Taiwanese Science Curriculum Reform and Earth System Education

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Abstract

Curriculum reform has been a significant emphasis for most of countries all over the world for the past few years. It was the first time for Taiwan to develop a new Science and Life Technology curriculum Standards (SaLTS) for grades 1 through 9 compulsory educations. The SaLTS features integrated science content with the aim at motivating students to learn science and encouraging students to apply science to their everyday life, which is practically well aligned with the philosophical essence and foundations of Earth Systems Education (ESE). This paper calls attention to the importance of the inclusion of ESE into the forthcoming science curricula of Taiwan and worldwide and provides some exemplary ESE-inspired curriculum and instructional modules that have been successfully implemented in the secondary schools of Taiwan. Hopefully, this paper can shed some lights on the future development of the ESE-based science curricula, instructional modules, and teacher preparation programs.

Introduction

During the past few years, curriculum reform has gained much attention from teachers and researchers in science education all over the world. Taiwan is at present on the same trail to develop the new 1-9 Grades Curriculum Guidelines (Ministry of Education, [MOE], 1998) for the primary and secondary levels with the goals of reforming pre-college education. According tothe curriculum guidelines, there are seven fields of study including Art and Humanity, Health and Physical Education, Language, Mathematics, Science and

Technology, Social Sciences, and Extracurricular activities. Permeating throughout these seven fieldsof study are several areas of interest such as career planning, environmental conservation, gender equity, human rights, and information and communication. For the last few years since 1998, many scientist, science educators, and science teachers have been involved in developing the Science and Life Technology curriculum Standards (SaLTS, MOE, 2001) for the study field of science and technology with the aim of integrating a broad range ofsubject matters such as biology, chemistry, earth sciences, physics, and technology.

The new science and technology curriculum standards aim at a systematic way of developing student's understanding and appreciation of three interactions including; human being and the individual, human being and the society, as well as human being and the nature. All of which are virtually well aligned with the philosophical essence and foundations of Earth Systems Education (ESE). Moreover, ESE has its practical significance to the structural, componential, and implementing aspects of the SaLTS and to the future development of pre-college science curricula in a broader sense in Taiwan.

The Importance of the Inclusion of Earth System Education into the Science Curriculum of Taiwan

Earth system sciences and system science methods are emerging as important science disciplines and science methodologies due to human awareness of the worlds deteriorating land, water and climate; yet, for the past decades its significance has not been reflected in the traditional "reduction" type of science curricula, as described by Mayer and Kumano (1999). As a matter of fact, the discipline-oriented science curriculum and "reduction" science methodology have not only dominated in the USA but also in Taiwan for many years. Mayer and Fortner (2002) made it clear that, "the science curriculum in the secondary schools of the USA and through its influence, in many countries around the world, came to focus on the type of science supportive of Cold War technology, that of the physical sciences". Unfortunately, Taiwan is exactly one of the countries that closely followed the steps of the USA in the past.

In all respects, Taiwan is not and should not be alone in terms of reforming science education and incorporating earth science or earth system education (ESE) into the contemporary science curriculum. Since learning earth science not only interests students in probing the mysteries of nature, but also can stimulate students' concern for environmental devastation around the world such as acid rain, global warming and climate change, El Nino's influence, ozone depletion, and groundwater pollution. Earth science, which consists of geology, meteorology, astronomy, and oceanography, is one of the science subjects most relevant to students' everyday lives. Accordingly, the National Science Education Standards in the USA (NRC, 1996) embraces "Earth and Space Science"as one of the eight categories of content standards along with Physical Science and Life Science. A detailed examination of the curriculum frameworks that served as the guideline for designing the achievement tests of the IEA's (International Association for the Evaluation of Educational Achievement) TIMSS (Third International Mathematics and Science Study) in 1994-1995 and TIMSS-Repeat in 1999 also revealed that earth science is formally taught at the secondary school levels in various countries (Robitaille et al. 1993; Martin, et al. 2000).

The interdisciplinary and integrated nature of earth science is unique among other sciences. Aldridge (1993) stated that,"Chemistry and physics are fundamental to an understanding of the life science and chemistry, physics, and the life science are fundamental to an understanding of the Earth and space sciences" (p. 27). However, current primary and secondary programs in Taiwan generally ignore those sciences and methods that teach us about how the Earth System functions and how to study science in a systematic and integrated way, but rather only concentrate on those seemingly fundamental science knowledge and "reduction" science methodologies.

Several Successful Implementations of the ESE-Inspired Curriculum or Instructional Modules in Taiwan

For the past several years, a group of secondary school science teachers and I have tried to incorporate Earth-system themes and system science methods into developing integrated science curriculum and instructional modules for the secondary schools of

Taiwan. The implementations of these ESE-inspired curriculum or teaching modules were all proven to be very successful. For example, an inquiry-oriented instruction organized around "Earth-Sun-Moon" theme in alignment with the Understanding # 6 of the Earth System Education, "Earth is a small subsystem of a solar system within the vast and ancient universe" and its sub-theme "The position and motions of Earth with respect to the Sun and Moon determine seasons, climates, and tidal changes", has been found to be fruitful in promoting student's science achievement and attitudes toward science (Chang & Mao, 1999). In the above study, we examined the comparative efficiency of ESE-based inquiry-group instruction and traditional teaching method on junior high school students' achievement and attitudes toward earth science in Taiwan. The results showed that students receiving the ESE-based inquiry-group instruction had significantly higher achievement scores than did students in the traditional groupand that there were also statistically significant differences in favor of the ESE-based inquiry-group instruction on student attitudes toward the subject matter.

Another study employing a problem-solving-based instruction, organized around a "plate tectonics" theme, in line with the Understanding # 4 of the Earth System Education, "The Earth system is composed of interacting subsystems of water, rock, ice, air, and life" and its sub theme "Plate tectonics is a theory that explains how internal forces and energy cause continual changes within Earth and on its surface", has also shown a significant improvement of student achievement and modification of their misconceptions (Chang & Barufaldi, 1999). The aforementioned investigation explored the effects of ESE-based problem-solving-based (PSB) instructional model on earth science students' achievement and alternative frameworksand found that the ESE-based PSB method did significantly improve the achievement of students (especially at higher cognitive domain) and promotesignificant conceptual changes of participating students.

We have also developed a computer-assisted instruction (CAI) on the topic of "Human activity and its impacts on the debris-flow hazards"organized around another important Earth-system theme: Natural hazards and their mitigations (Chang, 2001a, 2001b, 2002). This topic has also been proposed by the Understanding # 2 of ESE, "Human activities, collective and individual, conscious and inadvertent, affect planet Earth" and its sub theme

"The better we understand Earth, the better we can manage our resources and reduce our impact on the environment worldwide."

In this ESE-inspired computer-assisted instructional tutorial, students were first shown a video clip of the debris-flow hazard occurred in Nan-Tou Province of Taiwan in 1996. Then they were asked to identify facts associated with this specific problem on the natural hazard, and they were required to find out possible factors that might cause this hazard through guided inquiry provided by the computer program. Students were subsequently encouraged to prepare and implement their plans by analyzing and investigating the research questions, i.e., the factors causing the debris-flow hazards and collect necessary information in association with the debris-flow hazard. Students also need to go through a virtual field trip to conduct geological investigations provided by the CAI and to find out the solutions to the debris-flow hazard problems. Finally, student prepared final reports of their work and presented project results to their classmates by explaining and communicating with each other. The "human activity and its impact on the debris-flow hazards" CAI was found to have promise in supporting students'learning of earth science and leading to improved student achievement and attitudes toward the subject matter (Chang, 2001a, 2001b, 2002). Furthermore, result of the above studies have also revealed that the ESE-inspired CAIunanimously brought forth significantly greater gains in students' earth science achievement than did the traditional teaching approach supplemented with regular computer-internet usage.

Three Earth-System-Integrated Teaching Instructional Modules (ESITIM) for the secondary schoolswere also developed thanks to a three-year special grant from the National Science Council of Taiwan, which were also inspired by the philosophy and essences of Earth System Education. The ESE-based instructional modules cover the following four themes: 1) evolution and continuity, 2) dynamic-interacting subsystems of the earth, 3) earth resources, and 4) natural hazard and its mitigation. An ESE approach and a learning cycle model (Engage, Explore, Analysis/Explain, Apply/Evaluate, EEAA) were adopted. Field test implementations of the earth-system integrated teaching modules in the secondary classrooms were all quite successful and encouraging (Chang & Lai, 2001).

Earth-System Earth-Resources Instructional Module (ESERIM) was the first instructional module developed during the first year project. This module is based upon the Understanding # 2, "The better we understand Earth, and the better we can manage our resources and reduce our impact on the environment worldwide."We examined the effects of the ESERIM on 11th graders' science learning in three secondary schools of Taiwan and found that the ESERIM could significantly improve student achievement. We have also collected mostly positive responses of participating students, such as "the instruction is fairly interesting to me and motivates my own learning", "I have learned a lot of things related to my daily life", "I learned how to approach the issues of environmental pollution from different perspectives", and "I was aware of the dilemma between economic development and environmental preservation", which were all strongly aligned with the design and objectives of the ESERIM (Chang and Lai, 2001) and the foundations of ESE. In addition, we have also conducted in-depth semi-structural interviews with three participating teachers after they implemented ESERIM in their classrooms, with the aims at exploring their perceptions toward the ESERIM(Lai and Chang, 2003). The analyzed data indicated positive and supporting attitudes of the teachers toward the ESERIM and optimistic opinions about the viability of implementing this type of earth-system integrated science curriculum in senior high schools. Importantly, teachers expressed advantages of the ESERIM in terms of encouraging students to respect and value other's ideas, look at problems from different perspectives, work together with their peers to solve problems, and change their ways and attitudes of pursuing knowledge. The findings suggest that implementing the Earth-System integrated theme has the potential to serve as a model for future development of an integrated curriculum and instruction in Taiwan.

Conclusions

Past science curriculum in the secondary schools around the world mainly focused on traditional subjects or individual sciencedisciplines. This paper contends that the science curriculum should be taught through an Earth System Education approach in light ofsome empirical research evidences involving ESE-oriented instructional approaches that demonstrate promise in improving students' abilities. Being encouraged and impressed by the successful implementations of the ESE-inspired instructional modules in Taiwan, I sincerely believe that the dream of many countries throughout the world adopting and employing an earth-system integrated science curriculum in science classrooms will finally come true.

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