which obviously captivated students’ interest and attention, Kyle and Alice felt the lesson was too loaded in the first half that the time left for student discussion in the role play activity and their subsequent reporting was limited (with less than 15 min). Opportunities for quality student interaction and arguments were scarce. Kyle was very sensitive and reflective in identifying components with good engagement of students, for example, the 110 m-hurdle race with Liu Xiang. As an observer of Wayne’s lesson, Kyle acted as a critical friend for Wayne, identifying several lesson components that could be run more efficiently by (1) rephrasing some questions to ensure clarity and good understanding by students, (2) showing only selective parts of some videos while retaining its original purposes, and (3) rearranging some videos to make better linkage from one component to the next. Kyle’s immediate postlesson reflection on the codesigned lesson plan turned out to be very successful in addressing some inadequacies identified in Wayne’s implementation.

**Learning Outcomes of NOS Teaching**

Throughout Kyle’s lesson, the students were actively engaged and they contributed relevant and interesting ideas. With the modifications, the pace of the lesson flow was swifter as compared with Wayne’s class in the morning. The time allocation for the role play and subsequent reporting was about 23 min which allowed more well-thought-out views in supporting the students’ stances for each role. The following excerpts taken from student presentations reveal the stance and arguments presented by a group of representing scientists who developed the swimsuits and a group of sponsors of the swimsuits.

**Views of Scientists**

We do not agree to ban the use of the shark skin swimsuit. Our intention of designing shark skin swimsuit is to enhance the swimming speed of athletes. It is great that our product (shark skin swimsuit) is effective. However, the Olympic Council banned it…Improvement is made through competitions. If the Council does not allow athletes to use it, how can our invention spread all over the world? As scientists, we want to improve the quality of our technology. We design such kinds of products for humans. We hope that every country would support us. The use of our product by participants proves our success. Therefore, we absolutely support the use of shark skin swimsuit in sports competitions.
Views of Sponsors

We do not agree. The swimming sport is not to compete for the slowest, but for the fastest. We can give the shark skin swimsuits to all the swimming athletes, so that it can be fair and all the athletes can be faster. If we ban the shark skin swimsuit just because it is different from the traditional one, should all athletes be required to use the same swimsuit?

Right after Kyle’s lesson and before the postlesson discussion with Kyle and Wayne, Alice chatted with a girl of Kyle’s class to see if she captured the key message of the attempt of the teachers in teaching NOS with a specific focus on the STS connections. Alice delightfully shared the student’s responses to her questions with Wayne and Kyle.

(A – Alice; K – Kyle)

A: I asked her “… if you were to chat with your family about this lesson, what would be the take-home message of this lesson that you would share with them?” What message do you think she remembers best?

K: The message that she remembered best?

A: Yes…impressed her most…you tried convey quite a few messages in this lesson.

K: Surely I hope she can remember my summary made at the end of the lesson

A: Yeah…

K: …however, I am afraid she won’t remember this main point.

A: OK, what did you wish she could get from your conclusion?

K: Um … Now we have banned the use of shark skin swimsuits, which would affect the development of science and technology. It will also influence our society. There will be fewer technology products.

A: Um…You will be very happy. She actually mentioned this message…Yes, she did.

K: That’s great!

A: Yes. She did mention that.

K: Wow, at least I know one student got this message, right? This is so pleasing!

A: Yes. She actually pondered for a while before answering me. She didn’t simply recall what you just mentioned… She thought seriously and told me that … what she remembered best was that “now, the use of shark skin swimsuits is banned…however, shark skin swimsuits may be applied to athletic games some days in the future”. You know, probably she was prompted by your joke you made at the end of the lesson [would bring along a shark skin swimsuit for the running in the School Sports Day tomorrow]. She said further, “The ban may affect the development in other things…In athletic games, there are also many technological products, but they are not banned.”

K: She could even get this point?
A: Yes!
K: She did very well!
A: Yes, she did very well indeed.

What else could be more rewarding for teachers to know that their effort in preparing a lesson has turned nicely into students’ learning? To us, as teacher educators, what else could be more rewarding when hearing teachers’ excited acclaims on their students’ learning? We shall conduct more interviews with the teacher participants and their students toward the end of this professional development project to understand more about the relationship between the teaching NOS and students’ learning outcomes.

**Implications for Professional Development**

The data collected from the teachers and students seems to suggest that their learning of NOS through the use of timely SSIs has been promising. Teachers who experienced the learning more than 18 months ago through the SSIs in the SARS incident still possess very good NOS understanding and still recall the various contexts in which they learnt relevant NOS. Students’ discussion during the role play and their subsequent presentations also indicated that understanding of certain NOS features has been achieved, in particular the STS connections which were highlighted in the lesson on the *Ban of Shark Skin Swimsuits*.

We see several similarities of our teacher training lesson in promoting teacher NOS understanding and Wayne and Kyle’s lesson in promoting students NOS understanding (in particular STS connections). First, both lessons used timely contexts that were relevant to learners. SARS has captured much attention of all people in Hong Kong where it was most hard-hit by the epidemic. Thus it has been highly relevant to teachers in Hong Kong and its timeliness would last for years due to the unforgettable experience and the scare of a similar crisis due to another outbreak, like the recent swine flu. For Wayne and Kyle’s lesson, sports have been mostly liked by teenage students. Wayne and Kyle deliberately included examples of a diverse range of sports. Kyle reminded us that the effectiveness would be enhanced if the teachers also find the context relevant. He said, “I love sports very much and enjoy looking up information about sports…feel excited and at ease when talking about them to students.” They also capitalized on the timely context of the ban of shark skin swimsuits that happened a couple of months before their lessons. The use of the return of Liu Xiang (favorite sports star of many Hong Kong students) to the 110 m-hurdle competition 2 days before their lessons was both timely and relevant to the students. Students were obviously attracted to the many video clips of sports competitions and sports training used by them in the lesson. Similarly, the SARS teacher training materials also made heavy use of videos of scientists who fought against SARS and documentaries produced by reputable media about the inside story of SARS. Teachers felt excited to hear these inside stories. These videos were immensely helpful in the reconstruction of the relevant SSIs to give learners
a sense of authenticity about the events shown. This is the second common feature of the SARS training materials and Kyle and Wayne’s instructional materials that motivated the learners. Third, both lessons engaged learners in critically reflecting on dilemmas, issues, and problems faced in decision making. Instead of being a purely rational and logical exercise, such decision making mandated considerations of social demands, sentiments of public, incomplete scientific findings and possible consequences to different stakeholders, etc.

Although we have reported the unique features of the SARS instructional materials that may account for its effectiveness in promoting teachers’ understanding of NOS (Wong et al., 2008), we have not shared these features explicitly with the teacher participants who joined our professional development project. Our oversight was due to our belief that another similar incident as SARS would be unlikely, which embodied so many NOS features in one case. It was interesting to find that Kyle and Wayne somehow translated some of the unique features of the SARS training session to their teaching of NOS. Kyle and Wayne’s lesson demonstrated that the same features could still be nicely applied to a simple SSI embedded with just a few NOS aspects. Indeed Kyle said that he felt fairly at ease in running the role play activity as he had experience using one of the sets of teaching resources, LASIK, developed in our previous project from 2005 to 2007. In the LASIK package, there was an activity in which students were asked to advise, with justification, people of different backgrounds, careers, and eye problems whether they are suitable for taking laser-assisted in situ keratomileusis (LASIK) surgery. Kyle further commented that if he had not used the LASIK package, it would have been quite daunting for him to design a lesson teaching STSE on his own.

I used the LASIK package before…all information are there…I didn’t need to prepare anything extra, only implemented the activities…After the implementation, I felt relatively easily to design a new one…. If I have to design one right from the beginning, it would be hard. But if there is a sample, like LASIK…also on STS…I can follow it like a model.

The learning of Wayne and Kyle seems to suggest that teachers did learn from exemplars, or through the modeling of exemplars. They were able to make use of some features of exemplar SSIs, and to apply them in designing novel SSIs that fitted the needs of their students. The capability of identifying key features of exemplar materials and transferring such features to personalized teaching resources seems to be essential for teachers’ development. Developing such capability seems to be a way for our future teacher training programs. We envisage that such modeling is potentially applicable to other approaches of teaching NOS, for example, doing inquiry, history of science, etc.

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