From Prescribed Curriculum to Classroom Practice: An Examination of the Implementation of the New York State Earth Science Standards

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ABSTRACT

In New York State (NYS), Earth science teachers use the *National Science Education Standards* (NSES), the NYS *Learning Standards for Mathematics, Science and Technology* (NYS Standards), and the *Physical Setting/Earth Science Core Curriculum* (Core Curriculum) to create local curricula and daily lessons. In this study, a purposeful sample of experienced and innovative teachers provided insight on how NYS Earth science teachers organize their scope and sequences, align their lessons with the State standards–based documents, establish internal lesson coherence, and prepare their students for the state assessment, the Physical Setting/Earth Science Regents Examination (Regents Exam). Teachers provided responses to a questionnaire regarding their scope and sequence and typical lessons they teach for each unit. These data were then reviewed by the first author as well as by a team of Earth science education experts. Teachers' scope and sequences were well aligned with the Core Curriculum and Regents, but misalignment was found between their lessons and the Core Curriculum as well as between the stated objectives for their students and evaluation of those objectives. The insights gained from this analysis of the NYS system could be helpful to other states as they move toward increased standards-based Earth science curricula. Among other suggestions, it is recommended that the Core Curriculum be revised to emphasize alignment principles and more opportunity be provided for teacher professional development focused on alignment issues relative to the state standards and enhanced internal lesson coherence. © *2013 National Association of Geoscience Teachers*. [DOI: 10.5408/12-292.1]

Key words: alignment, assessment, Regents, secondary education

INTRODUCTION

Earth science is one of four "Regents" sciences that are currently taught in New York State (NYS) secondary schools. The curriculum for this course has been influenced by national, state, and local policy and is created in each district based on documents such as: the *National Science Education Standards* (NSES), the New York State *Learning Standards for Mathematics, Science and Technology* (NYS Standards), and the *Physical Setting/Earth Science Core Curriculum* (Core Curriculum). Although the State provides standards (goals for student learning that articulate what students should know and be able to do) that must be met, preparation for the end-of-course exam, the Regents Examination in Physical Setting/ Earth Science (Regents Exam), is determined by each district, and sometimes by individual teachers.

A search of published literature from 1950 through January 2011 indicated that there were only 50 published articles in peer-reviewed journals that were referenced to the keywords "Earth science standards." In general, the cited publications included a broad range of topics including assessment (e.g., Stearns and Courtney, 2000; Spooner et al., 2008), teacher education, (e.g., Gatrell, 2004; Hall and Buxton, 2004; Park et al., 2005), tools and methods (e.g., Boxie and Maring, 2002; Francek and Winstanley, 2004; Patterson, 2007), and curriculum (e.g., Park, 2005; Chang et al., 2006; Rule and Guggenheim, 2007). When searching "Earth science curricula," fewer than 20 published articles in peer-reviewed journals were recovered, and "Earth science and lesson plans" produced 13 records. Many of the articles in all three of these searches were duplicates, and they consistently covered the topics assessment, teacher education, tools and methods, and curriculum. However, none addressed specifically issues of how the standards were related to the broad topics: teachers developing curriculum, teacher implementation, and issues related to alignment.

While curriculum development and implementation by teachers for high school students is not addressed in the literature, Avard (2009) examined Earth science curricula for preservice elementary teachers in the form of a college course that included hands-on activities and a focus on student-centered learning. The course activities included discussions, conducting labs, and using proper scientific methods and tools. The goal was for these future teachers to learn science by using particular methods that they would later use in their teaching.

Others, such as Pyle (2008), have examined methods of instruction in Earth science classrooms. Pyle suggests inquiry-oriented science instruction should engage the students in the active processes of science knowledge construction and emulate the process of science. Because direct experimentation is often not possible in Earth science, students can do inquiry by using models, examining historic events, interpreting data, and making observations. Pyle gives examples of different types of inquiry (confirmational, structured, guided, and open) that can be used in a geosciences course.

NYS Earth Science Curriculum

In NYS Earth science courses, the Core Curriculum assists teachers and supervisors as they develop their scope

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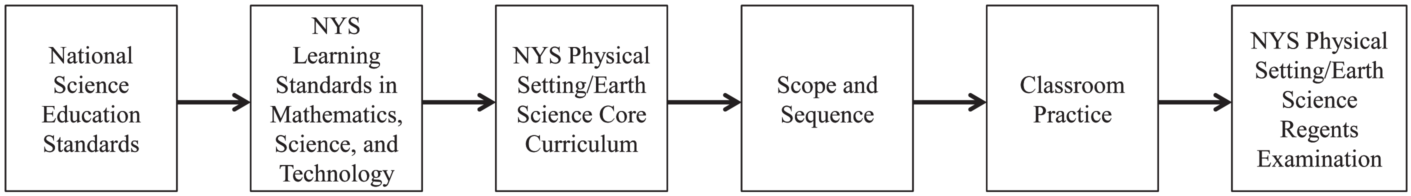

FIGURE 1: A schematic showing essential components of the NYS Earth science curriculum and their interrelationships.

and sequence (outline of the topics covered in the course and the approximate time spent on each topic), instruction (daily activities), and assessment (measures what students know or can do). This document elaborates the Earth science content of Standard 4 of the NYS Standards ("Students will understand and apply scientific concepts, principles, and theories pertaining to the physical setting and living environment and recognize the historical development of ideas in science"). The rationale for the Core Curriculum emphasizes that it is not a syllabus. Instead, it is a guide for teachers that includes the minimum content to be taught in order for students to meet the NYS Standards (New York State Education Department [NYSED], 2001). The Core Curriculum stresses teaching Earth science for understanding as opposed to memorization. Teachers have the flexibility to develop creative instruction and assessment. Additionally, the order and numbering of statements in the Core Curriculum are not meant to indicate any recommended sequence of instruction, and ideas have not been prioritized or organized to indicate teaching time allotments or test weighting. Last, teachers are expected to find and elaborate the conceptual cross-linkages that interconnect the key ideas of the Core Curriculum (NYSED, 2001). Figure 1 shows the hierarchal relationships among the components in this system. Each component informs the subsequent component to its immediate right.

Taking all of this into consideration, teachers are expected to use the Core Curriculum to create a local curriculum that includes a scope and sequence and daily activities, including lab work. Some districts create a district-wide local curriculum, while others allow individual teachers to develop their own curricula. How each teacher interprets the Core Curriculum and organizes the curriculum with regard to the allotment of time to each topic and sequence varies. Additionally, it is possible that the actual implementation of the teacher's local curriculum might look considerably different across classrooms.

Effectiveness of the Teacher's Implemented Curriculum

According to NYSED (2001), the Core Curriculum addresses the content and process skills that are assessed by the Regents Exam. The assessment tests students' ability to explain, analyze, and interpret Earth science processes and phenomena, and generate science inquiry. Students demonstrate their knowledge of Earth science through explanations in their own words, and by exhibiting creative problem solving, reasoning, and informed decision making. The Core Curriculum does not list topics by priority, teaching time allotment, or test weight.

Given the clearly established importance of coherence in curriculum design and alignment (the degree to which the components of the system are in agreement and work toward a common goal) of lesson structure with the curriculum guidelines, and ultimately with high-stakes cumulative tests such as the Regents Exam, it is important to examine teachers' scope and sequence patterns and judge how productive they will be in meeting the State-mandated learning, especially as assessed by the Regents Exam. Additionally, the daily practices and lab experiences chosen by the teacher will undoubtedly affect the success of the students on the examination. Webb (1997) states that it is necessary for the assessment and standards to be aligned in order to strengthen the integrity of the system and improve its effectiveness in working toward the intended learning goals. Thus, evidence for this alignment among these multiple levels in the teacher's lessons including objectives (what the students should learn as a result of the lesson), classroom practice (daily activity or classroom-based activity chosen by the teacher), and evaluation (how the teacher determines if the objective has been met) became a major focus of this study. The following set of case studies is intended to provide insights into how a select group of highly experienced and respected teachers cope with the challenges of adapting the NYS guidelines to their teaching and should also inform teacher educators and curriculum developers.

Given the results of the literature survey and the relatively recent emergence of some of the major issues being addressed in this study, the rationale for this research is largely grounded in prior, more general research studies on curriculum alignment (e.g., Webb, 1997, 1999; La Marca et al., 2000; Wilson and Bertenthal, 2006; Liu and Fulmer, 2008), and the research questions are largely derived from this prior research and the more general curriculum guidelines and advice to teachers published by NYS.

Research Questions

Based on a purposeful sample of experienced, in-service, secondary school science teachers, how do the teachers prepare students to meet the standards in the *Physical Setting/Earth Science Core Curriculum* in relation to each of the following three research questions: (1) What is the scope and sequence of the curriculum that each of the teachers uses? (2) What is each of the teacher's daily practices, and to what extent are they aligned with the teacher's stated goals in her/his curriculum plan (scope and sequence)? (3) As judged by a panel of Earth science education experts, will each of the teacher's methods (reported in questions 1 and 2) lead to student success on the New York State *Physical Setting/Earth Science Regents Examination*?

METHODS

Participants

The names of teachers to be invited to participate in this study came from two major sources, the Earth Science Program Resource Innovation Team (ESPRIT) listserv and advice of professional contacts with whom the first author has had extensive past experience. The ESPRIT listserv is owned and operated by the State University of New York (SUNY)–Oneonta as a mentoring tool to assist Earth science teachers across NYS. It consists of approximately 1,295 members (as of November 2009), largely educators associated with Earth science and/or science education. These sources were chosen to obtain a suitable representation of Earth science teachers across NYS. According to Bercharlie (2010) of the Information and Reporting Services department in the NYSED, there were 3,410 Earth science teachers during the 2008–2009 school year, with an average of 12.7 years of total teaching experience. All of these teachers had completed a bachelor's degree, 12.6% had no further degrees, 86.7% had additionally completed a master's degree, and 0.7% had achieved a doctorate degree. Sixty-eight percent of these teachers have a permanent certification from New York State.

A purposeful sample of experienced (>4 years) teachers was chosen for this study in order to analyze how experienced and innovative teachers use the Core Curriculum to develop their own scope and sequence. To be included, a teacher must have taught Regents Earth Science, past or present, for more than 4 years, in New York State. Many of these teachers had previously demonstrated innovation and creativity on the ESPRIT listserv. They also had a well-articulated rationale for their curricular choices. The names of 31 highly active participants on the listserv were submitted to three established Earth science education advisors, who were asked to determine who among the list met the established criteria. These advisors all had experience in Earth science education and had taught or otherwise interacted with many of the members of the listserv. They were asked to suggest any other qualified potential participants. The advisors recommended 24 of the original 31, and 12 additional teachers were suggested. All 43 teachers were contacted, 19 agreed to participate as per our Institutional Review Board–approved procedures, and 10 of these teachers completed the questionnaire. Each received a $50 gift card for participating. Of these 10 participants, 5 were recommended by only the advisors, 1 was identified on the initial list, and 4 were identified on the initial list and also recommended by an advisor.

Questionnaires

Those who elected to participate were sent the questionnaire via email to obtain basic background information including current professional role, number of years teaching, teaching experience, educational background, and Earth science courses that they had taken. They also received directions on how to report their scope and sequence and summarize a representative lesson for each topic. Each teacher was instructed to use a list of the major topics taught in the Earth science curriculum to report (1) his/her scope and sequence, (2) the major understandings and process skills associated with each topic, and (3) the number of days spent teaching the topic. The directions stated that it did not have to be the specific scope and sequence taught during the 2009–2010 school year. This allowed each teacher to select a representative example or one that he/she believed was representative of the typical lessons in his/her course. A total of 10 responses to the questionnaire were documented and the scope and sequences were coded based on topics, major understandings, and process skills. Then, using an emergent analytical scheme, the scope and sequences were cross-compared among the participating teachers to describe the similarities and differences. The scope and sequence used by each teacher serves as a plan for what order he/she will teach the content and for how much time. The sequence, or order of the content, reveals each teacher's beliefs about how he/she thinks the content should be organized to build in a logical way and be appropriate to the students' need to ensure his/her students will best learn the content. The scope, or amount of time spent on each topic, reveals how much time the teacher thinks should be spent on each topic based on importance or how long it takes for students to grasp concepts. The Major Understandings and Process Skills from the Core Curriculum were categorized for each unit, for example, Major Understanding 1.1a would be taught during the Astronomy unit. Each teacher's scope and sequence was analyzed by noting his/her report of where each Major Understanding and Process Skill is incorporated into his/her curriculum and comparing it to the aforementioned categorization.

Analysis

Each teacher's questionnaire responses were analyzed with an evaluative rubric (Appendix A) that included eight relationships of alignment within their lessons and in relation to the Regents Exam and Core Curriculum as follows: alignment of (1) Objectives and Core Curriculum, (2) Activities and Objectives, (3) Evaluation and Objectives, (4) Evaluation and Activities, (5) Activities and Core Curriculum, (6) Evaluation and Regents Exam, (7) Topic and Core Curriculum, and (8) Scope and Core Curriculum. This five-category rubric consistently uses the same set of dimensions ranging from fully aligned to no alignment. It was created by the first author, then edited and revised by the second author.

These eight relationships contributed to an overall assessment. Relationship (1) established whether or not the entire lesson is on track with respect to alignment with the Core Curriculum. Relationship (2) established whether the teacher is building alignment of the activities relative to the lesson objectives, regardless of the intent of the objectives in relation to the Core Curriculum. Relationships (3) and (4) provided evidence of the evaluation alignment with the objectives and the activities, respectively. Relationships (5) and (6) examined the details of the activities and evaluation respectively and augment the analyses of relationships (1) through (4). This sequence of relationships (1–6) provides evidence of how the entire lesson aligns logically with the Core Curriculum. The last two relationships (7 and 8) examine broader aspects of how well the lesson topic and the lesson scope align with the Core Curriculum.

The lessons and scope and sequences were coded by the first author and a second coder, who was carefully selected based on background, experiences, and knowledge of the NYS Earth Science Curriculum. The second coder was thoroughly trained in the use of the coding scheme, and

TABLE I: Teacher data from questionnaires.

Name	Years teaching	Location by county	Undergrad Major	Graduate Major	Earth science courses (*n*)
Ms. Allen	5	Genesee	Environmental Science	Science Education	12
Mr. Brown	16	St. Lawrence	Geology	Science Education	16
Mr. Clark	5	Chenango	Environmental Geology	Science Education	16
Ms. Davis	10	Bronx	Computer Systems	Geosciences	16
Mr. Evans	15	Suffolk	Earth and Space Science	Science Education	12
Ms. Foster	6	Delaware	Earth System Science	Science Education	10
Ms. Green	5	Bronx	Biology	Science Education	3
Ms. Harris	16	Schenectady	Biological Sciences	Science Education	7
Mr. Isaac	35	Suffolk	Geology	Earth Science	28
Mr. Jones	24	Suffolk	Earth Science	Geology	18

independently applied the scoring rubric to a sample of 10 items. A weighted Cohen's kappa reliability index (Cohen, 1960) of 0.8 was obtained, which is deemed good according to Cohen's guidelines. A binary decision tree (Appendix B) was used to assess the alignment between the components of each representative lesson and the Core Curriculum. There were four levels in the alignment decision tree. These were used to assign each lesson into 1 of 16 categories, based on a yes-or-no decision criterion at each node. A rubric score (Appendix A) of 1 or 2 was assigned as "No" and a score of 3, 4, or 5 was assigned as "Yes." The rubric score was inserted at each decision point, and the consequent defined category at the base of the tree was identified. Next, a composite tree was created for each teacher. The mean rubric score for all of the topics among a teacher's lessons was used to make a "Yes" or "No" assignment at each node in the binary tree and create an overall categorization for the entire set of lessons.

This is a hierarchical systems analysis. Therefore, the higher dichotomies are more significant than the lower ones in terms of the overall contribution that each level makes to coherent lesson design and evaluation. That is, a categorization at the highest level (level 1) being the alignment of the lesson with the Core Curriculum is clearly one of major importance because if that is not met, then the teacher might be teaching a very coherent lesson, but one that might not help the students meet the NYS standards very well or to fully prepare them to successfully take the Regents Exam.

Earth Science Education Experts

To obtain a broader professional judgment whether each of the teacher's methods would lead to student's success on the Regents, the materials submitted by the teachers were given to a panel of three Earth science education experts. These experts were selected from professional contacts and included Dr. James R. Ebert, Distinguished Teaching Professor and Chair of the Earth Sciences Department at SUNY Oneonta; Thomas McGuire, retired secondary school Earth science educator, author of four Earth science review books, and consultant to NYSED; and Dr. Michael Passow, a senior secondary school Earth science educator and adjunct associate research scientist at Lamont–Doherty Earth Observatory.

Each expert was asked to judge a set of sample representative lessons and scope and sequences chosen from those submitted by the 10 teachers. The sample included one lesson from each of five general topics (astronomy, historical geology, measurement and maps, meteorology, and physical geology). These five lessons were chosen based on how typical their topic, objectives, activities, and evaluation methods were and their detailed descriptions. They were taken from lessons submitted by four of the 10 participants. The experts used scoring rubrics prepared by the authors (Appendices C and D). These rubrics were a condensed version of the rubric used by the first author to rate the lessons in order to decrease the amount of time necessary to rate each lesson. The rubric assessed to what extent the content of the lessons (topic, objectives, activities, and lesson evaluation plan) were aligned with the Core Curriculum and with one to four sample Regents Exam questions that pertained to the topic of the lesson from the June 2010 Regents Exam. The experts provided a written comment to explain their rating and what components did not meet Core Curriculum requirements or did not align with the sample Regents Exam questions (Appendix C). Additionally, the expert judges rated the overall alignment of the sample scope and sequences with the Core Curriculum requirements, and provided a written explanation for their rating (Appendix D).

RESULTS

The following section begins with an examination of the teachers' background data. It is followed by an analysis of the scope and sequences reported by the teachers to address research question 1. Next, the representative lessons are examined to address research question 2. Last, research question 3 is addressed by examining the rubric scores from the Earth science education experts.

Teacher Data

A summary of the basic, questionnaire-based, background information for each teacher is presented in Table I. In order to protect confidentiality, pseudonyms were used to identify the participating teachers and all identifying characteristics, other than those essential to the integrity of this study, were changed. There were equal numbers of male and female teachers, from seven counties throughout NYS, with an average ± standard deviation of 13.7 ± 9.8 years of teaching experience. All 10 teachers had a master's degree. The State average number of years teaching in 2008–2009 for Earth science teachers was 12.7, with 99.3% having a master's degree (Bercharlie, 2010) making this sample fairly representative. Nine of the 10 teachers majored in a science discipline for their undergraduate degree, 6 in the Earth sciences (including environmental science) and 2 in biology. One teacher majored in computer systems. Seven teachers majored in science education for their graduate degree and three majored in the Earth sciences. The mean number of Earth science courses taken by each teacher was 13.8 ± 6.8.

Scope and Sequences

In relation to research question 1, Table II displays the reported scope and sequences for the 10 participant teachers. Teachers stated justifications for the organization of their scope and sequences, such as fostering student understanding (e.g., from concrete concepts to more abstract, the story of Earth's evolution, etc.), the amount of time it takes to learn different concepts, and the emphasis of the topics on the Regents Exam. Curriculum units that were listed by the teachers across all scope and sequences were (1) Measurement, (2) Maps, (3) Rocks and Minerals, (4) Dynamic Earth, (5) Weathering, Erosion, and Deposition (WED) and Landscapes, (6) Earth History, (7) Weather and Climate, and (8) Astronomy. The first unit for Messrs. Brown, Clark, Evans, and Ms. Harris is shown in parentheses, because these units were integrated throughout the entire course. Measurement was included in the first unit in 80% of the responses. The Maps unit followed the first unit in 70% of the sequences and was always taught near the beginning of the year. The Rocks and Minerals unit followed the Maps unit in 70% of these cases, and was taught at the beginning of the year in 80% of the sequences. The Dynamic Earth unit was adjacent (proximally, before or after) to the Rocks and Minerals unit or WED and Landscapes unit in 90% of the sequences and was taught in the middle of the curriculum. In 80% of the sequences, the WED and Landscapes unit was adjacent to the Dynamic Earth and Earth History units and was taught in the middle of the course in 90% of the sequences. Mr. Evans integrated the WED and Landscapes unit throughout the entire year. The Earth History unit placement was not consistent across teachers, but was always taught during the second half of the course. The Atmosphere unit was found adjacent to the Astronomy unit in 80% of the sequences and was taught at the end of the course 70% of the time. In 70% of the sequences, the Astronomy unit was taught at the end of the course.

Based on an analysis of the scope of each unit (Table III), the mean number of days spent on each unit was calculated to determine the mean percentage of time spent on each unit. The least amount of time was spent on the Introduction (5.7 ± 2.1 days) followed by: (1) Environmental Awareness (8.0 days), (2) Measurement (11.6 ± 6.0 days), (3) Maps (13.0 ± 4.7 days), (4) Earth History (16.9 ± 5.4 days), (5) Rocks and Minerals (17.1 ± 6.2 days), (6) Dynamic Earth (20.5 ± 7.7 days), (7) WED and Landscapes (21.8 ± 5.6 days), (8) Astronomy (28.9 ± 12.7 days), and (9) Atmosphere (34.2 ± 11.5 days).

In order to discover the general patterns in the organization of the scope and sequences across the entire set of teachers, each unit in the scope and sequences reported were grouped into one of five topics: (1) Meteorology, (2) Astronomy, (3) Physical Geology, (4) Historical Geology, and (5) Measurement and Maps. Physical Geology included the units Rocks and Minerals and WED and Landscapes. The Dynamic Earth and Earth History units were grouped in Historical Geology. Ms. Davis was the only teacher to include an Environmental Awareness unit and only Mr. Clark, Ms. Foster, and Ms. Green included introductory units; therefore, these units were not included in the five topics used in the generalized scope and sequence analysis. The five topics were compiled into a chart showing the overall or generalized scope and sequences (Table IV).

Each of the 10 scope and sequences fell into one of six patterns (Table IV), based on the distribution of the five topics used in the analysis. Scope and sequences 1 and 2 are the same, except for an interchange of Meteorology and Astronomy at the end of the curriculum. Scope and sequences 3 and 4 also interchange Meteorology and Astronomy, but these units appear much earlier in the curriculum. Scope and sequence 5 contains the Measurement and Maps unit in the middle of the curriculum, while scope and sequence 6 has this unit in between Physical Geology and Historical Geology. Additionally, scope and sequence 6 has the Astronomy and Meteorology units at opposite ends of the curriculum, unlike the other scope and sequences.

The mean curriculum time (based on the number of days per unit) for the generalized scope (Table V) was 161 days. Percentage of curriculum time devoted to each unit was also reported. The Measurement and Maps unit was given the least amount of time, followed by Astronomy, Meteorology, Historical Geology, and finally Physical Geology.

Figure 2 shows the average percentage of curriculum time devoted to each of the generalized units (Table V).

Representative Lessons

To address research question 2, representative lessons from each teacher for every unit reported were examined for the eight relationships by using the alignment rubric (Appendix A) and binary decision tree (Appendix B). The results (Table VI) showed that 82 of the 97 lessons received a 1, i.e., full alignment internal to the lesson and with the Core Curriculum. It is important to point out that a teacher could have scored all 3s, all 5s, or a combination of 3s, 4s, and 5s and still receive a 1 by using the binary decision tree. Nonetheless, all of the components presented by teachers who received a 1 showed partial, significant, or full alignment according to the rubric. The difficulty here lies in trying to quantitatively measure variables that are of a more qualitative type.

Misalignment can occur at a variety of levels. Ms. Green's lesson no. 9 received a 2 due to the misalignment of the evaluation of the activities in the lesson. Also, her lesson no. 11 was assigned a score of 4 because the evaluation was misaligned with both the activities and lesson objectives. The following lessons were internally aligned but misaligned with the Core Curriculum and received a score of 9: Ms. Allen's lesson no. 7; Ms. Davis' lessons nos. 4 and 7, and 12; Mr. Evans' lessons nos. 2 and 4; Ms. Harris' lessons nos. 8 and 10; and Mr. Isaac's lesson no. 4. Ms. Harris' lesson no. 3 had objectives that were not aligned with the Core Curriculum but were internally aligned except for the

TABLE II: Scope and sequences submitted by teachers.

Ms. Allen	Mr. Brown	Mr. Clark	Ms. Davis	Mr. Evans
Measurement	(Measurement)	(Measurement)	Measurement	(Landscapes)
Maps	Astronomy	Introductory	Maps	Measurement
Rocks and Minerals	Rocks and Minerals	Maps	Rocks and Minerals	Maps
Dynamic Earth	WED and Landscapes	Rocks and Minerals	Dynamic Earth	Rocks and Minerals
WED and Landscapes	Maps	WED and Landscapes	WED and Landscapes	WED and Landscapes
Earth History	Earth History	Dynamic Earth	Earth History	Dynamic Earth
Atmosphere	Dynamic Earth	Earth History	Atmosphere	Earth History
Astronomy	Atmosphere	Astronomy	Astronomy	Atmosphere
n/a	n/a	Atmosphere	Environmental Awareness	Astronomy

evaluation of the activities and received a 10. Mr. Clark's lesson no. 1 only had alignment between the activities and lesson objectives and received a 12. Only two lessons had misalignment on all levels, Mr. Evans' lesson no. 7 and Ms. Green's lesson no. 10.

Results from the composite trees of the median rubric scores for all lessons are presented in Table VII. All teachers received an overall alignment of 1, indicating full alignment within the lesson and in relation to the Core Curriculum. However, some teachers had stronger alignment than others because rubric scores of 3, 4, and 5 (Appendix A) all were considered a "Yes" in the alignment decision tree (Appendix B). Ms. Allen, Mr. Brown, Mr. Clark, Ms. Foster, Ms. Harris, Mr. Isaac, and Mr. Jones were scored as high 3s, 4s, and 5s. They had the strongest alignment. Ms. Davis and Ms. Green had low 3s and 4s, signifying less alignment, and Mr. Evans' lessons all had scores of high 2s and low 3s.

Experts' Analysis of Scope and Sequences

The three experts also rated a set of five scope and sequences (Table VIII) by using a set of rubrics (Appendix D). These five scope and sequences represent 5 of the 6 generalized scope and sequences presented in Table IV. A higher rubric score indicated better alignment and more support of student understanding. All five scope and sequences were well-aligned with the Core Curriculum, with nos. 1 and 4 having perfect alignment according to the experts. Of the five scope and sequences, nos. 3 and 1 received scores indicating best support of student understanding while nos. 2, 4, and 5 gave less support.

TABLE III: Analysis of scope of each unit (mean ± SD).

Unit	Range of days	Mean no. of days	Mean % of curriculum
Astronomy	15–59	28.9 ± 12.7	16.3
Atmosphere	11–53	34.2 ± 11.5	19.3
Dynamic Earth	10–31	20.5 ± 7.7	11.5
Earth History	8–25	16.9 ± 5.4	9.5
Environmental Awareness[1]	8	8.0	4.5
Introduction	4–8	5.7 ± 2.1	3.2
Maps	7–22	13.0 ± 4.7	7.3
Measurement	3–20	11.6 ± 6.0	6.5
Rocks and Minerals	8–27	17.1 ± 6.2	9.6
WED and Landscapes	15–30	21.8 ± 5.6	12.3

[1]This unit was reported by only one teacher and therefore has a value of 8.

Experts' Analysis of Representative Lessons

To address research question 3 regarding experts' judgment of the quality of teachers' lessons, the five best representative lessons, one from each of the generalized units, were chosen and sent to the experts. They were Ms. Davis' lesson no. 10, Ms. Allen's lesson no. 10, Ms. Davis' lesson no. 5, Mr. Isaac's lesson no. 7, and Mr. Jones' lesson no. 2. The lessons were chosen based on the quality of the detail of the descriptions, and how typical they were among the group (objectives, activities, evaluation, tools, skills, etc.). Overall, these lessons tended to use more inquiry methods and were student-centered. Experts rated each lesson's alignment with the Core Curriculum and with a set of sample Regents questions from the June 2010 Regents Exam (Table IX). For each lesson, only one to four sample questions were found in the June 2010 Exam. Each lesson was analyzed using a rubric specifically designed for use by the experts (Appendix C). A higher rubric score indicated greater alignment. Lessons no. 2 and no. 4 had the best rubric score for alignment with the Core Curriculum, while lessons nos. 4 and 1 had the best alignment with the sample Regents questions. Lesson no. 3 had the lowest alignment with the Core Curriculum, while lesson no. 2 had the lowest alignment with the sample Regents questions. Overall, the ratings of the experts provided some interesting data on their consensus about perceptions of the alignment of the lessons with the Core Curriculum and Regents Exam.

Distinctive Characteristics of Lessons

A brief summary of some distinctive characteristics for each of the five lessons is presented to more fully exemplify its organization and degree of coherence. Objectives in lesson no. 1 stated students would understand and describe concepts related to the apparent motion of the Sun. The activities description portrayed specifically what students would do and what content they would be addressing (e.g., "First, students will determine the height of the noon Sun, next they will place a dot representing...; next they will draw and label a line..."). Student outcomes from the lesson were evaluated with a lab write up. In terms of alignment of this lesson with the Regents Exam, the sample Regents questions given to the experts included four constructed response

TABLE II: extended.

Ms. Foster	Ms. Green	Ms. Harris	Mr. Isaac	Mr. Jones
Introductory	Introductory	(Measurement)	Measurement	Measurement
Measurement	Measurement	Atmosphere	Astronomy	Maps
Maps	Maps	Astronomy	Atmosphere	Rocks and Minerals
Atmosphere	Rocks and Minerals	Maps	Maps	Dynamic Earth
Astronomy	Dynamic Earth	Rocks and Minerals	Dynamic Earth	WED and Landscapes
WED and Landscapes	WED and Landscapes	Dynamic Earth	Rocks and Minerals	Earth History
Rocks and Minerals	Earth History	WED and Landscapes	WED and Landscapes	Astronomy
Earth History	Atmosphere	Earth History	Earth History	Atmosphere
Dynamic Earth	Astronomy	Astronomy	n/a	n/a

questions that closely corresponded to the activities planned in the lesson. Experts commented that this lesson was comprehensive and well organized, and that it addressed the sample Regents questions. Also, this lesson was directly linked to an activity that was included in the old Regents performance test (part D). The experts were in agreement that this lesson was in alignment with more than half of the related concepts in the Core Curriculum and two out of three felt that it was fully aligned with the Regents questions.

Students were expected to measure and compare dew point and humidity in the objectives for lesson no. 2. For the activities, the teacher explained what the students were taught but not specifically what they would do (e.g., "Students are taught how to find humidity…"). Students completed multiple assessments during this lesson including informal interviews, quizzes, and lab questions. Two sample Regents questions were provided for this lesson. The multiple-choice question included a chart to be used to determine the answer. Additional content knowledge was needed to answer the constructed response question. According to the experts, the evaluation section was not very specific. They also commented that additional skills and content were needed to answer the sample questions. Two of the three experts rated this lesson as aligned with more than half of the related concepts in the Core Curriculum, while the third rated it as aligned with all of the concepts. As for alignment with the Regents questions, the experts were not in agreement and gave scores ranging from alignment with all of the questions to more than half of the questions to half of the questions. Experts rated this lesson as having the highest alignment with the Core Curriculum.

Lesson no. 3 was a lesson on surface processes, specifically, physical weathering. Both objectives indicated what the students would understand (e.g., "understand what weathering is…understand the definition of abrasion…"). The activities were very detailed and included materials used, what students would do, and prior knowledge needed. Students were evaluated based on their lab write-up and explanation for different weathering rates. The teacher mentioned that the students would need prior knowledge to complete this lesson. Sample Regents questions included two multiple-choice questions that demonstrated application of the concepts. It was noted by the experts that the objectives were not clear and that more should have been listed. Also, the experts stated that it was a conceptual leap for students to go from the lesson to answering the sample questions and that more knowledge was needed to answer the questions. Experts rated this lesson as being aligned with half to more than half of the related concepts in the Core Curriculum and Regents questions. Experts rated this lesson as having the lowest alignment with the Core Curriculum and sample Regents questions.

The objectives for lesson no. 4 included some review, as well as students distinguishing between parent isotope and daughter product, demonstrating decay by using two elements, and understanding half-life and how it is used to determine the age of a rock. The entire lesson description was presented much more like an outline rather than a detailed narrative, due probably to the relatively less amount of content provided by the teacher and limited space it was given. A thorough description of the activities was provided, including a PowerPoint presentation, discussion, and lab activities (both what the students were to do and write).

TABLE IV: Generalized scope and sequences.

Scope and sequence					
1	2	3	4	5	6
Measurement and Maps	Measurement and Maps	Measurement and Maps	Measurement and Maps	Meteorology	Astronomy
Physical Geology	Physical Geology	Astronomy	Meteorology	Astronomy	Physical Geology
Historical Geology	Historical Geology	Meteorology	Astronomy	Measurement and Maps	Measurement and Maps
Meteorology	Astronomy	Physical Geology	Physical Geology	Physical Geology	Historical Geology
Astronomy	Meteorology	Historical Geology	Historical Geology	Historical Geology	Meteorology

TABLE V: Analysis of generalized scope for each unit (mean ± SD).

Unit	Range of days	Mean no. of days	Mean of curriculum
Astronomy	15–59	31.3 ± 14.8	19.4
Historical Geology	18–55	38.4 ± 10.9	23.8
Measurement and Maps	9–42	21.1 ± 10.2	13.1
Meteorology	11–53	31.7 ± 11.6	19.7
Physical Geology	28–50	38.8 ± 8.0	24.1

Students were evaluated based on their lab reports. The one multiple-choice sample Regents question included a visual representation of the concepts in this lesson. Experts commented that this lesson included multiple modes of instruction, addressed student learning, and could have easily addressed additional standards. In general, the concepts and content included in the lesson were more than what was needed to answer the sample Regents question. While two of the experts rated the lesson as being aligned with all of the related concepts in the Core Curriculum, one rated it as being aligned with about half of the related concepts. All three experts rated the lesson as aligned with all of the Regents questions. Experts rated this lesson as having the highest alignment with both the Core Curriculum and sample Regents questions.

There were many objectives for lesson no. 5, including learning to construct and interpret a map, draw isolines, calculate gradient, and construct a profile. The teacher wrote the activities in a narrative style and explained what the experiences in the class would look like, what students would do, and how they would accomplish these tasks. Students were evaluated by the components of their lab reports including calculations, drawings of profiles and maps, and conclusions. The four sample Regents questions were constructed response questions that included drawings and calculations. Overall, these questions were more detailed than the lesson. The experts wrote that the lesson included good details and involved procedures that were necessary for student understanding. They commented that the lesson would allow students to answer the questions although some content and skills needed were not taught in this lesson. The experts were not in agreement regarding the alignment between the lesson and the Core Curriculum. Scores ranged from full alignment with all of the related concepts in the Core Curriculum to alignment with more than half to alignment with half of the related concepts. Two of the three experts rated the lesson as aligned with all of the Regents questions while one rated it as aligned with half of the questions.

DISCUSSION

This study found that within a purposeful sample of experienced and innovative NYS teachers, the scope and sequence and lesson foci can look rather different from one teacher to the next. Given the relatively few prior published research studies on the major themes of this study, much of the discussion largely focuses on how the specific findings from this study are related to larger issues of how Earth science teachers adopt and adapt the State-generated guidelines in their daily practices of teaching and assessment.

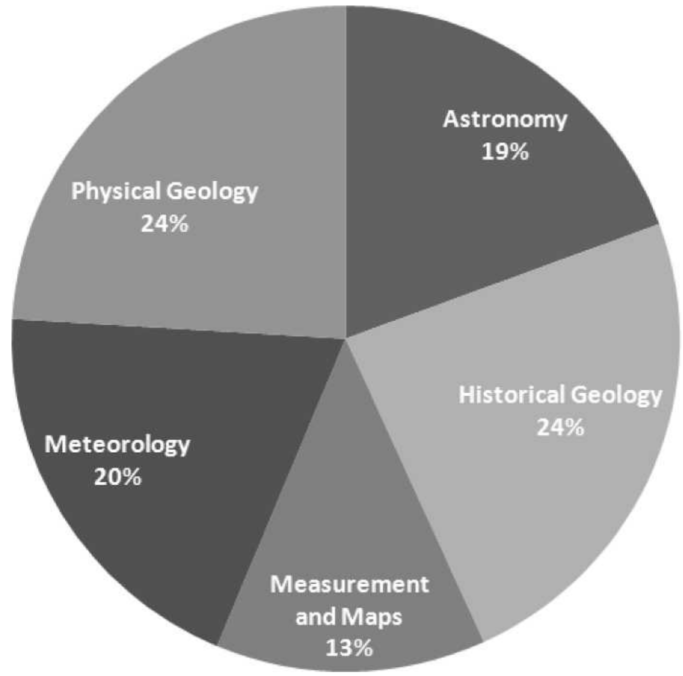

FIGURE 2: Percentage of days spent on generalized topics.

Alignment of Curriculum, Lessons, and Assessment

Although the Core Curriculum does not organize the content into particular units, overall, the teachers seemed to separate the content into similar units. They attempted to organize their curricula in a way that maximized student understanding (including strong evidence of alignment), but there is evidence that even these experienced teachers might need guidance to actually accomplish this goal. This could be achieved through a professional development course focusing on curriculum writing or as a course for preservice teachers to be included in their degree programs. The teachers also struggled with aligning their lessons with the Core Curriculum, which was mainly due to creating well-designed lessons that included content that was not specifically addressed in the Core but often found on the Regents Exam. Better alignment between the Core and the Regents would lead to higher alignment scores for these teachers' lessons (see Contino, 2012). The results in Tables VI and VII reveal that teachers struggled with aligning objectives and activities with the evaluation of their lessons. Teachers need to think critically about how they are measuring whether the objectives were met. In the Science Lesson Plan Rating Instrument developed by Hacker and Sova (1998), four questions that teachers should ask when planning lessons that would aid in alignment between evaluation and other lesson components are provided:

1. Is there provision for summarizing the main ideas that emerge during the lesson?

TABLE VI: Alignment of representative lessons.

Teacher	Lesson no.											
	1	2	3	4	5	6	7	8	9	10	11	12
Ms. Allen	1	1	1	1	1	1	9	1	1	1	1	1
Mr. Brown	1	1	1	1	1	1	1	NA[1]	NA	NA	NA	NA
Mr. Clark	12	1	1	1	1	1	1	1	1	1	1	NA
Ms. Davis	1	1	1	9	1	1	9	1	1	1	1	9
Mr. Evans	1	9	1	9	1	1	16	1	NA	NA	NA	NA
Ms. Foster	1	1	1	1	1	NA	NA	NA	NA	NA	NA	NA
Ms. Green	1	1	1	1	1	1	1	1	2	16	4	1
Ms. Harris	1	1	10	1	1	1	1	9	1	9	1	NA
Mr. Isaac	1	1	1	9	1	1	1	1	1	NA	NA	NA
Mr. Jones	1	1	1	1	1	1	1	1	1	1	NA	NA

[1]NA = not applicable.

2. Will the main findings of the lesson be related to the objectives of the lesson?
3. Will the degree to which students have attained the lesson objectives be assessed?
4. Has provision been made for homework or recommended follow-up activities?

Dunn et al. (2010) also suggest that teachers explain how mastery is shown by listing ways that students are formatively assessed during the lesson to assure that the objectives were met. This would strengthen the internal alignment related to evaluation as well.

Experts stated that the methods used by these teachers should lead to success on the Regents Exam after examining five lessons that represented the five major topics taught in the Earth Science curriculum. These experts were given only five lessons due to the time commitment required to thoroughly judge each lesson and these five lessons were deemed "typical" by the authors and included topics and approaches that curriculum developers and Earth science teachers need to consider. The lessons that received the highest ratings were inquiry-based, well-written, descriptive, and student-centered, and overall, there was evidence of considerable concordance in the experts' ratings.

Educational Implications

The principle of alignment is an important and essential aspect of the planning practice and is necessary to strengthen the integrity of a system and improve its effectiveness (Webb, 1997). Within this perspective, these teachers have, on the whole, presented some well-aligned examples of how they adapted the materials that NYS provided; however, some teachers, in spite of their excellent attempts, had difficulty with certain alignments relating their lesson with the Core Curriculum (nine lessons) or the evaluation of the lesson with other components (seven lessons). A follow-up (more qualitative) study that asks these teachers about their struggles might reveal why this is the case. The materials provided by NYS should be commended for the freedom they provide to teachers when planning their daily lessons. Nonetheless, not enough assistance is given for teachers to fully understand the principles of alignment nor is sufficient clarity and presentation of the expectations given. For example, while the flexibility of the NYS curriculum is noteworthy, NYS has not

TABLE VII: Median rubric scores and interquartile range for all lessons (median (interquartile range = upper quartile-lower quartile)).

Teacher	Objectives and Core	Activities and Objectives	Evaluation and Objectives	Evaluation and Activities	Alignment
Ms. Allen	4 (4–3)	5 (5–3.75)	4 (4–4)	4 (4–4)	1
Mr. Brown	5 (5–5)	4 (4–3)	4 (4–4)	4 (4–4)	1
Mr. Clark	4 (5–4)	3 (4–3)	4 (4–4)	4 (4–4)	1
Ms. Davis	3.5 (4–2.75)	4 (5–3)	3 (4–3)	4 (4–3)	1
Mr. Evans	3 (3–2)	3 (4–3)	3 (4–3)	3 (3–3)	1
Ms. Foster	4 (5–4)	4 (4–4)	4 (4–4)	5 (5–4)	1
Ms. Green	4 (5–3)	3 (4–3)	3 (3.25–3)	3 (4–2.75)	1
Ms. Harris	4 (4.5–3)	4 (4–3)	4 (4–3)	4 (5–4)	1
Mr. Isaac	4 (4–3)	4 (5–4)	4 (4–4)	4 (4–4)	1
Mr. Jones	4.5 (5–4)	5 (5–5)	4 (5–4)	4 (5–4)	1

TABLE VIII: Three experts' judgment of alignment of scope and sequences (median (interquartile range = upper quartile-lower quartile).

Teacher	Scope and sequence	Generalized scope and sequence	Median alignment with Core Curriculum	Median score for supports student understanding
Ms. Davis	1	1	5 (5–5)	4 (5–3)
Mr. Jones	2	2	4 (5–4)	3 (5–3)
Ms. Foster	3	3	5 (5–4)	4 (5–4)
Ms. Harris	4	5	5 (5–5)	4 (4–3)
Mr. Brown	5	6	5 (5–4)	3 (4–2)

clearly and consistently presented important alignment principles that are necessary to make the system effective.

The Earth Science Program Modifications, also known as the Modification Syllabus, was offered as an alternate curriculum to NYS teachers from 1993 to 2001 (Passow, 2004). In this document, alignment was more clearly presented using a three-column approach that outlined (1) Specific Concepts, Contents and Understandings; (2) Applications, Skills, Required Activities, and Discrepancies; and (3) Extensions, Suggested Activities, Laboratories, Demonstrations, and Reference to Options (NYSED, 1991). However, the rationale for, and the means of, achieving consistent alignment at all levels of curriculum implementation need to be made more explicit throughout the curriculum planning documents that state departments of education publish. Indeed, this three-column approach provides an excellent context to achieve this. Wilson and Bertenthal (2006) suggest that state standards be organized in ways that specify what students need to know and be able to do as well as how their knowledge and skills will develop over time. Incorporating these ideas would result in standards that resemble the American Association for the Advancement of Science's (2001) *Atlas of Science Literacy* or more recently, learning progressions across grade levels (e.g., Corcoran et al., 2009). These conceptual strand maps provide learning progressions for students who are becoming literate in science. Last, NYS should consider including learning performances in the Core Curriculum that specify what a student can do if they have achieved a standard and how they would demonstrate this achievement (Wilson and Bertenthal, 2006).

We must be careful when clarifying the standards not to narrow the curriculum or restrict teachers. The standards must be flexible to allow teachers to be creative and to meet the needs of all of their students. Other state education departments might take notice when planning their state curricula. It might be helpful to think of the NYS materials as a good example of a strong attempt at well-aligned curricula, but alignment between the standards, daily practices, and assessment must be highlighted in order for teachers to understand and implement these principles. Given the current less-than-ideal presentation of alignment principles in some state curriculum guides, teacher educators and professional developers might need to be more conscientious in emphasizing how the Core Curriculum can be rationalized from a thoroughly consistent alignment perspective. This could include demonstrating how to apply a consistent alignment perspective by illustrating the path from standards and Core Curriculum through lesson planning and eventually assessment phases. While these principles are central to the teaching of all school disciplines, there are likely reasons why they are particularly important for the Earth sciences, and some insights have emerged from the study presented here.

The research presented here elucidates how a select sample of teachers has interpreted the NYS materials for Earth science when creating their scope and sequences, and how they implement the guidelines in their classroom practices. The 10 teachers in this study all had legitimate justifications for the organization of their scope and sequences such as for student understanding (e.g., from concrete concepts to more abstract, the story of Earth's evolution, etc.), the amount of time it takes to learn different concepts, and the emphasis of the topics on the Regents Exam. Although the scope and sequences fell into one of six patterns, they were all rated relatively high by the experts for alignment with the Core Curriculum and supporting student understanding. These examples are productive as models of how the content can be arranged in a variety of ways and still align with the Core Curriculum and support students. However, they should not be considered ideal types to be emulated without creative insights that each teacher can bring to his/her own planning.

TABLE IX: Three experts' judgments of alignment of representative lessons (median (interquartile range = upper quartile-lower quartile).

Representative lesson	Author and lesson	Median alignment with Core Curriculum	Median alignment with Regents questions
1. Astronomy	Ms. Davis' no. 10	4 (4–4)	5 (5–4)
2. Meteorology	Ms. Allen's no. 10	4 (5–4)	4 (5–3)
3. Physical Geology	Ms. Davis' no. 5	4 (4–3)	3 (4–3)
4. Historical Geology	Mr. Isaac's no. 7	5 (5–3)	5 (5–5)
5. Measurement and Maps	Mr. Jones' no. 2	4 (5–3)	5 (5–3)

TABLE X: Example sequence by using a systems approach.

Unit	Topics
1. Earth's Systems	Systems
	Subsystems
	Measuring Change in Systems
2. Mapping	Map Scale
	Latitude/Longitude
	Topography
	Land Use, Urbanization, Deforestation
	Satellite Data
	Air Quality, Air Pollution, Ozone Depletion
3. Atmosphere and Hydrosphere	Seasons
	Weather
	Climate
	Land/Water Interactions
	Water Cycle
	Forecasting
	Technology
	Climate Change
	Emergency preparedness
4. Geosphere and Biosphere	Minerals
	Rock Cycle
	Mining and Fossil Fuels
	WED and Landscapes
	Shore Erosion
	Oceans
	Sea Level Change
	Earth History, Fossils, Geologic Time
	Dynamic Earth, Plate Tectonics, Earthquakes and Volcanoes

Although multiple scope and sequences are presented, there are still additional approaches for arranging the standards that could be implemented. For example, teachers could take a systems approach to an Earth science curriculum that examines how processes from each of Earth's spheres are related to and affect one another. The Earth Science Literacy Principles (Earth Science Literacy Initiative, 2010) stress that understanding systems and how humans interact with them is vital for survival. Using this approach, students investigate the four Earth systems (geosphere, hydrosphere, atmosphere, and biosphere) and the cycles of each system. Relationships among subsystems are emphasized when studying these cycles and their influences on humans and connections with technology are examined. By organizing the course in terms of systems and cycles as experienced by people, students develop environmental insight on how cycles composed of subsystems interact and exchange materials and an understanding of how people fit with nature (Orion, 2007). Teachers who follow this approach would have a scope and sequence that would more fully integrate the general topics from the Core Curriculum. Table X presents how the topics from the Core Curriculum might be arranged by using a systems approach. Each unit would include topics from the Core Curriculum and focus on an environmental issue such as deforestation, water usage, climate change, or air pollution and integrate the topics related to each system. Using this approach would allow students to relate the content to real-world issues. This global approach to learning how Earth systems operate would make the content relevant. By examining environmental issues, students would engage in scientific processes while developing problem solving and critical thinking skills.

A similar approach is Duggan-Haas and Ross' (2010) "Big Ideas," which include the concepts of systems, energy flow, influences on life, physical and chemical principles, and modeling. These big ideas are coupled with the questions "How do we know what we know?" and "How does what we know inform our decision-making?" Duggan-Haas and Ross explain Big Ideas as those that cut across the curriculum, are attainable and retained by students, are essential to understanding many topics, require deeper exploration, and represent the curriculum. The Earth Science Literacy Initiative (2010) also presents a set of nine Big Ideas that all scientifically literate citizens should know about Earth sciences. Using Big Ideas as a framework would lead to a scope and sequence that could look quite different from those presented by teachers in this study.

Work is currently being done on the Next Generation Science Standards, led by Achieve, the National Science Teachers Association, the American Association for the Advancement of Science, and the National Research Council (National Research Council, 2012). The new framework already addresses learning progressions for the outlined scientific and engineering practices, crosscutting concepts, and disciplinary core ideas. These progressions will inform future standards and which will in turn, effect teachers' scope and sequences and classroom practices.

This research provides evidence of multiple ways to organize an Earth science curriculum and presents case studies of lessons exhibiting teachers' creative adaptations that can lead to student enhanced learning as judged by a panel of experts. Alignment is crucial in the effective design of scope and sequences and daily lessons. Alignment principles need to be incorporated into lesson planning, and particular attention should be given to the alignment between lessons and standards, as well as internal alignment of the lessons, specifically when evaluating lessons. To aid in this alignment, NYS must improve the clarity of the Core Curriculum as suggested by the foregoing analysis presented here. As other states begin standards-based curriculum and assessment designs, some of the information presented here are informative toward improving total alignment in their systems. In the entire alignment process, it is very important to ensure that the design of Regents Exam questions is consistent with Core Curriculum. If teachers do all they can to achieve alignment and the Regents Exam is not aligned, then full alignment is not achievable. The standards-based system can only be effective if all components—standards, scope and sequence, classroom practice, and assessments—are fully aligned.

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York State Earth Science Curriculum with Respect to Standards, Classroom Practices, and the Regents Examination by J. Contino.

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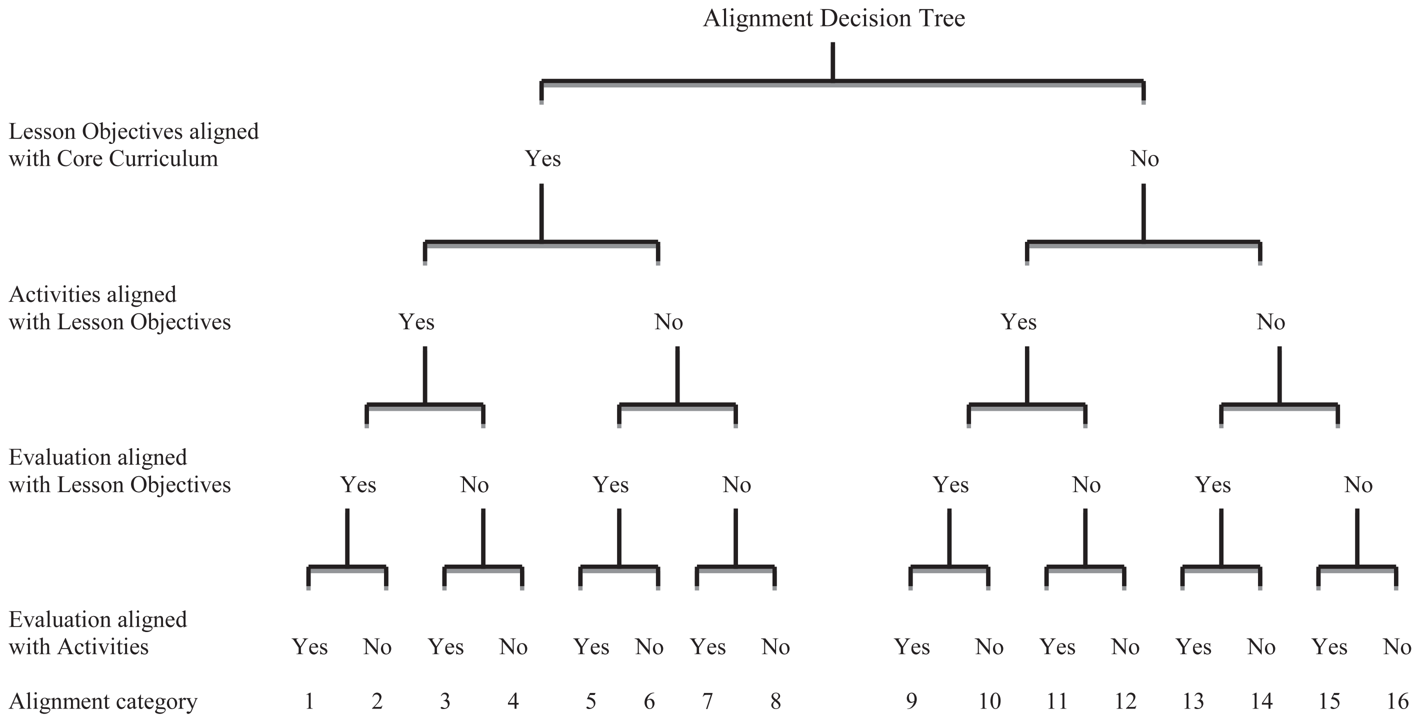
APPENDIX A

TABLE AI: Scoring rubric used by authors to rate teachers' representative lessons.

Category	Score criterion				
	5	4	3	2	1
1. Objectives and Core Curriculum	Teaching objectives align fully and clearly with the big ideas or concepts in the Core Curriculum	Teaching objectives align significantly but not fully with the big ideas or concepts in the Core Curriculum	Teaching objectives align only partially with the big ideas or concepts in the Core Curriculum	Teaching objectives align poorly with the big ideas or concepts in the Core Curriculum	Teaching objectives do not align with the big ideas or concepts in the Core Curriculum
2. Activities and Objectives	Learning activities align fully and clearly with the objectives	Learning activities align significantly but not fully with the objectives	Learning activities align only partially with the objectives	Learning activities align poorly with the objectives	Learning activities do not align with the objectives
3. Evaluation and Objectives	Evaluation used in the lesson aligns fully and clearly with the objectives	Evaluation used in the lesson aligns significantly but not fully with the objectives	Evaluation used in the lesson aligns only partially with the objectives	Evaluation used in the lesson aligns poorly with the objectives	Evaluation used in the lesson does not align with the objectives
4. Evaluation and Activities	Evaluation used in the lesson aligns fully and clearly with the activities	Evaluation used in the lesson aligns significantly but not fully with the activities	Evaluation used in the lesson aligns only partially with the activities	Evaluation used in the lesson aligns poorly with the activities	Evaluation used in the lesson does not align with the activities
5. Activities and Core Curriculum	Activities align fully and clearly with the big ideas or concepts in the Core Curriculum	Activities align significantly but not fully with the big ideas or concepts in the Core Curriculum	Activities align only partially with the big ideas or concepts in the Core Curriculum	Activities align poorly with the big ideas or concepts in the Core Curriculum	Activities do not align with the big ideas or concepts in the Core Curriculum
6. Evaluation and Regents Exam	Evaluation used in the lesson aligns fully and clearly with the sample Regents Exam Questions	Evaluation used in the lesson aligns significantly but not fully with the sample Regents Exam Questions	Evaluation used in the lesson aligns only partially with the sample Regents Exam Questions	Evaluation used in the lesson aligns poorly with the sample Regents Exam Questions	Evaluation used in the lesson does not align with the sample Regents Exam Questions
7. Topic and Core Curriculum	Topic presented aligns fully and clearly with the big ideas or concepts in the Core Curriculum	Topic presented aligns significantly but not fully with the big ideas or concepts in the Core Curriculum	Topic presented aligns only partially with the big ideas or concepts in the Core Curriculum	Topic presented aligns poorly with the big ideas or concepts in the Core Curriculum	Topic presented does not align with the big ideas or concepts in the Core Curriculum
8. Scope and Core Curriculum	Scope fully and clearly addresses all content areas and skills in the Core Curriculum	Scope significantly but not fully addresses the content areas and skills in the Core Curriculum	Scope only partially addresses the content areas and skills in the Core Curriculum	Scope poorly addresses the content areas and skills in the Core Curriculum	Scope does not address content areas and skills in the Core Curriculum

APPENDIX B



Alignment decision tree used by authors to determine alignment.

1. Full alignment within lesson and with Core Curriculum.
2. Aligned except for final evaluation with activities.
3. Aligned except for final evaluation with objectives.
4. Aligned except for final evaluation at all levels.
5. Aligned except for activities with lesson objectives.
6. Activities not aligned with objectives, evaluation not with activities.
7. Activities not aligned with objectives, evaluation not with objectives.
8. No internal alignment except for lesson objectives with Core Curriculum.
9. Internally aligned, but not with Core Curriculum.
10. Internally aligned except for final evaluation with activities.
11. Internally aligned except for final evaluation with objectives.
12. Internally aligned except for final evaluation at all levels.
13. Internally aligned except for activities with lesson objectives.
14. No alignment with Core Curriculum, neither activities nor their evaluation.
15. No alignment with Core Curriculum, neither activities nor objectives with evaluation.
16. No alignment on all levels.

APPENDIX C

Scoring rubric used by Earth science education experts to rate representative lessons.

TABLE AII: With respect to each representative lesson along with its objectives, activities, and evaluation, please make an overall judgment about to what extent it aligns with the Core Curriculum.

	Scoring criterion					
Category	5	4	3	2	1	Score
Lesson alignment with Core Curriculum	Lesson presented aligns with a clear majority or all of the big ideas or concepts in the Core Curriculum	Lesson presented aligns with more than half of the big ideas or concepts in the Core Curriculum	Lesson presented aligns with about half of the big ideas or concepts in the Core Curriculum	Lesson presented aligns with less than half of the big ideas or concepts in the Core Curriculum	Lesson presented does not align with the big ideas or concepts in the Core Curriculum	
Explain your rating, e.g., what parts do not meet the core requirements, etc.:						

TABLE AIII: With respect to each representative lesson along with its objectives, activities, and evaluation, please make an overall judgment of how well the lesson prepares the students for the set of sample Regents Exam questions that are provided as pertinent to that lesson topic.

	Scoring criterion					
Category	5	4	3	2	1	Score
Lesson alignment with sample Regents Exam questions	Lesson presented aligns with a clear majority or all of the sample Regents Exam questions	Lesson presented aligns with more than half of the sample Regents Exam questions	Lesson presented aligns with about half of the sample Regents Exam questions	Lesson presented aligns with less than half of the sample Regents Exam questions	Lesson presented does not align with the sample Regents Exam questions	
Explain your rating, e.g., what parts do not align with the Regents questions, etc.:						

APPENDIX D

Scoring rubric used by Earth science education experts to rate entire scope and sequence.

TABLE AIV: With respect to each scope and sequence, please make an overall judgment about how well it aligns with the Core Curriculum requirements.

Category	Scoring criterion					Score
	5	4	3	2	1	
Overall alignment of scope and sequence	Scope and sequence addresses all content areas in the Core Curriculum	Scope and sequence addresses more than half of the content areas in the Core Curriculum	Scope and sequence addresses about half of the content areas in the Core Curriculum	Scope and sequence addresses less than half of the content areas in the Core Curriculum	Scope and sequence does not address content areas in the Core Curriculum	
Explain your rating, e.g., what parts do not align with the Core Curriculum, etc.:						

TABLE AV: With respect to each scope and sequence, please make an overall judgment about the merit of the scope and sequence in regards to being arranged to support student understanding.

Category	Scoring criterion					Score
	5	4	3	2	1	
Overall merit of scope and sequence	Scope and sequence arrangement strongly supports student understanding	Scope and sequence arrangement mostly supports student understanding	Scope and sequence somewhat supports student understanding	Scope and sequence arrangement hardly supports student understanding	Scope and sequence arrangement does not support student understanding	
Explain your rating, e.g., what parts do not lead to student understanding, etc.:						