Taiwanese Earth Science Curriculum Guidelines and Their Relationships to the Earth Systems Education of the United States

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ABSTRACT

The purpose of this paper is four fold as follows: (1) to sketch the Taiwanese educational system and Earth science education; (2) to introduce the mandatory Earth science components of SaLTS (Science and Life Technology curriculum Standards) for grade nine and the requisite components of TESCG (Tentative Earth Science Curriculum Guidelines) at the tenth-grade level in Taiwan; (3) to make a critical analysis comparing SaLTS (as well as TESCG) and the Earth Systems Education (ESE) of the Untied States; and finally (4) to provide a framework of school Earth-science curriculum content in the global context from the perspectives of Taiwan.

INTRODUCTION

In the past decade, curriculum reform has received increasing attention from educators in many countries around the world. Taiwan is at present on the same path, as educators work toward the goal of educational reform at the primary and secondary levels. This effort has led to the development of new curriculum guidelines for grades one to nine (Ministry of Education, 1998). The guidelines recognize seven major fields of study at the elementary and secondary levels urging integration among the fields of study. Since then a range of science experts, educators, and teachers have developed the Science and Life Technology curriculum Standards (SaLTS) (Ministry of Education, 2001) for the study of Science and Life Technology. The standards attempt to integrate the traditional subjects of biology, chemistry, Earth science, physics, and life technology into one major field of study with the goals of reducing the amount of science content for students to learn and promoting connections between science and students' daily lives.

Following the same rationale of curriculum reform, the tentative curriculum guidelines (Ministry of Education, 2004) for grades ten to twelve were also developed over three years by a group of educators summoned by the Ministry of Education of Taiwan. Recently, basing upon the aforementioned guidelines, a number of Earth scientists, Earth science educators including Chang (the senior author), and Earth science teachers completed the Tentative Earth Science Curriculum Guidelines (TESCG) for grades ten through twelve in October, 2004. Both of the Earth-science components of SaLTS (mainly at the ninth-grade level) and TESCG (mainly at the tenth-grade level) feature a systematic way for developing students' understanding, investigating skills, and appreciation of our planet Earth. The objectives of the present paper are to describe the Taiwanese educational system and Earth science education with mandatory requirement in Science and Life Technology studies and the tentative Earth science curriculum guidelines, make a critical analysis comparing SaLTS and TESCG of Taiwan and the Earth Systems Education (ESE) of the Untied States, and finally try to provide a syllabus of school Earth science curriculum in a global context from the perspectives of Taiwan.

TAIWANESE EDUCATIONAL SYSTEM AND EARTH SYSTEM SCIENCE EDUCATION

It is necessary to elaborate upon the educational system and Earth science education origins of Taiwan before discussing the major components of SaLTS and TESCG for the compulsory grades nine and ten. There are five levels in the contemporary educational structure in Taiwan: Kindergarten (K), Elementary School (1-6), Junior High School (7-9), Senior High School (10-12), and College or University.

After junior high school, students who wish to attend college in the future must take the Basic Competency TEST (twice a year, effective 2001) to enroll in a senior high school. Then, senior high school students, who wish to continue their studies at the tertiary level, must take another annual national competitive entrance examination, Entrance Examination for Colleges (effective 1994). Entrance Examination for Colleges basically comprises two different tests: one is the fundamental and required subject test called Scholastic Achievement Test and the other is the advanced and optional subject test named Departmental Required Test. In traditional Asian culture, this kind of competitive selective process has survived for many years because it provided an opportunity for members of low-ranking social groups to move upward in society.

The Basic Competency TEST and Scholastic Achievement Test consist of a two-day written test program, covering subjects such as Chinese, English, Mathematics, Natural Sciences, and Social Sciences. To be prepared for these important entrance examinations, students must work on many exercises and problems along with taking thousands of tests in secondary school. Owing to the importance of the entrance examinations to students' futures, improving students' science achievement has long been a major goal for science educators in Taiwan, especially at the senior high school level. Every year more than 130,000 12th grade students (almost the total amount of 12th graders in Taiwan) take the Scholastic Achievement Test; their scores in each subject are therefore treated by the University as the essential measure of achievement in that subject. Accordingly, many researchers have tried to develop a variety of instructional modules for secondary schools of

SaLTS Earth Science Components		ESE	TESCG Components	
Themes	Content	Content	Themes	Content
Composition and characteristics of nature Interactions in nature	Composition of Earth (rocks, water, air)* Earth and space Changes in the Earth surface and crust Changes in weather Days/nights and seasons Global warming	Understanding #4: The Earth system is composed of interacting subsystems of water, rock, ice, air, and life: Each component of the Earth system has characteristic properties, structure, and composition that may be changed by interactions of subsystems Understanding #6: Earth is a small subsystem of a solar system within the vast and ancient universe	Human and the Earth environment Dynamic Earth Earth in space	Exploring the origins of Earth Overview of human and the Earth environment The structure of Earth The changes in atmosphere and ocean The changes in the solid Earth Viewing Earth from space Viewing space and stars from Earth
Evolution and continuity	Stratigraphy and fossils	Understanding #5: Planet Earth is more than 4 billion years old and its subsystems are continually evolving	Earth environment change	Climate change Seashore change
Life and environment	Natural hazards and mitigations Environmental pollution and prevention	Understanding #3: The development of scientific thinking and technology increases our ability to understand and utilize Earth and space	Earth resources and sustainable development	Resources, environment and sustainable development
Lifelong develoment	Lives and environment Human beings and nature Preservation and usage of resources Exploitation and usage of energy	Understanding #2: Human activities, collective and individual, conscious and inadvertent, affect planet Earth	Natural hazards	Meterological hazards Geological hazards

Table 1. The strong correlations between SaLTS and TESCG components and the ESE understandings.

Taiwan to improve student Earth science achievement (Chang, 2001, 2002, 2003; Chang and Barufaldi, 1999; Chang and Mao, 1999).

Addressing the needs of students to understand the Earth and its increasing environmental issues, the Ministry of Education in Taiwan first included a required Earth science course in the junior high school science curriculum (the ninth grade), and further incorporated an Earth science subtest into natural science subjects on the annual Entrance Examination for Senior High School in 1987. Thereafter, the Ministry of Education introduced a mandatory two-credit-hour Earth science course at the senior high school level (tenth grade) in 1995, and additionally included Earth science subject in the natural science subjects on the Scholastic Achievement Test in 1995. The inclusion of an Earth science subtest encouraged parents, teachers, and students in Taiwan to pay attention to the science of the Earth, which deals with the materials of our planet and the processes which bring about change. The current Earth science curriculum at the secondary level mainly consists of four major topics: Astronomy, Geology, Meteorology, and Oceanography.

SCIENCE AND LIFE TECHNOLOGY CURRICULUM STANDARDS (SaLTS) FOR GRADES ONE THROUGH NINE

There are six objectives included in SaLTS: (1) to stimulate students' interest in science along with autonomous learning habits; (2) to help students acquire fundamental knowledge and inquiry methods in science and life technology and apply these to their daily life; (3) to increase students' positive perceptions of cherishing the environment, treasuring resources, and respecting life; (4) to help students develop skills useful in cooperation and communication with others; (5) to develop students' abilities of independent thinking, problem solving, and creativity; and (6) to promote students' awareness of the human- technology interactions. Besides the six objectives, eight categories of scientific literacy were also developed to serve as indicators of science abilities or learning outcomes. These indicators are process skills, science and life technology knowledge, nature of science, development of science and life technology, scientific attitudes, intellectual ability, science applications, and design and creativity.

The major characteristics of SaLTS were reduction of science content, motivation of students to learn science, and application of science learning to everyday life (Chang, 2005). There are five main themes, each with sub-themes that form the curriculum content standards. The main ideas of SaLTS are similar to the ideas proposed by Mayer et al. (1990, p.66), who proposed that the "Earth System could very well serve as the conceptual framework upon which to base the entire K-12 science curriculum as the new integrated science curricula evolve" - because not only the 'Earth System' itself is an integrated topic or theme, but because of emphasis on

Themes	Content	Sub-Contents	
Dynamic Earth	1. The structure and properties of Earth 2. The changes in atmosphere and ocean 3. The changes in solid Earth	1-1 1-2 1-3 2-1 2-2 3-1 3-2 3-3	The structure and properties of atmosphere The structure and properties of ocean The structure and properties of solid Earth Atmosphereic changes and water cycle Currents, waves and tides Changes in Earth surfaces Ring of fires and Earthquakes Plate tectonics
Earth in space	1. Viewing Earth from space 2. Viewing space from Earth	1-1 1-2 2-1 2-2	Earth in space environment Earth and the solar system Knowing space and stars Observing space and stars
Natural hazards	1. Meteorological hazards 2. Geological hazards 3. Mitigation of natural hazards	1-1 1-2 2-1 2-2 3-1	Typhoon Flooding Earthquakes Landslide and debris flow Natural hazards mitigation
Earth environment change	Climate Change	1-1 1-2 1-3	Climate change in history and its impacts on the environment Short-term climate change Long-term climate change
Earth resources and sustainable development	Resources, environment and sustainable development	1-1 1-2 1-3	Utilizing resources wisely Diminishing environmental damage Rationale for sustainable development
Unique Earth and diverse professions	1. Earth is unique and beautiful 2. Earth science related professions and work	1-1 1-2	Appreciation of Earth's uniqueness, beauty, and great values Earth science related professions included its work, processes and values

Table 2. A tentative outline of school Earth science content in a global context

interdisciplinary methodology. Considering the important role of the Earth system in the development of future science curricula and meeting the contemporary call worldwide for an integrated science curriculum, 20 authors representing ten countries developed a theoretical curriculum framework based on the Earth system theme and provided some empirical research with regard to the implementation of Earth Systems Education (ESE) (Mayer, 1997, 2002, 2003; Mayer and Tokuyama, 2002).

TENTATIVE EARTH SCIENCE CURRICULUM GUIDELINES (TESCG) FOR THE TENTH GRADE

To cultivate Earth science literate citizens with appropriate knowledge, skills, and attitudes, TESCG of Taiwanese senior high school emphasize the following three objectives: (1) to equip students with fundamental core knowledge in Earth science and help students understand or be aware of Earth-science related news/report in their daily life; (2) to help students apply the acquired Earth-science knowledge and methods to their daily lives and develop their problem solving abilities; (3) to stimulate students' interest in and learning enthusiasm for Earth science and environment and to promote students' energetic awareness and appreciation of the Earth environment. The major characteristics of TESCG put much emphasis on the interaction between human beings and their environment. There are six main themes to shape the curriculum content guidelines and each theme contains its own content and sub-contents.

A COMPARISON OF THE SaLTS AND TESCG CURRICULA WITH THE SEVEN UNDERSTANDINGS OF THE EARTH SYSTEMS EDUCATION OF THE UNITED STATES

Table 1 illustrates the strong correlation between the SaLTS and TESCG of Taiwan and the ESE content proposed in the United States. Both the major themes of SaLTS and the major themes of TESCG correspond with Understandings 2-6 of ESE. It is noted, however, Understanding #1 "Earth is unique, a planet of rare beauty and great value" and Understanding #7 "There are many people with careers that involve study of Earth's origin, processes, and evolution" are not included and/or emphasized in both SaLTS and TESCG. It maybe because Taiwanese conventional curriculum has not paid much attention to the affective domain in terms of appreciating the beauty and uniqueness of Earth and being aware of Earth-science related professions, possibly resulting from enormous influences of content learning and entrance examinations. Although these curricula guidelines and ESE content generally fit together quite well, they do have different specific content emphases because of students' grade levels and cognitive abilities. For example, this TESCG guideline emphasizes a range of more integrated and interdisciplinary topics including Meteorological hazards and Geological hazards, which are not the major focus of either SaLTS or ESE. Taiwan is located on the ring of fire and is confronted with many natural hazards yearly, including climate-related natural hazards such as typhoons and flooding. For example, at the end of July

1996, Typhoon Herb roared through Taiwan causing heavy rain over the course of three to four days which resulted in the loss of many lives and extensive property damage due to flooding, landslides, and a large-scaled debris-flow hazard. Therefore, topics dealing with meteorological and geological hazards are relevant to students' daily lives. Additionally, mitigation of calamities such as typhoons, flooding and mudflows is emerging as an important issue for all humankind. The significance of these topics is therefore reflected in the tenth-grade curriculum guideline.

Because the aforementioned guidelines are strongly aligned with the ESE content, future curriculum development and planning based on SaLTS and TESCG can also be realized in the primary and secondary schools by adopting the ESE model.

To gather insights and feedback from scientists, science educators, science teachers, and school administrators all over the country, the first drafts of SaLTS along with an opinion questionnaire were randomly sent out to 500 elementary and junior high school science teachers to acquire their professional opinions and comments on SaLTS. Overall, a total of 235 surveys were returned, resulting in a response rate of 47 %. This response rate is disappointing but acceptable, as research has suggested that returns of less than 40 or 50 percent are common in mail surveys (Kerlinger, 1986). The results of this initial survey suggest that science teachers hold very positive attitudes toward the goals of SaLTS, the eight themes of scientific literacy, and indicators of abilities for each stage, content, suggested implementation plans, teaching strategies, and assessment methods of SaLTS. The teachers' responses are also generally aligned with the attempted proposal of ESE, which emphasizes an integrated, systematic approach of studying science.

A TENTATIVE OUTLINE OF SCHOOL EARTH SCIENCE SYLLABUS FROM THE PERSPECTIVE OF TAIWAN

After analyzing both of the major compulsory components of SaLTS and TESCG and conducting an empirical study by surveying a nationally representative group of secondary school Earth science teachers (n = 702), a new framework of school Earth science content, from the perspectives of Taiwan, might be realized as illustrated in Table 2. There are six themes proposed and included in the tentative framework of school Earth science content in a global context. Both the first theme 'Dynamic Earth' and the second theme 'Earth in space' emphasize traditional school curriculum content such as the structure and properties of Earth, changes in Earth, and Earth in space. The remainder of the major themes not only focuses on the Earth environment and resources but also on the impact of humans, technology and natural hazards on Earth's environment and affective domains of Earth science. These environment-oriented themes are the most important concepts valued by secondary Earth science teachers in Taiwan, as shown in the findings of a two-year survey study (Chang, 2004).

CONCLUSION

This paper has sketched the Taiwanese educational system and Earth science education, introduced the mandatory Earth science components of SaLTS for grade nine and the requisite components of TESCG at the tenth-grade level, compared SaLTS and TESCG of Taiwan and the Earth Systems Education (ESE) of the United States, and finally provided a framework of school Earth-science curriculum content, from the perspectives of Taiwan with the hope of setting up further discussion on the future global Earth science school curriculum content among different countries.

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