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Information

Professional Services Committee

Overview of the Next Generation Science Standards for California with a Focus on Implications for Teacher Preparation

Executive Summary: This agenda item provides an overview of the Next Generation Science Standards (NGSS) for California and discusses implications for teacher preparation. The Commission's discussion and potential direction will guide future agenda items on this topic.

Policy Question: What should be the scope of work for the Commission in implementing the NGSS for California within teacher preparation?

Recommended Action: For information only.

Presenter: Katie Croy and Roxann L. Purdue, Consultants, Professional Services Division

Strategic Plan Goal

II. Program Quality and Accountability

Develop and maintain rigorous, meaningful, and relevant standards that drive program quality and effectiveness for the preparation of the education workforce and are responsive to the needs of California's diverse student population.

Overview of the Next Generation Science Standards for California with a Focus on Implications for Teacher Preparation

Introduction

This agenda item provides an overview of the Next Generation Science Standards for California and discusses implications for teacher preparation. The Commission's discussion and potential direction will guide future agenda items on this topic. This agenda item is organized into three parts:

Part I: Current Subject Matter and Pedagogy Requirements for Teaching Science
Part II: Overview of Next Generation Science Standards (NGSS) for California
Part III: Implications of the NGSS for Teacher Preparation in California

Staff invited a speaker to present information on the NGSS to inform the discussion on this item. Kathy DiRanna, WestEd's K-12 Alliance Director, will present information pertaining to the implementation of NGSS for California.

Background

The Commission is responsible for ensuring alignment between the adopted K-12 content standards and California's subject matter requirements (SMRs) and teacher preparation standards. Several agenda items have previously been presented to the Commission regarding the work already accomplished in terms of aligning program standards, subject matter requirements, and the CSET: Multiple Subjects, Single Subject English and Single Subject mathematics examinations to the Common Core State Standards (CCSS).

Both the Common Core State Standards and the Next Generation Science Standards focus on rigorous expectations for students and represent a major shift in standards-based reform within education. In both sets of standards there is an increased emphasis on the ability of students to use English language arts skills effectively across the curriculum to learn core concepts, understand the cross-disciplinary implications of these concepts, and to express themselves effectively in communicating their understandings and their depth and breadth of knowledge.

Similarly, the NGSS also focus on identifying key literacy connections and on students' ability to use English language arts effectively to address and express their Science-related learnings and understandings. This focus is specified in the NGSS appendices A-M (*Appendix A*), "To ensure the CCSS literacy standards work in tandem with the specific content demands outlined in the NGSS, the NGSS development team worked with the CCSS writing team to identify key literacy connections to the specific content demands outlined in the NGSS." A diagram showing the intersection of Common Core (English Language Arts and Mathematics) State Standards and the Next Generation of Science Standards can be found in *Appendix B*.

Given that the Commission is responsible for assuring alignment between the most current state-adopted K-12 content standards and (a) subject matter requirements for preparation programs and examinations as well as (b) pedagogy-related issues relative to the specific content area as expressed in teacher preparation program standard 8, it is appropriate to look at the current requirements related to preparation for teaching science at all grade levels and what might need to be done in order to bring these requirements into alignment with the NGSS. Part I of this agenda item addresses the current requirements, standards, and authorizations related to preparation for teaching science.

Part I: Current Subject Matter and Pedagogy Requirements for Teaching Science

Current Science Authorization Structure in California

California's present credential structure offers two basic types of general education teaching credentials: "multiple subject," or elementary, and "single subject," or middle/secondary. The Multiple Subject teaching credential authorizes the holder to teach science in a self-contained setting most commonly in the elementary grades as well as in core settings at the middle school level in grades five through eight. In addition, there are nine distinct Single Subject teaching credential content areas that authorize an individual to teach specified science courses in departmentalized settings.

Prior to 1995, the Commission issued Single Subject teaching credentials in the content areas of Life Science and Physical Science. At that time, the Commission developed four Single Subject discipline-specific science content area authorizations: *Biological Sciences, Chemistry, Geosciences, and Physics* to align with statutory requirements. These four science content area authorizations have a much broader authorization than the previous Life and Physical Science content areas. The four science content area authorizations on Single Subject teaching credentials allow the holder to teach coordinated science, introductory science, integrated science, general science, and specialized classes in the area of concentration in Kindergarten through grade twelve.

In 2003, the Commission created Specialized Science authorizations for Single Subject teaching credentials in these same four content areas with the intent of increasing our supply of science teachers at the high school level by attracting second career professionals with advanced degrees, coursework and/or knowledge in a specific science discipline. Individuals issued a credential in one of the four specialized science content areas have an authorization limited to teaching content within that specific science discipline only. Individuals with these specialized authorizations do not complete subject matter requirements related to general, introductory, or integrated science and are <u>not</u> authorized to teach an integrated science pathway course at the middle or high school level without earning an additional broad science content area authorization on their Single Subject teaching credential.

In 2009, the Commission developed an additional science content area authorization for Single Subject teaching credentials: Foundational-Level General Science (FLGS). The FLGS authorization was developed with the intent of increasing the potential supply of science teachers at the middle school level. The holder of a Single Subject teaching credential in FLGS is authorized to teach integrated science in Kindergarten through grade 8. Holders of a FLGS credential are also authorized to teach introductory and general science courses to students

through grade 12. Individuals holding a FLGS authorization are not authorized to teach an integrated science pathway course at the high school level without earning an additional science content area authorization on their Single Subject teaching credential.

Subject Matter Requirements

Subject Matter Requirements define the range of content an individual is expected to know in order to be potentially qualified to teach that particular content area to K-12 students. The Subject Matter Requirements (SMRs) for all of California's teaching credentials are developed by panels of California subject matter content experts appointed by the Executive Director. For each set of SMRs a public field review and content validation take place and the SMRs are formally adopted by the Commission. Each prospective science teacher must demonstrate subject matter competence prior to beginning student teaching or work as an intern.

There are six sets of Commission-adopted SMRs addressing the content areas of science: Elementary, General, Biology, Physics, Earth/Geosciences, and Chemistry. The SMRs addressing science for the Multiple Subject teaching credential are provided in *Appendix C.* For each of the nine Single Subject credential content areas a specified subset of the five sets of single subject SMRs is required and assessed as indicated below. The Single Subject science domain names are provided in *Appendix D* and the full SMRs can be found in the Science Subject Matter Handbook (http://www.ctc.ca.gov/educator-prep/standards/SSMP-Handbook-Science.pdf).

Table 1: Commission-Adopted SMRs for Science

Multiple Subject Credential	Elementary Subject Matter: Science				
Single Subject Credential Science Content Areas	**General and Integrated**	**Biology**	**Chemistry**	**Earth/ Geosciences**	**Physics**
Foundational-Level General Science	X				
Science: Biological Sciences	X	X			
Science: Chemistry	X		X		
Science: Geosciences	X			X	
Science: Physics	X				X
Specialized Biological Sciences		X			
Specialized Chemistry			X		
Specialized Geosciences				X	
Specialized Physics					X

Table 2: Options for a Candidate to Satisfy the Subject Matter Requirement

Credential	**Satisfy Subject Matter Requirement**
Multiple Subject Teaching Credential	Pass CSET: Multiple Subject exam
Single Subject in Foundational-Level General Science (FLGS)	Pass CSET subtests or complete Commission-approved subject matter program

Credential	Satisfy Subject Matter Requirement
Single Subject in Science: Biological Sciences, Chemistry, Geosciences, or Physics Credential	Pass CSET subtests or complete Commission-approved subject matter program
Single Subject in Biological Sciences, Chemistry, Geosciences, and Physics (*Specialized)* Credential	Pass CSET subtests or complete advanced degree or coursework

Pedagogical Preparation for Science Teachers
Prospective teachers must complete a Commission-approved teacher preparation program which includes both coursework and fieldwork. Program Standard 8 and Teaching Performance Expectation 1 together define the pedagogical knowledge and skills that a prospective teacher must have and be able to demonstrate in order to be eligible to be recommended for a preliminary teaching credential.

Program Standard 8A(b) defines the pedagogical skills the Multiple Subject teacher must demonstrate while Program Standard 8B(b) defines the pedagogical skills the Single Subject Science teacher must demonstrate.

> ***8A(b) Science.*** During interrelated activities in program coursework and fieldwork, MS candidates learn specific teaching strategies that are effective in supporting them to teach the state-adopted academic content standards for students in science (K-8). They balance the focus of instruction between science information, concepts, and investigations. Their explanations, demonstrations, and class activities serve to illustrate science concepts and principles, scientific investigation, and experimentation. Candidates emphasize the importance of accuracy, precision, and estimation.
>
> ***8B(b)Science.*** During interrelated activities in program coursework and fieldwork, candidates learn specific teaching strategies that are effective in supporting them to teach the state-adopted academic content standards for students in science (7-12). They balance the focus of instruction between science information, concepts, and principles. Their explanations, demonstrations and class activities serve to illustrate science concepts, principles, scientific investigation, and experimentation. Candidates emphasize the importance of accuracy, precision, and estimation. Candidates encourage students to pursue science interests, especially students from groups underrepresented in science careers. When live animals are present in the classroom, candidates teach students to provide ethical care. They demonstrate sensitivity to students' cultural and ethnic backgrounds in designing science instruction.
>
> Additionally, single subject candidates guide, monitor, and encourage students during investigations and experiments. They demonstrate and encourage use of multiple ways to measure and record scientific data, including the use of mathematical symbols. Single subject candidates structure and sequence science instruction to enhance students' academic knowledge to meet or exceed the state-

adopted academic content standards for students. They establish and monitor procedures for the care, safe use, and storage of equipment and materials, and for the disposal of potentially hazardous materials.

In recent years, concerns have been expressed that not all Multiple Subject candidates have a sufficiently strong content background in one or more of the disciplines they will be teaching. Prior to 2004, Commission-approved elementary subject matter programs provided a level of assurance that candidates were sufficiently prepared across the array of discipline areas authorized by the Multiple Subject teaching credential. Now that all prospective elementary teachers must pass the CSET, fewer candidates are completing a liberal studies or elementary subject matter program as part of the work towards a bachelor's degree. These concerns regarding preparation for Multiple Subject candidates have been focused primarily in the content areas of mathematics and science.

Single Subject Teaching Credentials Issued by Science Content Area, 2012-2013

Data on the number of Preliminary Single Subject teaching credentials issued by science content area authorization is provided in Table 3. During 2012-2013, a total of 7,825 Single Subject teaching credential content area authorizations were initially issued. A total of 1,575 (20%) were issued in one of nine science content area authorizations.

Table 3: Single Subject Teaching Credentials Issued by Science Content Area, 2012-2013

Single Subject Teaching Credential Science Content Areas	Number of Science Content Areas Issued*	Percentage of Total Science Content Areas Issued
Foundational-Level General Science (FLGS)	302	19.17%
Biological Sciences (Specialized)	65	4.13%
Chemistry (Specialized)	27	1.71%
Earth/Geosciences (Specialized)	13	0.83%
Physics (Specialized)	28	1.78%
Science: Biological Sciences	631	40.06%
Science: Chemistry	258	16.38%
Science: Earth/Geosciences	122	7.75%
Science: Physics	129	8.19%
Science Totals	**1,575**	**100%**

**Preliminary Single Subject Teaching Credentials as first-time or new-type documents only*

These data show that in 2012-13, 72% of individuals issued a Preliminary Single Subject teaching credential with a science content area authorization earned one of the four full science content areas that includes an authorization for teaching introductory, general and integrated science in grades K-12. An additional 19% earned the content area that authorizes Integrated Science through grade 8. Approximately 8% of candidates earned one of the four Specialized Science content areas that do not authorize teaching general, introductory or integrated science at any grade level. A summary of this data is provided in Figure A.

Figure A: Single Subject Teaching Credentials by Science Authorization Type, 2012–13

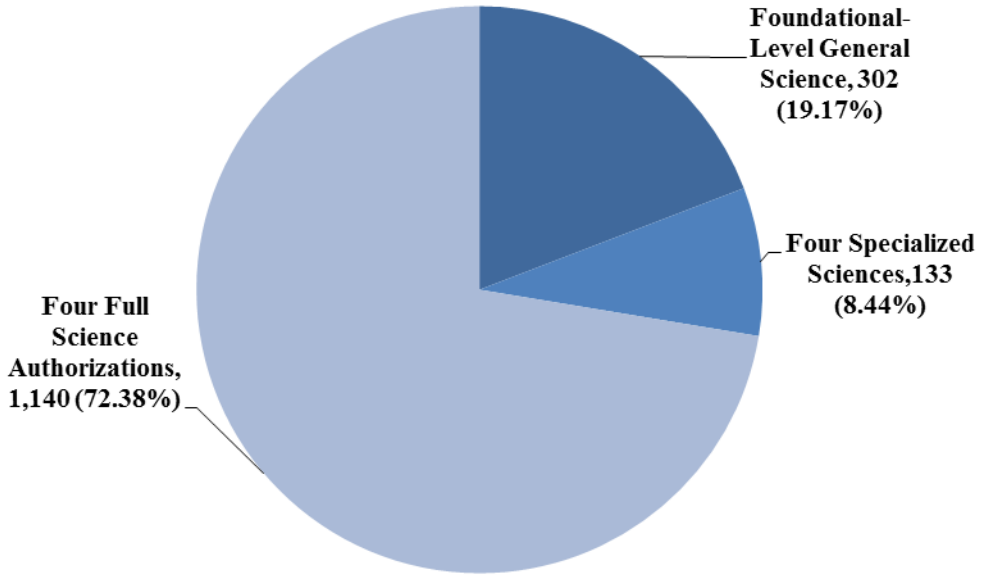


Table 4 provides information on the current alignment between the most common science course content offered in Kindergarten through grade twelve in California public schools and the Commission's current Single Subject science content area authorization structure. The table is formatted to first address all discipline specific science courses in the first four columns with introductory level courses in broader science categories addressed in the last four columns. The middle column provides information on those science content areas that are authorized to teach integrated science courses at the grade levels indicated.

Table 4: Current Alignment Between K-12 Course Content and Science Authorizations

Science Content Area Authorization	All Courses*					Only Introductory		
	Biological Science	Chemistry	Physics	Earth/ Geosciences	Integrated Science	General Science	Life Science	Physical Science
Foundational-Level General Science					**K-8**	**X**	**X**	**X**
Science: Biological Sciences	**X**				**K-12**	**X**	**X**	**X**
Science: Chemistry		**X**			**K-12**	**X**	**X**	**X**
Science: Physics			**X**		**K-12**	**X**	**X**	**X**
Science: Geosciences				**X**	**K-12**	**X**	**X**	**X**
Biological Sciences (Specialized)	**X**							
Chemistry (Specialized)		**X**						

Science Content Area Authorization	All Courses*				Integrated Science	Only Introductory		
	Biological Science	Chemistry	Physics	Earth/ Geosciences		General Science	Life Science	Physical Science
Physics (Specialized)			**X**					
Geosciences (Specialized)				**X**				
Life Science**	**X**				**7-9**	**X**	**X**	
Physical Science**		**X**	**X**	**X**	**7-9**	**X**		**X**

**grades preschool, K - 12, and adults*
***science content areas no longer initially issued*

Part II: Overview of Next Generation Science Standards (NGSS) for California
This part of the agenda item describes the development and current status of the NGSS within California.

California Education Code (EC) section 60605.85 requires the State Superintendent of Public Instruction (SSPI) to submit revised science content standards for K-12 students to the State Board of Education (SBE) based upon the nationally developed NGSS. The National Research Council's (NRC) *Framework for K-12 Science* served as the basis for the development of the NGSS *(Appendix A).* California was a partner with 25 other states in the development of the national NGSS.

The SSPI convened a Science Expert Panel (SEP) comprised of 25 science classroom teachers, county science leaders, 27 faculty from institutions of higher education (IHEs), and business, industry, and science center leaders. California's SEP reviewed the NGSS and recommended adoption, including an integrated science middle school learning progression which they developed for grades 6 through 8. The SBE adopted the SSPI's recommended *Next Generation Science Standards for California Public Schools, Kindergarten through Grade Twelve and Appendices A - M* as a whole on September 2, 2013; however, action on the proposed middle school learning progression was deferred by the SBE to allow additional time for stakeholder feedback. In November 2013, the SBE adopted the integrated middle school learning progression for grades 6 through 8 as the preferred model for California. At the same meeting, the SBE directed CDE to reconvene the SEP in order to develop an alternative discipline-specific model.

The Instructional Quality Commission (IQC), an advisory body to SBE, is moving forward with the development of the Science Curriculum framework for California with an anticipated release in Fall 2015. Senate Bill 300 (2013) added section 60200.9 to the Education Code and requires the SBE to consider the adoption of a revised curriculum framework and evaluation criteria for new instructional materials in science on or before January 31, 2016. Curriculum frameworks in California offer guidance to the local level for implementing the associated content standards and include selected research-based approaches for implementing instruction for all students. The

revised science framework will be based on NGSS and is required to include strategies for English language development and address the needs of students with disabilities.

The NGSS for California are significantly different than the California Science Standards adopted by the SBE in 1998 (*Appendix A).* The NGSS focus on a deeper conceptual understanding of science as well as application of the content rather than an emphasis on the knowledge of discrete science facts. The NGSS for California also emphasize:

- learning progressions that develop from kindergarten through grade twelve;
- integration of skills and practices across content areas as the foundation of STEM (Science, Technology, Engineering, and Mathematics) education; and
- integration of both science and engineering practices within the content.

The NGSS describe in detail the key scientific ideas and practices that all students should learn prior to their graduation from high school. The NGSS provides student performance expectations, not a specific curriculum. The NGSS are aligned with the CCSS in English Language Arts and Mathematics. A Venn diagram is included in *Appendix B* in order to demonstrate the nexus between these standards.

The NGSS Appendices A-M were also adopted in order to assist teachers with the implementation of these new standards and to inform the development of a new science curriculum framework for California. An abbreviated implementation timeline for NGSS in California public schools is provided in *Appendix E*. The adopted standards and appendices are available on the California Department of Education website as provided in the References within *Appendix A.*

Key NGSS Terms and Concepts

Some of the key terms and concepts for NGSS are included below to provide additional context in understanding the significant changes present in these newly adopted standards. These key terms and concepts are also explained in more depth within several of the documents identified in the *References* contained within *Appendix A.*

1. *Disciplinary Core Ideas (DCI) Progression*

   DCI describes the learning progression of how core ideas could be developed across K-12 - within the National Research Council (NRC) Framework *(Appendix A)*. The NRC Framework is based on the principle that students should develop their understanding of core ideas in a coherent and connected way across multiple years. The learning progression is laid out in "grade band end points", the targets for what students should understand by the end of specific grade levels. The learning progressions are summarized in the NGSS Appendices A-M *(Appendix A*). The NRC Framework emphasizes that teachers must understand that there is a focus on core ideas—not just the scientific facts and details associated with them. *The core ideas also can provide an organizational structure for the acquisition of new knowledge. Understanding the core ideas and engaging in the scientific and engineering practices helps to prepare students for broader understanding, and deeper levels of scientific and engineering investigation, later on—in high school, college, and beyond.* (NRC *Framework*, 2012, p. 25)

2. *Cross-Cutting Concepts*
   Cross-cutting concepts provide students with an organizational framework for connecting knowledge from the various disciplines into a coherent and scientifically based view of the world. These concepts also provide students with tools for asking questions across disciplines. The list of NGSS Cross-cutting concepts includes: Patterns; Cause and effect: Mechanism and explanation; Scale, proportion and quantity; Systems and system models; Energy and matter: Flows, cycles and conservation; Structure and function; Stability and change.

   Each of these concepts is identified across the science disciplines in common language in order to assist students with their understanding of how the various science topics they are learning are interconnected.

3. *Scientific and Engineering Practices*
   The eight scientific and engineering practices identified in the NRC Framework were developed to ensure that students are engaged in all parts of the process. Scientific and engineering practices are intended to go beyond labs and hands-on activities. These multiple practices identify behaviors that scientists engage in as they investigate and build models and theories about the natural world and that engineers engage in as they define and solve problems. The eight practices identified in the NRC Framework are considered essential for all students to learn and include:
   a) Asking questions (*science*) and defining problems (*engineering*)
   b) Developing and using models
   c) Planning and carrying out investigations
   d) Analyzing and interpreting data
   e) Using mathematics and computational thinking
   f) Constructing explanations (*science*) and designing solutions (*engineering*)
   g) Engaging in argument from evidence; and
   h) Obtaining, evaluating, and communicating information

The NRC Framework uses the term "engineering" broadly to *mean any engagement in a systematic practice of design to achieve solutions to particular human problems.* (NRC *Framework*, 2012, p. 11-12) Students demonstrate their understanding of science concepts through the application of engineering practice. The NRC uses *the term "practices" instead of a term such as "skills" to emphasize that engaging in scientific investigation requires not only skill but also knowledge that is specific to each practice.* (NRC *Framework*, 2012, p. 30)

The inclusion of these practices, particularly engineering design, has important implications that should be considered for teacher preparation in both subject matter knowledge and pedagogy.

Part III: Implications of the Next Generation Science Standards (NGSS) for Teacher Preparation in California

This section of the agenda item discusses the implications for future Commission work relating to implementation of the NGSS with both subject matter preparation and teacher preparation.

When the SBE changes the academic content standards for K-12 students in California public schools, the Commission typically reviews and modifies as needed its adopted Subject Matter Requirements (SMRs), subject matter preparation program standards, and teacher preparation program standards, as applicable. Implementation of the NGSS for California will trigger this process in order for the Commission's standards and examinations to remain in alignment with the most current California K-12 student academic content standards.

Subject Matter Requirements

Due to the adoption of the NGSS the subject matter requirements for the Multiple Subject teaching credential and the nine Single Subject teaching credentials in Science will need to be reviewed and revised. A brief description of the steps involved in reviewing, revising the SMRs and developing the new CSET items is provided here:

1. *Defining the content for the exam*. In the case of NGSS, there are already sets of Subject Matter Requirements in Science that will form the basis for NGSS-related revisions (1 year activity). This work is done with a panel of California subject matter experts and is validated through a field review. The final revised content is adopted by the Commission.

    1a. *Parallel activity: Revising subject matter program standards to align with the updated content* (3-6 months). This work is done with the same panel of California subject matter experts and is validated through a field review. The final revised standards are adopted by the Commission.

2. *Developing test items.* In the case of NGSS, there are already item banks for each of the science areas that will form the basis for looking at each item, determining if it is still congruent with NGSS, making revisions to existing items, and developing new items as necessary (1 year activity) This work is done with a panel of California subject matter experts and is reviewed with the Commission's standing Bias Review Committee.

3. *Setting passing score standards*. In the case of NGSS, once the exams are revised, there will need to be a passing standard study. A separate Standard Setting panel of content experts assists with this activity. This will be done after the first administration of the revised examinations and a recommendation will be provided to the Commission for action (2-4 months after initial examination administration).

All Commission-approved subject matter programs in science will need to submit updated alignment matrices to demonstrate that the approved program addresses all aspects of the revised SMRs aligned with NGSS.

Pedagogical Preparation
Teaching Performance Expectation 1 (Subject Specific Pedagogy) and Program Standard 8 define the pedagogical knowledge an individual must be able to demonstrate. The current TPE and pedagogy standard will need to be reviewed and revisions proposed to align with NGSS. This work will be completed by a panel of California content pedagogy experts and will be validated through a field review. The revised TPE 1 and Preparation Program Standard 8 will be presented to the Commission for adoption.

Once TPE 1 has been revised, then the tasks and rubrics for the Teaching Performance Assessments (TPA) will need to be reviewed. When the Commission adopts revised program standards it also adopts a timeline for implementation of the revised requirements.

Additional Considerations
Teacher Preparation Advisory (TAP) Panel Recommendations
The Teacher Preparation Advisory (TAP) Panel *(Appendix A)* made a recommendation to simplify the structure of the Single Subject teaching credentials in science content areas. The recommendation was to reduce the number of Single Subject teaching credentials in science. Based on input from the California Department of Education (CDE) staff, the Commission opted to defer the recommendations related to teaching science until the adoption of the NGSS for California by the SBE. As the NGSS for California have been now adopted by the SBE, the TAP Panel recommendations related to teaching science should be revisited.

In recommending that the Commission consider streamlining the current science authorization structure, the TAP Panel considered the preparation and authorization for each as well as data on the number of each type issued. Education Code section 44257.2(c) mandates that the Commission issue Single Subject teaching credentials in science in the four specific disciplines of biological science, chemistry, physics and geosciences. These four full science authorizations represented over 72% of the science content areas issued in 2012-13 and include the broadest preparation and authorization for science teachers.

The TAP Panel also specifically recommended that the Commission continue to issue the Foundational-Level General Science credential as it represents more than 19% of the science content areas issued in 2012-2013 and fills a staffing need at the middle school level. The preparation and authorization provide a better alignment with the NGSS for California as it includes integrated science through grade 8.

In contrast, the four specialized science authorizations represent only 8% of the science content area credentials issued in 2012-2013. The specialized science authorizations were initially developed in 2003 as a recruitment avenue for those individuals with advanced degrees and knowledge in a specialized science discipline. While these individuals complete a full teacher preparation program, their subject matter requirements reflect very specific and specialized knowledge within a discipline and do not include integrated and introductory content in general or integrated science. Additionally, teachers may also verify subject matter competence for the specialized science authorization based on a post-baccalaureate degree or a baccalaureate degree and 30 semester (45 quarter) units in the science discipline or a closely related area. As these

requirements are not Commission-approved subject matter programs, they may or may not have completed courses with content aligned with the NGSS for California.

Multiple Subject Teaching Credentials
The CCSS and NGSS heighten the expectations for teacher candidates to have deep content knowledge in multiple subject areas. They have already resulted in changes to the K-12 Content Standards; these changes necessarily impact teacher preparation program standards, especially those that relate to teaching Math, English/Language Arts and Science. However, because the CSET continues to be the sole method for prospective elementary candidates to demonstrate subject matter knowledge, the TAP panel expressed concerns that alignment of the K-12 Content Standards to the Common Core State Standards will likely have little impact on elementary teacher subject matter preparation.

The Subject Matter Requirements (SMRs) for the CSET: Multiple Subjects, Single Subject English and Single Subject Mathematics examinations were updated in order to align with the CCSS. These SMRs are currently undergoing a content validation study with stakeholders, and are being presented to the Commission for potential adoption at the June 2013 meeting.

This heightened focus will be especially needed as the state transitions to full implementation of the CCSS followed by the NGSS for California; both sets of these standards require in-depth knowledge of subject matter and the ability to design complex tasks appropriate for particular grade levels and age spans. These changes also support recommendations in *Greatness by Design* (Task Force on Educator Excellence, 2012) to update licensure standards so that they better reflect the knowledge and skills pre-service teachers need to provide effective instruction of a more robust curriculum to an ever-diversifying student population.

Next Steps
The Commission's discussion and potential direction will guide future agenda items on the topics presented in this item.

Appendix A

References

1. *Next Generation Science Standards for California Public Schools, Kindergarten through Grade 12*: http://www.cde.ca.gov/pd/ca/sc/ngssstandards.asp

2. *Next Generation Science Standards: Appendices A-M* adopted to assist teachers in the implementation of NGSS and in the development of the new science curriculum framework: http://www.nextgenscience.org/next-generation-science-standards

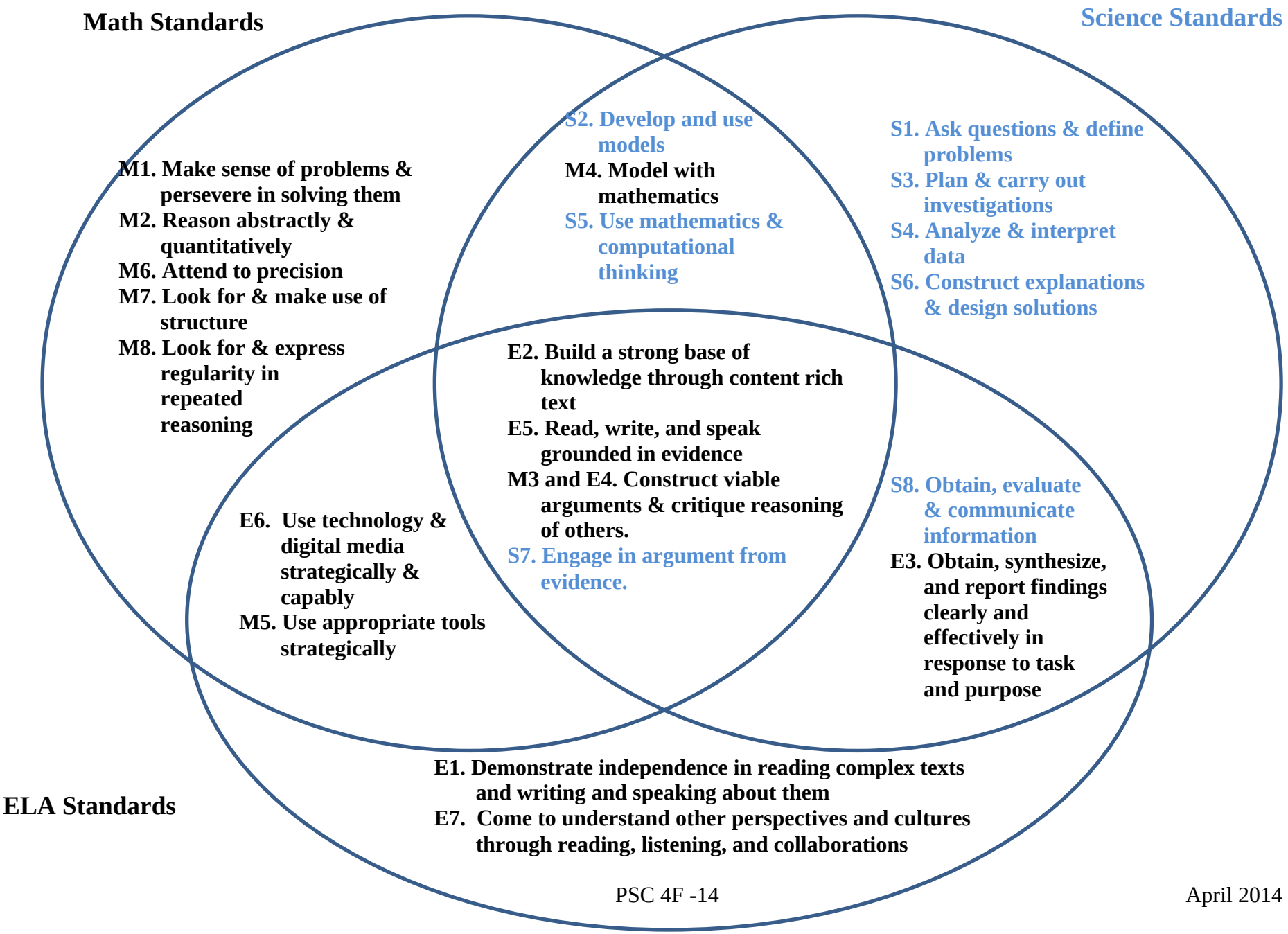
3. 1998 California Science Standards – *Science Content Standards for California Public Schools, Kindergarten Through Grade Twelve:* http://www.cde.ca.gov/be/st/ss/documents/sciencestnd.pdf

4. National Research Council (NRC) National Science Framework (2012) – *A Framework for K-12 Science Education: Practices, Crosscutting Concepts, and Core Ideas*: http://www.nap.edu/catalog.php?record_id=13165#

5. California Department of Education Next Generation Science Standards - Frequently Asked Questions: http://www.cde.ca.gov/pd/ca/sc/ngssfaq.asp

6. Teacher Preparation Advisory (TAP) Panel Recommendations: http://www.ctc.ca.gov/commission/agendas/2013-06/2013-06-4D.pdf

Appendix B


Math Standards
Science Standards
M1. Make sense of problems & persevere in solving them
M2. Reason abstractly & quantitatively
M6. Attend to precision
M7. Look for & make use of structure
M8. Look for & express regularity in repeated reasoning
S2. Develop and use models
M4. Model with mathematics
S5. Use mathematics & computational thinking
S1. Ask questions & define problems
S3. Plan & carry out investigations
S4. Analyze & interpret data
S6. Construct explanations & design solutions
E2. Build a strong base of knowledge through content rich text
E5. Read, write, and speak grounded in evidence
M3 and E4. Construct viable arguments & critique reasoning of others.
S7. Engage in argument from evidence.
E6. Use technology & digital media strategically & capably
M5. Use appropriate tools strategically
S8. Obtain, evaluate & communicate information
E3. Obtain, synthesize, and report findings clearly and effectively in response to task and purpose
E1. Demonstrate independence in reading complex texts and writing and speaking about them
E7. Come to understand other perspectives and cultures through reading, listening, and collaborations
ELA Standards

Appendix C

Subject Matter Requirements for Multiple Subject Candidates

Domain 1: Physical Science

1.1 Structure and Properties of Matter. Candidates for Multiple Subject Teaching Credentials understand the physical properties of solids, liquids, and gases, such as color, mass, density, hardness, and electrical and thermal conductivity. They know that matter can undergo physical changes (e.g., changes in state such as the evaporation and freezing of water) and chemical changes (i.e., atoms in reactants rearrange to form products with new physical and chemical properties). They know that matter consists of atoms and molecules in various arrangements, and can give the location and motions of the parts of an atom (protons, neutrons, and electrons). They can describe the constituents of molecules and compounds, naming common elements (e.g., hydrogen, oxygen, and iron), and explain how elements are organized on the Periodic Table on the basis of their atomic and chemical properties. They can describe characteristics of solutions (such as acidic, basic, and neutral solutions) and they know examples with different pH levels such as soft drinks, liquid detergents, and water. They know that mixtures may often be separated based on physical or chemical properties.

1.2 Principles of Motion and Energy. Candidates for Multiple Subject Teaching Credentials describe an object's motion based on position, displacement, speed, velocity, and acceleration. They know that forces (pushes and pulls), such as gravity, magnetism, and friction act on objects and may change their motion if these forces are not in balance. They know that "like" electrical charges or magnetic poles produce repulsive forces and "unlike" charges or poles produce attractive forces. They describe simple machines in which small forces are exerted over long distances to accomplish difficult tasks (e.g., using levers or pulleys to move or lift heavy objects). Candidates identify forms of energy including solar, chemical, electrical, magnetic, nuclear, sound, light, and electromagnetic. They know that total energy in a system is conserved but may be changed from one form to another, as in an electrical motor or generator. They understand the difference between heat, (thermal energy) and temperature, and understand temperature measurement systems. Candidates know how heat may be transferred by conduction, convection, and radiation (e.g., involving a stove, the Earth's mantle, or the sun). They describe sources of light including the sun, light bulbs, or excited atoms (e.g., neon in neon lights) and interactions of light with matter (e.g., vision and photosynthesis). They know and can apply the optical properties of waves, especially light and sound, including reflection (e.g., by a mirror) or refraction (e.g., bending light through a prism). They explain conservation of energy resources in terms of renewable and non-renewable natural resources and their use in society.

Domain 2: Life Science

2.1 Structure of Living Organisms and Their Function (Physiology and Cell Biology). Candidates for Multiple Subject Teaching Credentials describe levels of organization and related functions in plants and animals, including, organ systems (e.g., the digestive system), organs, tissues (e.g., ovules in plants, heart chambers in humans), cells, and subcellular organelles (e.g., nucleus, chloroplast, mitochondrion). They know structures and related functions of systems in plants and animals, such as reproductive, respiratory,

circulatory, and digestive. They understand principles of chemistry underlying the functioning of biological systems (e.g., carbon's central role in living organisms, water and salt, DNA, and the energetics of photosynthesis).

2.2 Living and Nonliving Components in Environments (Ecology). Candidates for Multiple Subject Teaching Credentials know the characteristics of many living organisms (e.g., growth, reproduction, and stimulus response). They understand the basic needs of all living organisms (e.g., food, water, and space), and can distinguish between environmental adaptations and accommodations. They describe the relationship between the number and types of organisms an ecosystem can support and relationships among members of a species and across species. They illustrate the flow of energy and matter through an ecosystem from sunlight to food chains and food webs (including primary producers, consumers, and decomposers). They identify the resources available in an ecosystem, and describe the environmental factors that support the ecosystem, such as temperature, water, and soil composition.

2.3 Life Cycle, Reproduction, and Evolution (Genetics and Evolution). Candidates for Multiple Subject Teaching Credentials diagram life cycles of familiar organisms (e.g., butterfly, frog, mouse). They explain the factors that affect the growth and development of plants, such as light, gravity, and stress. They distinguish between sexual and asexual reproduction, and understand the process of cell division (mitosis), the types of cells and their functions, and the replication of plants and animals. They distinguish between environmental and genetic sources of variation, and understand the principles of natural and artificial selection. They know how evidence from the fossil record, comparative anatomy, and DNA sequences can be used to support the theory that life gradually evolved on earth over billions of years. They understand the basis of Darwin's theory, that species evolved by a process of natural selection.

Domain 3: Earth and Space Science

3.1 The Solar System and the Universe (Astronomy). Candidates for Multiple Subject Teaching Credentials identify and describe the planets, their motion, and that of other planetary bodies (e.g., comets and asteroids) around the sun. They explain time zones in terms of longitude and the rotation of the earth, and understand the reasons for changes in the observed position of the sun and moon in the sky during the course of the day and from season to season. They name and describe bodies in the universe including the sun, stars, and galaxies.

3.2 The Structure and Composition of the Earth (Geology). Candidates for Multiple Subject Teaching Credentials describe the formation and observable physical characteristics of minerals (e.g., quartz, calcite, hornblende, mica, and common ore minerals) and different types of rocks (e.g., sedimentary, igneous, and metamorphic). They identify characteristics of landforms, such as mountains, rivers, deserts, and oceans. They explain chemical and physical weathering, erosion, deposition, and other rock forming and soil changing processes and the formation and properties of different types of soils and rocks. They describe layers of the earth (crust, lithosphere, mantle, and core) and plate tectonics, including its convective source. They explain how mountains are created and why

volcanoes and earthquakes occur, and describe their mechanisms and effects. They know the commonly cited evidence supporting the theory of plate tectonics. They identify factors influencing the location and intensity of earthquakes. They describe the effects of plate tectonic motion over time on climate, geography, and distribution of organisms, as well as more general changes on the earth over geologic time as evidenced in landforms and the rock and fossil records, including plant and animal extinction.

3.3 The Earth's Atmosphere (Meteorology). Candidates for Multiple Subject Teaching Credentials explain the influence and role of the sun and oceans in weather and climate and the role of the water cycle. They describe causes and effects of air movements and ocean currents (based on convection of air and water) on daily and seasonal weather and on climate.

3.4 The Earth's Water (Oceanography). Candidates for Multiple Subject Teaching Credentials compare the characteristics of bodies of water, such as rivers, lakes, oceans, and estuaries. They describe tides and explain the mechanisms causing and modifying them, such as the gravitational attraction of the moon, sun, and coastal topography.

Appendix D

Subject Matter Requirements for Single Subject Science Teachers
Domain Names and Organization

<table>
<tr><th colspan="4">Organization of the Subject Matter Domains for Science</th></tr>
<tr><td colspan="4">A)General Science Requirements
1. Astronomy
2. Dynamic Processes of the Earth
3. Earth Resources
4. Ecology
5. Genetics and Evolution
6. Molecular Biology and Biochemistry
7. Cell and Organismal Biology
8. Waves
9. Forces and Motions
10. Electricity and Magnetism
11. Heat Transfer and Thermodynamics
12. Structure and Properties of Matter</td></tr>
<tr><td>B)Biology/Life Science Subject Matter Requirements
1. Cell Biology and Physiology
2. Genetics
3. Evolution
4. Ecology</td><td>C)Chemistry Subject Matter Requirements
1. Atomic and Molecular Structure
2. Chemical Reactions
3. Kinetic Molecular Theory
4. Solution Chemistry
5. Chemical Thermodynamics
6. Organic Chemistry and Biochemistry
7. Nuclear Processes</td><td>D)Earth and Planetary Science Subject Matter Requirements
1. Earth’s Place in the Universe
2. Planet Earth
3. Energy in the Earth System
4. Biogeochemical Cycles
5. California Geology</td><td>E)Physics Subject Matter Requirements
1. Motion and Forces
2. Conservation of Energy and Momentum
3. Heat and Thermodynamics
4. Waves
5. Electromagnetism
6. Quantum Mechanics and the Standard Model of Particles</td></tr>
<tr><td colspan="4">F)Subject Matter Skills and Abilities Applicable to the All Content Domains in Science
1. Investigation and Experimentation 2. Nature of Science 3. Science and Society</td></tr>
</table>

Subject Matter Domains and the Single Subject Teaching Credential in Science

Teaching Credential	SMR Domains	Teaching Credential	SMR Domains
Science: Biological Sciences	A, B, F	Biological (Specialized)	A:4-7, B, F
Science: Chemistry	A, C, F	Chemistry (Specialized)	A:6,11-12, C, F
Science: Geociences	A, D, F	Geociences (Specialized)	A:1-3, D, F
Science: Physics	A, E, F	Physics (Specialized)	A:8-11, E, F
Foundational-Level General Science Teachers			A, F

Appendix E

NGSS Implementation Timeline for California's Public Schools

2013	
September	California's State Board of Education (SBE) adopts the Next Generation Science Standards (NGSS) for California Public Schools, Kindergarten through Grade 12
November	SBE approves a middle school learning progression that specified integrated science content with cross-cutting concepts as California's preferred model as well as authorized the development of an alternative discipline specific model by the State Superintendent of Public Instruction's Science Expert Panel
2014	
January	SBE approves Instructional Quality Commission (IQC) schedule of significant events for 2016 revision of the Science Framework for California public schools
2015	
May	IQC approves draft Science Framework for initial 60-day public review period
Fall	NGSS Transition Phase begins for LEA's and concentrates on building foundational resources, implementing needs assessments, establishing new professional learning opportunities, and expanding collaborations between all stakeholders
2016	
January	SBE action on IQC's recommended Science Framework includes public hearing with a statutory deadline of January 31, 2016 per SB 300
2016/2017	NGSS Implementation Phase expands new professional learning support, fully aligns curriculum, instruction, and assessments, and effectively integrates these elements across the field
2017/2018	
2017/2018	Instructional Materials Adoption