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# Comparing the Formats and Content of the State Science Content Standards of Six States in U. S. with Emphasis on Earth Science

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**Abstract:** This study identifies and compares science content standards that are approved by departments of education in six states: California, Connecticut, Michigan, New Jersey, Texas, and Virginia. Specifically, the study examines the goals/visions, the organizing/progression principles, the strands of science content, and earth science content found in the states curriculum standards compared to National Science Education Standards. Although many states followed the recommendations of NSES or Project 2061, the format and content of the state science standards reviewed are very diverse. The diversity seems to reflect the diverse perspectives and needs of the states. The results of this study provide Korean educators and teachers with useful models or examples to incorporate Korean national science curriculum guides into the science curriculum frameworks of their regions or schools.

Keywords: science education standards, science curriculum, organization of curriculum, content of curriculum

## Introduction

This study is a part of a project investigating the content of exhibition in Smithonian National Museum of Natural History and American Natural History Museums with regard to school science curriculum. At first, to develop a framework for analysis, science curriculum guides of the states around Washington, D.C. and New York City were collected and reviewed. It was assumed that the museums reflect into their exhibition the school science curriculum of the states nearby. This will increase the attracting power of the museums over the teachers and students, because school administrators tend to encourage field trips to the natural history museums whose exhibitions are well aligned to their school science curriculum. In the process of data collection, several states had to be excluded from the study because of insufficient data. Major states such as California, Texas, and Michigan were added to the list to identify general aspects of state content standards in US.

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Recently, science education reform movements in US have focused on developing curriculum guides at national level, such as Project 2061 and National Science Education Standards (NSES). Although NSES provides recommendations to improve science education in various aspects and levels, content standards of NSES give profound impact on American school science education, state science content standards, NSF-funded science curriculum development, and commercial science textbooks. However, each state is supposed to interpret the recommendations of NSES with its own perspectives and needs, and develop its own science content standards tailored to its needs and contexts.

Understanding the experience of US states to incorporate NSES to their state science content standards provides valuable insight to us, because Korea has very centralized educational system and National Curriculum, however, at the same time, recently the Korean Ministry of Education has a new policy to strengthening the role of local offices of education and schools in determining local or school curriculum from 7th National Curriculum. Although they had limited autonomy in determining the content of curriculum, local offices of education or schools usually failed to establish local or school curricu-

**Table 1.** Selected states and documents analyzed

| State | Year | Available Internet address |
|---|---|---|
| California (CA) | 2003 | http://www.cde.ca.gov/re/pn/fd/documents/sci-stnd.pdf |
| | 2004 | http://www.cde.ca.gov/re/pn/fd/documents/science-framework-pt1.pdf |
| Connecticut (CT) | 2005 | http://www.state.ct.us/sde/dtl/curriculum/currsci.htm |
| Michigan (MI) | 2000 | http://www.michigan.gov/documents/Science_Standards_122916_7.pdf |
| New Jersey (NJ) | 1998 | http://www.state.nj.us/njded/frameworks/science/ |
| Texas (TX) | 1998 | http://www.tea.state.tx.us/rules/tac/chapter112/index.html |
| Virginia (VA) | 2003 | http://www.pen.k12.va.us/VDOE/Instruction/Science/ScienceCF-Complete.pdf |

lum to meet the local needs and contexts' and ended up with curricula with little diversity. Lack of experiences in curriculum development at local or school level and lack of expertise of the educational administrators may be attributed to this failure.

The purpose of this study is to investigate and compare how six states in U. S. incorporate NSES on their own state science content standards and what kind of intentions they bring to their curriculum frameworks. To achieve this goal, the following research questions were formulated.

1. What are common and idiosyncratic goals or visions of the science content standards of six states?
2. What are the organizing/progression principles of the science content standards of six states?
3. What are the strands of the science content standards of six states?
4. What are common and idiosyncratic parts in the content of earth science in science content standards of six states?

## Research Methods

To compare and contrast the general aspects and the content of earth science in science content standards of the major states of US, six states were selected. At first, Maryland, Virginia, and West Virginia were selected from the region around Washington, D.C., and New York, Pennsylvania, Connecticut, and New Jersey were selected around New York City. Maryland, West Virginia, Pennsylvania, and New York were excluded from the study because only limited data could be available from on-line sources. Major states, such as California, Texas, Florida and Michigan were added to grasp the general trend of the state science standards of the US. Florida was also excluded from the study because of insufficient data.

To analyze science curriculum frameworks of six states, the documents provided from the departments of the states were analyzed (Table 1). The characteristics of states' science curriculum frameworks were analyzed in terms of goals/visions, progression principles, clustering levels, and organizing strands. The content of earth science in each state was also analyzed on the basis of the categories on earth science topics of NSES.

The analysis was conducted by one graduate student majoring earth science education, and two science education specialists. The research method used in this study is document analysis. The analysis was based on the documents and data were collected when they were explicitly stated in the documents. On the basis of the characteristics identified among six states, the similarities and the differences in the state science content standards among the states were compared.

## Results

The states science curriculum frameworks were analyzed in five areas: goals or visions, organizing principles, progression principles, standard strands and earth science content by clustering levels. The results were presented for each research question.

**Table 2.** Literatures reflected on the states' science curriculum frameworks

| States / Literatures | CA | CT | MI | NJ | TX | VA |
|---|---|---|---|---|---|---|
| National Science Education Standards (NSES) | ○ | ○ | - | ○ | - | - |
| Benchmarks for Science Literacy (Project 2061) | ○ | ○ | - | ○ | - | - |
| Scope, Sequence & Coordination | - | - | - | ○ | - | - |
| Standards for Technological Literacy | - | ○ | - | - | - | - |

### What are common and idiosyncratic goals or visions of the science content standards of six states?

To understand the backgrounds of the states' science curriculum frameworks, literatures which had major effects on the states' documents were sought. The curriculum guides recently developed, such as NSES and Project 2061, listed in Table 2 are reported as major sources of state standards development by three states; California, Connecticut, and New Jersey. All three states established the concepts and content format in their own curriculum model based on "National Science Education Standards" (NRC, 1996) and "Benchmarks for Science Literacy" (AAAS, 1993). In addition to the major curriculum guides, Connecticut also referred "Standards for Technological Literacy" (ITEA, 2000) and New Jersey referred "Scope, Sequence & Coordination of Secondary School Science" (NSTA, 1992) in its state content standards, respectively. However, this result does not necessarily suggest that NSES or Project 2061 is not reflected in the state content standards of Michigan, Texas or Virginia. As NSES or Project 2061 have had strong impact on US science education, this rather means that they might not explicitly state about the background of the state content standards in the documents analyzed. The literatures reflected are not mentioned in the science content standards of Michigan, Texas, and Virginia.

As science educators develop the state curriculum frameworks, they offer the core learning goals/visions to present the fundamental scope and skills for all students. Table 3 shows the main three goals in science learning which are compared by the states selected. The main three goals are scientific literacy, science & technology in society, and technology education. Although there is a strong relationship between scientific literacy and science & technology in society, they are categorized into two different domains in order to reflect the importance of STS in science education.

Among three goals, scientific literacy seems to be considered as the most important and comprehensive term. According to NSES (NRC, 1996), scientific literacy is a goal that all students should achieve. NRC (1996) defines that scientific literacy is the knowledge and understanding of scientific concepts and processes required for personal decision making, participation in civic and cultural affairs, and economic productivity. In other words, scientific literacy implies that a person can identify scientific issues underlying national and local decisions and express positions that are scientifically and technologically informed.

As seen in Table 3, all the states stress the development of scientific literacy as a main goal. They want schools to prepare all students to be scientifically literate. For this, ten components are found to be considered although all components are not common to all the states. Each state presents four through eight components for the goal of development of scientific literacy: key concepts & principles of science (all states), scientific methods or process skills (CA, CT, NJ, TX, VA), critical or scientific thinking (CT, MI, NJ, TX, VA), use and apply scientific knowledge & thinking (CT, MI, VA), connection to other subject dependency (CA, MI, NJ), decision-making (MI, NJ, VA), own natural resources (NJ), safety (CA, NJ, TX, VA), attitude or career (CA, CT, MI, NJ, VA), and language of science (CA, CT, VA).

Among the states, STS is presented as a main goal in California, Connecticut, and Michigan. Michigan has more emphasis on STS than other states do. Michigan document says that "as citizens, we are asked to make decisions about social issues that involve science and technology". Connecticut document says that "... by providing students with opportunities to explore the context of science and its applications, and to develop an understanding of the interconnections among science, technology and society". Connecticut's emphasis on STS seems to be closely related to its interest in technology, and it is the only state to consider "Standards for Technological Literacy" as one of major sources for its state science content standards.

California document represents specific topics related to STS as well as what STS means, as saying that: "... students have the opportunity to build connections that link science to technology and societal impacts. Science, technology, and societal issues are strongly connected to community health, population, natural resources, environmental quality, natural and human-induced hazards, and other global challenges".

Technology is recognized as another main goal in some states. Although most of states mentioned the importance of students' understanding technology, California and Virginia put up technology as a main goal. However, California and Virginia show different perspectives about technology as a goal. California suggests that: "effective science programs use technology to teach students, assess their knowledge, develop information resources, and enhance computer literacy". It is thought that technology-based models are used to design and guide experiments, making it possible to eliminate some experiments and to suggest other experiments that previously might not have been considered. That is, students have the opportunity to use technology and imitate the ways of modern science. Teaching science by using technology is important for preparing students to be scientifically and technologically literate.

Virginia emphasizes that the use of current and emerging technologies is essential to the K-12 science instructional program. It is recommended that students' functional literacy (communication) be improved through reading and information retrieval (the use of telecommunications), writing (word processing), organization and analysis of data (databases, spreadsheets, and graphics programs), presentation of one's ideas (presentation software), and resource management (project management software). Furthermore, technology means to use of modern instruments such as computers and software, as well as traditional instruments including microscopes or labware.

**Table 3.** Educational goals or visions presented in six states' science curriculum frameworks

| States / Goal/Vision | CA | CT | MI | NJ | TX | VA |
|---|---|---|---|---|---|---|
| Scientific Literacy | ○ | ◎ | ◎ | ◎ | ○ | ◎ |
| • key concepts & principles of science | ○ | ○ | ○ | ○ | ○ | ○ |
| • scientific methods (process skills) | ○ | ○ | | ○ | ○ | ○ |
| • critical, scientific thinking | | ◎ | ○ | ◎ | ○ | |
| • use and apply scientific knowledge & thinking | | ○ | ○ | | | ○ |
| • connection to other subject dependency | ○ | | ○ | ○ | | |
| • decision-making | | | ○ | ○ | | ○ |
| • own natural resources | | | | ○ | | |
| • safety | ○ | | | ○ | ○ | ○ |
| • attitude, career | ○ | ○ | ○ | ○ | | ○ |
| • language of science | ○ | ○ | | | | ○ |
| STS | ○ | ○ | ◎ | | | |
| Technology | ○ | | | | | ○ |

○: mentioned, ◎: emphasized

**What are the organizing and progression principles of the science content standards of six states?**

To get deeper understandings of the states content standards, the organizing and progression principles and grade clustering were analyzed. The organizing principles for the standards do not identify specific personal and societal challenges, rather they form a set of conceptual organizers, fundamental understandings, and implied actions for most comtemporary issues (NRC, 1996). It can be said that the organizing principle involved in all the states curriculum framework is "spiral" (Table 4). The term "spiral" is clearly shown in the documents of Connecticut (CT). An excerpt from CT document is following: "each theme is addressed by several content standards and related concepts that spiral through the grades, each time treated with more depth and breadth, and developmentally appropriate for the students." Although it is not denoted, the principle of spiral seems to be connoted in the documents of CA, MI, TX, and VA. For example, CA document says that: "The standards are organized in sets under broad concepts. This organization is intended to help the reader move between topics and follow them as the content systematically increases in depth, breadth, and complexity through the grade levels." However, NJ emphasizes cumulative progression in organizing its curriculum. NJ uses cumulative progress indicators as "by the end of grade 4, students will..." in presenting the strands of science curriculum. It can be said that NJ assumes science learning as cumulative activities in that they presents only what students should reach to by grades 2, 4, 6, 8, and 10.

Among six states, only three states presented progression principles of the science curriculum frameworks. CT, MI, and VA address their progression principles of science framework including the skills as well as the content required in science education (Table 4). CT science curriculum framework describes an approach to science learning that starts with simple, concrete explorations of the natural world by elementary school students, moves into explorations and explanations of foundational science concepts in the middle school, and advances to explorations of science concepts and related global issues during the high school years. Michigan content standards and benchmarks describe three broad categories of activities that are common in scientifically literate individuals: using scientific knowledge; constructing new scientific knowledge, and reflecting on scientific knowledge. The content strands in MI curriculum are directly related to these types of activities. Virginia shows that the standards of learning in each strand progress in complexity at each grade level K-6 and are represented indirectly throughout the high school courses.

National Science Education Standards are presented in the format of grade ranges K-4, 5-8 and 9-12. Table 5 shows the variation of grade ranges used in clustering the content standards of the six states. The standards are presented in the format of each grade in the states of CA, CT, TX, and VA. But MI standards are clustered for levels of elementary, middle school, and high school, and NJ are clustered for grade by 2, 4, 6, 8, and 12.

**Table 4.** The organizing and progression principles presented in six states' science content standards

| States | CA | CT | MI | NJ | TX | VA |
|---|---|---|---|---|---|---|
| **Organizing principle** | | | | | | |
| • Spiral | △ | ○ | △ | | △ | △ |
| • Cumulative | | | | ○ | | |
| **Progression principle** | | | | | | |
| • wonder, describe, explanation & interest in global issues | | ○ | | | | |
| • constructing → reflecting → using scientific knowledge | | | ○ | | | |
| • basic → complex investigate and understanding | | | | | | ○ |

△: connoted, ○: denoted

**Table 5.** Clustering levels in six states' science content standards

| | NSES | CA | CT | MI[2] | NJ | TX | VA |
|---|---|---|---|---|---|---|---|
| Clustering (Grade range) | K-4, 5-8, 9-12 | K, 1, 2, 3, 4, 5, 6, 7, 8, (9-12)[1] | Pre K-2, 3-5, 6-8, 9-10, Enrichment[3] | E, MS, HS | by 2<br>by 4<br>by 6<br>by 8<br>by 12 | K, 1, 2, 3, 4, 5, 6, 7, 8, (9-12)[3] | K, 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, Enrichment[3] |

[1]Physics, Chemistry, Biology/Life Science, Earth Science
[2]E: Elementary, MS: Middle School, HS: High School
[3]Integrated Physics and Chemistry, Biology, Environmental Systems, Chemistry, Aquatic Science, Physics, Astronomy, Geology, Meteorology and Oceanography, AP (Advanced Placement) courses, IB (International Baccalaureate) courses

### What are the strands of the science content standards of six states?

Strands are big categories representing the content of the standards. By analyzing the strands, perspectives or positions of the curriculum developers can be revealed. National Science Education Standards presents eight strands in the standards of science content as shown in Table 6. The first category, 'unifying concepts and processes in science', is presented for all grade levels, because the understandings and abilities associated with these concepts need to be developed throughout a student's educational experiences. The other seven categories, which are science as inquiry, physical science, life science, earth and space science, science and technology, science in personal and social perspectives, and history and nature of science, are presented by clustering of grade level K-4, 5-8, 9-12. In addition to the four traditional science domains, NSES incorporated strands about the nature of science and STS.

Table 5 shows the content strands of six states compared to National Science Education Standards. Among the categories, the common strands all the states present are four: science as inquiry; physical science; life science, and earth science. The strands used in organizing the science curriculum framework are slightly different by each state. The strand of science as inquiry (CT) is also represented as at least one and more categories of the following; scientific processes (NJ and TX), scientific investigation, reasoning & Logic (VA), scientific investigation & experimentation (CA), mathematical applications (NJ) or constructing & reflecting scientific knowledge (MI). Whereas CA, MI, and NJ involves physical science, life science, and earth science as the strands related to science contents, CT and VA presents their standards in the forms of unifying concepts in science (Table 5).

However, three strands are found not to be common to all states. The strand of science and technology is presented in the states of CT and NJ. The strand of science in personal and social perspectives is presented in the states CT, NJ and VA. And, the strand of history and nature of science are not found in any state.

### What are common and idiosyncratic parts of earth science in the science content standards of six states?

As shown above the Table 7, the main concepts of earth science defined in NSES are compared with those of six states. Even though many states developed their earth science curriculum based on NSES, some contents are excluded, included or modified according to states' own perspectives or needs.

NSES clustered the grades by three groups which are K to 4, 5 to 8 and 9 to 12. Followings are the content strands categorized by the clustering groups. The first group, K to 4, contains three main concepts which are 'properties of earth materials', 'object in the sky' and 'changes in earth and sky'. The concept, 'properties of earth materials', includes 'earth materials', 'properties of soils' and 'fossils' as detailed contents. All six states contain 'earth mate-

**Table 6.** The strands presented in six states' science curriculum frameworks

| Strands | NSES | CA | CT | MI | NJ | TX | VA |
|---|---|---|---|---|---|---|---|
| Unifying concepts and processes in science | ○ | | | | | | |
| Science as Inquiry | ○ | | ○ | | | | |
| Scientific Processes | | | | | ○ | ○ | |
| Scientific Investigation, Reasoning, & Logic | | | | | | | ○ |
| Investigation & Experimentation | | ○ | | | | | |
| Mathematical Applications | | | | | ○ | | |
| Constructing & Reflecting Scientific Knowledge | | | | ○ | | | |
| Science | | | | | | ○* | |
| Physical Science | ○ | ○ | | ○ | | | |
| Chemical Science, Chemistry & Physics | | | | | ○ | | |
| Life Science | ○ | ○ | | ○ | ○ | | |
| Biological Science | | | | | | | |
| Earth and Space Science | ○ | | | | | | |
| Earth Science | | ○ | | ○ | ○ | | |
| Astronomy & Space Science | | | | | ○ | | |
| Science and Technology | ○ | | ○ | | | | |
| Nature & Process of Technology | | | | | ○ | | |
| Science in Personal and Social Perspectives | ○ | | | | | | |
| Science & Society | | | | ○ | | | |
| Environmental Studies | | | | | ○ | | |
| Resources | | | | | | | ○ |
| History and Nature of Science | ○ | | | | | | |

*TX presents essential knowledge and skills for science in its curriculum.

: Properties of matter; Energy transfer and transformations; Forces and motion; Matter and energy in ecosystems; Structure and function; Heredity and evolution; The changing earth; Energy in the earth's systems; Earth in the solar system

: Force, motion, and energy; Matter; Life processes; Living systems; Interrelationships in earth/space systems; Earth patterns, cycles, and change

rials' in their curriculums mostly covering K to 4. However the contents, 'properties of soils', are not included in the curriculum of Michigan, and also the contents, 'fossils', are excluded in the curriculums of Connecticut, Texas, and Virginia.

The concept 'objects in the sky' contains two main contents; 'properties, locations, and movements of objects' and 'the sun'. California, Connecticut, Michigan, Texas, and Virginia excluded 'properties, locations and movements of objects', in their K to 4 science curriculum. Only New Jersey included this topic 'properties, locations and movements of objects'. Most states excluding MI have the topic 'the sun' in their curriculum. Connecticut presented the topic 'the sun' in fourth grade and also in the area of physics, 'Force and Motion'.

'Changes in earth and sky' is the concept composed of 'the surface of the earth changes', 'wether changes', and 'patterns of movement'. Due to the importance and the fundamentalness, California, New Jersey, and Virginia contain these three contents in their curriculums over all through K to 4. Connecticut and Michigan involved 'weather changes' and 'patterns of movement', and Texas have only the topic 'weather changes'.

There are contents related to earth science, although included in other science areas. 'Resources', 'Natural disaster' and 'Observation tools' are the representative examples. Mostly the contents of 'Resources' and 'Natural disaster' are dealt in 'Resources' (VA), 'Environmental science' (NJ) or 'Ecosystem' (CT) subject areas. 'Observation tools' are typically contained in 'Science and technology in society' (CT).

**Table 7.** The earth science content standards of six states at levels K to 4

| NSES | CA | CT | MI | NJ | TX | VA |
|---|---|---|---|---|---|---|
| ■ Properties of earth materials | | | | | | |
| Earth materials | 2,4 | 3,4 | E | K-4 | K,1,2,4 | K,3 |
| Properties of soils | 2 | 2 | | K-4 | 3 | 3 |
| Fossils | 2 | | E | 3-4 | | |
| ■ Object in the sky | | | | | | |
| Properties, locations, and movements of objects | | | | K-4 | | |
| The Sun | 1,3 | 4,(F&M) | | K-2 | 3 | K,1,3 |
| ■ Changes in earth and sky | | | | | | |
| The surface of the earth changes | 2,4 | | | 3-4 | | 2,3,4 |
| Weather changes | 1 | K | E | K-4 | 4 | K,2,4 |
| Patterns of movement | 3 | 1 | E | 3-4 | | 1,3,4 |
| □ etc. | | | | | | |
| Resources | 2 | (STS) | E | (EVR) | K,1,2,3 | (RSC)-K,1,3,4 |
| Natural disaster | | (ECO) | E | (EVR) | | (RSC)-3 |
| Observation tools | 3 | (STS) | | 3-4 | | |

F&M: Forces and Motion, STS: Science and Technology in Society, ECO: Matter and Energy in Ecosystems, E: Elementary, EVR: Environmental Studies, RSC: Resources

The second group in NSES, 5 to 8, includes three main concepts; 'structure of the earth system', 'earth history' and 'earth in the solar system'. In 5 to 8 curriculums, the contents ranges are developed from the objects to the systems compared to the K to 4.

'Structure of the earth system' is the concept included the most contents and mainly dealt in 5 to 8 curriculums. 'The solid earth is layered with a lithosphere', 'movements of lithospheric plates', 'constructive and destructive forces', 'rock cycle', 'global patterns of atmospheric movement', 'water cycle', 'soil composition', 'water as a solvent', 'the composition of atmosphere', and 'clouds' are the contents composed of. At least 3 states include the first six contents in their earth science curriculums, which are 'the solid earth is layered with a lithosphere', 'movements of lithospheric plates', 'constructive and destructive forces', 'rock cycle', 'global patterns of atmospheric movement' and 'water cycle'.

'Earth's history' consists two main contents, 'the earth processes we see today' and 'fossils'. California includes both content but Connecticut does not involve any content of them. The other states cover the content of 'the earth processes we see today' (MI and TX) or 'Fossils' (NJ and VA) in their curriculums. And it reveals that Connecticut does not cover any contents regarding 'earth history' in its curriculum.

'Earth in the solar system' is comprised of 'solar system and the planets', 'predictable motion', 'gravity and its influences' and 'the sun, the major source of energy'. Among these contents, 'solar system and the planets' is in all state curriculums except Connecticut. 'Predictable motion' and 'gravity and its influences' are in four state curriculums, i.e, CT, NJ, TX, and VA. And 'the sun, the major source of energy' is the topic involved in three states of CA, CT, and TX.

'Earth system', 'Resources' and 'Natural disaster' are the learning substances related to earth science in 5 to 8 curriculums. California and Texas include these substances in earth science area, yet Connecticut, New Jersey, and Virginia include them in other science area, for example of 'resources' (VA), 'environmental sciences' (NJ) and 'Science and Technology in Society' (CT).

The last clustering group, 9 to 12, includes four main concepts which are 'energy in the earth system', 'geochemical cycles', 'origin and evolution of the earth system' and 'origin and evolution of the universe'. The contents ranges are developed into

**Table 8.** The earth science content standards of six states at levels 5 to 8

| NSES | CA | CT | MI | NJ | TX | VA |
|---|---|---|---|---|---|---|
| ■ Structure of the earth system | | | | | | |
| The solid earth is layered with a lithosphere | 6 | 7 | MS | | | 5 |
| Movements of lithospheric plates | 6 | 7 | | | 6 | 5 |
| Constructive and destructive forces | 6 | 7 | MS | 5-8 | 5,6 | 5 |
| Rock cycle | 6 | | MS | 5,6 | 6,8 | 5 |
| Soil composition | | | MS | | | |
| Water cycle | 5 | | MS | 5-6 | 6 | |
| The composition of atmosphere | | | MS | | | |
| Clouds | 5 | | | | | |
| Global patterns of atmospheric movement | 5 | 6 | MS | 5-6 | 6,8 | |
| ■ Earth's history | | | | | | |
| The earth processes we see today | 6,7 | | MS | | 5 | |
| Fossils | 7 | | | 7-8 | | 5 |
| ■ Earth in the solar system | | | | | | |
| Solar system and the planets | 5,8 | | MS | 5-8 | 6,8 | 6 |
| Predictable motion | | 5,8 | | 5-8 | 5,6,8 | 6 |
| Gravity and its influences | | 8 | | 5-8 | 5 | 6 |
| The sun, the major source of energy | 6 | 6 | | | 6,8 | |
| □ etc. | | | | | | |
| Earth system | 5,6 | (STS) | | | 8 | |
| Resource | 6 | | | 5,6 | | |
| Natural disaster | | (STS) | | (EVR) | 8 | (RSC)-5 |

STS: Science and Technology in Society, MS: Middle School, EVR: Environmental Studies, RSC: Resources.

deep understanding of science concepts and principles in 9 to 12 curriculums. Virginia is excluded in the comparison table owing to absence of the 9 to 12 learning plans in its curriculums. Connecticut presents the content strands for 11 & 12 as an advanced curriculums.

The concept 'energy in the earth system' contains four contents; 'internal and external sources of energy in earth system', 'the outward transfer of earth's internal heat', 'heating of earth's surface and atmosphere', and 'global climate'. CA, CT, and MI include all the contents in their curriculums. TX involves all the contents except the topic 'the outward transfer of earth's internal heat', and NJ does two contents of 'the outward transfer of earth's internal heat' and 'global climate'. The concept 'geochemical cycles' is composed of two contents; 'chemical atom or element contained in earth system' and 'movement of matter between reservoirs'. CT, MI, and TX include these two contents, but CA and NJ include 'movement of matter between reservoirs' and 'chemical atom or element contained in earth system', respectively. The concept 'origin and evolution of the earth system' contains four contents; 'the origin of the solar system', 'geologic time', 'the ongoing evolution of the earth system', and 'evidence'. TX involves these contents in two subjects, 'Astronomy' and 'Geology, Meteorology & Oceanography'. However, the other states include two or three contents in their curriculums. Among these contents, 'the origin of the solar system' and 'evidence' are treated in at least four states as shown in Table 9. The concept 'origin and evolution of the universe' is considered for learning earth science in most of tje states. CT involves only one content of 'the origin of the universe'.

In addition, it reveals that 'observation tools' and 'resources' in other areas are related to earth science. 'Observation tool' is contained in all six states' curriculum, and 'resources' is involved in all except NJ.

**Table 9.** The earth science content standards of six states at levels 9 to 12

| NSES | CA | CT | MI | NJ | TX | VA |
|---|---|---|---|---|---|---|
| ■ Energy in the earth system | | | | | | |
| Internal and external sources of energy in earth system | ES | AES | HS | | GMO | |
| The outward transfer of earth's internal heat | ES | AES | HS | 11-12 | | |
| Heating of earth's surface and atmosphere | ES | AES | HS | | GMO | |
| Global climate | ES | AES | HS | 11-12 | GMO | |
| ■ Geochemical cycles | | | | | | |
| Chemical atom or element contained in earth system | | AES | HS | 11-12 | GMO | |
| Movement of matter between reservoirs | ES | 9,AES | HS | | GMO | |
| ■ Origin and evolution of the earth system | | | | | | |
| The origin of the solar system | ES | AES | HS | | Ast | |
| Geologic time | ES | | | 11-12 | GMO | |
| The ongoing evolution of the earth system | ES | | | | GMO | |
| Evidence | | AES | HS | 11-12 | GMO | |
| ■ Origin and evolution of the universe | | | | | | |
| The origin of the universe | ES | AES | | 11-12 | Ast | |
| The history of the universe | ES | | 11-12 | Ast | | |
| Process in stars | ES | | HS | 11-12 | Ast | |
| □ etc. | | | | | | |
| Observation tools | ES | AES | HS | 11-12 | Ast, GMO | |
| Resources | ES | (STS) | HS | | GMO, EnS | |

ES: Earth Science, STS: Science and Technology in Society, AES: Advanced Earth Science, HS: High School, EnS: Environmental Science, Ast: Astronomy, GMO: Geology, Meteorology & Oceanography.

## Summary and Conclusion

At national level, curriculum guides, such as National Science Education Standards and Project 2061 were developed and provided substantial impact on science curriculum development at various levels in US. Many US states followed this movement and developed state science content standards. The format and content of the state standards seem to reflect the perspectives and needs of the each state.

All states examined propose scientific literacy as the major goal for science education. Some states also include STS, and technology as important goals of science education. This reflects the awareness of the importance of science for educating future citizens and technology for economic development.

Most states prefer spiral curriculum as an organizing principle. Some states propose progression principles of interest, such as, "basic to complex", "constructing, reflecting, and using", and "wonder, describe, explanation, interest in global issues".

The strands of the six states are also very diverse. Basically, nature of science, four domains of science, and STS form the major divisions of the strands. Some states use topic areas rather than traditional science domains for strands.

The content becomes more diverse as the grade level goes down. The diversity of topics among states also becomes greater in K-4 and 5-8. However, the topics and coverages are strikingly uniform in high school, in spite of the diversity of the courses offered.

In high school, the themes are more theoretical, and global. In contrast, K-4 topics deal with materials or phenomena easily found everyday. Some states pay more attention to natural disasters or natural resources from early grades.

From the study, it is found that US states interpret and reflect national curriculum guides, such as NSES or Project 2061, in various ways to develop state science content standards. To meet the new challenges of increased autonomy in local or school curriculum, local offices of education or school administrators should pay more attention to the needs of the community and developing the expertise of science curriculum development.

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