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EURASIA Journal of Mathematics, Science and Technology Education, 2018, 14(6), 2693-2709
ISSN:1305-8223 (online) 1305-8215 (print)
Research Paper https://doi.org/10.29333/ejmste/90267

Comparison of Science and Engineering Concepts in Next Generation Science Standards with Jordan Science Standards

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Received 30 January 2018 ▪ Revised 9 March 2018 ▪ Accepted 9 March 2018

ABSTRACT

The purpose of this Science Standards Content Crosswalk study is to compare the degree of alignment between Next Generation Science Standards (NGSS) and Jordan's science standards in K-8. A team of 5 science educators worked together to review each NGSS standard and decide whether there is a conceptual match for it in current Jordan science standards. Rigorous content analysis and interpretation approach was used to make decisions about matches between both sets of standards. Results revealed significant misalignments between the science learning outcomes identified by NGSS and those of Jordan. Results also showed that, Physical Sciences concepts had the highest percentage (58%) of not addressed concepts in 3-5 grade band followed by Earth and Space Sciences (42%) and Life Sciences concepts (36%). However, the highest percentage of not addressed concepts in grade band 6-8 were Earth and Space Sciences (58%) followed by Physical Sciences (46%) and Life Sciences (36%) concepts. This finding can support projections of the needs for new instructional materials and for subject-specific teachers' professional development. The results also provide a clear direction for the newly established national center for curriculum to revise the national science standards and curricula.

Keywords: NGSS, Jordan, alignment, science standards

INTRODUCTION

Textbooks quality has been correlated directly and indirectly to the success of education reforms and to the enhancement of students' understanding (Abd-El-Khalick, Boujaoude, Duschl, Lederman, Mamlok-Naaman, & Hofstein, 2004; Chambliss & Calfee, 1989; Chiappetta & Fillman, 2007; Koppal & Caldwell, 2004). Rich textbooks are shown to help students better understand the difficult concepts and overcome scientific misconceptions. They are also serve as a powerful instrument to raise students' interests in learning science topics and improve their achievements in science. Researchers also consider them a critical component of the educational system that is used to promote specific curriculum vision and type (Clement, 2008; Koppal & Caldwell, 2004). The importance of school science textbooks has been further emphasized by several educators (Aldahmash, Mansour, & Alshamrani, 2016; Mansour 2010; Schmidt, McKnight & Raizen, 1996).

According to the Trends in International Mathematics and Science Studies, teachers tend to spend fifty percent of their time in the class learning from textbooks (Schmidt et al., 1996). This precious time that student spend working with science textbooks necessitate paying serious attention from educators and textbooks designers to offer the best learning experiences to students.

As a response to the importance of continually revise science curricula, Jordan Ministry of Education (MoE) initiated in 2011 a comprehensive project to revise the national science education standards and curricula. According to the MoE, the revised framework of science education and the national science education standards are both comprehensive and comparable to those of international education systems (Mullis, Martin, Goh, & Cotter, 2016). They intend to provide each student with the suitable science content knowledge and procedures that is

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Contribution of this paper to the literature

- This study offers ways to compare science education standards internationally and identify ways to enable students to utilize the metalanguage of both science and education.
- It provides knowledge for both educators and science curriculum designers about the impact of adopting Next Generation Science Standards on advancing students' performance in international benchmarking assessments.
- It demonstrates ways for educators to revise science education standards to help build the capacity of future workforce and contribute in advancing the economic status of countries.

needed for the 21st century (UNESCO, 2014). This curricular reform was driven from a need to elevate students' numeracy and literacy levels, which have deteriorated on average in recent years, and address the gap between the curriculum and students' competencies in international assessments. As a result of such huge reform activity, new school curricula have been produced and put into effect as of the 2014/2015 academic year.

Reforming Science Curricula in Jordan

As a result of TIMSS and PISA results over the last few years, national committees were formed by MoE to revise the national science standards and curricula (Royal Hashemite Court, n.d) in order to align the national science standards and curricula with those of international standards. Consequently, new science textbooks were developed that are informed by previously used and released TIMSS and PISA items (Ababneh, Al-Tweissi, & Abulibdeh, 2016). The Curricula and Textbooks Directorate has benefitted from the international studies in two ways. First, by analyzing the assessment frameworks of the international studies to identify any possible mismatch in content between the content domain in the assessment frameworks and the content of the Jordanian science textbooks. Second, by integrating similar TIMSS and PISA assessment questions in the national science textbooks in order to familiarize students with such types of questions.

Learning from High Performing Countries

There are ongoing attempts in Jordan to benefit from the experiences of countries that have performed at high levels in large-scale assessments (Ababneh et al., 2016). The United States of America has recently developed an outstanding document that maps the future trends of science education in the 21st century. As an attempt to enhance their students' performance in science and better prepare them for the next generation, the USA produced advanced sets of standards for science education "Next Generation Science Standards (NGSS)". The development of such standards was triggered by many recent calls for improvements in K-12 science education from science and engineering professionals in order to keep the United States competitive in the international arena (NRC, 2012).

In addition to that, the analysis of international science benchmarking in high-performing countries was utilized to inform the standards development process (NRC, 2012). According to NRC, it is hoped that these standards when implemented with fidelity, have the potential to fundamentally alter the landscape of American science education and prepare students for college, careers and life in the 21st century (NRC, 2012).

Next Generation Science Standards (NGSS)

In 2012, the National Research Council (NRC) of the USA National Academy of Sciences authored a Framework for K-12 Science Education: Practices, Crosscutting Concepts and Core Ideas. This document provides the underlying basis for the NGSS, which draw on evidence-based research in science, including research on the ways students learn science effectively (NRC, 2012). The three dimensions of the framework (Science Practices, crosscutting concepts, and disciplinary core ideas) provide the foundation for the NGSS performance expectations, which clarify what students will know and be able to do by the end of each grade or grade band. According to the Framework, the Practices describe behaviors that scientists engage in as they investigate and build models and theories about the natural world and the key set of engineering practices that engineers use as they design and build models and systems (NRC, 2013). The Crosscutting Concepts have application across all domains of science. The Disciplinary Core Ideas are designed to focus on what students should know by the time they graduate from high school. They are based on progressions outlined in the Framework and include the Physical Sciences, Life Sciences, Earth and Space Sciences, and Engineering, Technology, and Application of Science. Engineering and technology are also integrated into all grade levels in the NGSS.

Disciplinary core ideas in NGSS are grouped in three domains: the physical sciences; the life sciences, and the earth and space sciences (NGSS Lead States, 2013).

In life sciences (LS), students are expected to learn content knowledge about the development from (Molecules to Organisms); Structures and Processes, (Ecosystems): Interactions, Energy, and Dynamics, (Heredity): Inheritance and Variation of Traits, and (Biological Evolution): Unity and Diversity.

In Earth and Space Sciences (ESS), students are expected to learn content related to the following topics, Earth's Place in the Universe, Earth's Systems, and Earth and Human Activity.

In the Physical Sciences (PS), students will learn content related to Matter and Its Interactions, Motion and Stability: Forces and Interactions, Energy, and Waves and Their Applications in Technologies for Information Transfer.

Jordan Science Standards and learning outcomes in Primary and Lower Secondary Grades

In 2013, a new science curriculum was introduced based on a revised national science content standards. For Grades 1 to 8, there is an integrated curriculum, while in Grades 9 and 10, science is taught as four subjects: biology, chemistry, physics, and earth science. The expectations for students in Grades 1 to 8 are as follows (Mullis et al., 2016):

- ***Force and Movement***—Acquire concepts, facts, and basic principles of force and movement, and understand their relationship; use laboratory equipment and instruments to explore concepts, facts, and various scientific measurements; follow safety rules and procedures in the classroom, school, and laboratory; and use oral and written communication and mathematical and physical representations to describe scientific concepts related to force and movement
- ***Matter and Energy***—Acquire concepts, facts, and basic principles related to matter and energy; recognize the work of God in the universe and understand that the universe's materials have significant impact on our life; investigate by using the scientific method; use laboratory materials and tools to explore science principles; and follow safety rules and procedures in the laboratory, classroom, school, and home.
- ***Organisms and Their Environment***—Show an understanding of the characteristics of living organisms and their needs, life cycles, and relationships with each other and their environment; and demonstrate the knowledge and skills necessary for understanding the nature of the human body and maintaining one's health.
- ***Meteorology***—Understand the components and characteristics of the atmosphere and its interaction with Earth's surface Terrestrial Materials—Understand the components and characteristics of land and water systems, their interactions, and human impact on them.
- ***Astronomy***—Understand the components of the universe, its characteristics and origin, and the physical laws governing it.
- ***Earth's History***—Describe Earth's changes over time.
- ***Geological Processes***—Understand geological processes and their role in the formation of topographic features and geological phenomena.
- ***Oceans***—Understand that the oceans are a complex, dynamic system in which interactions occur among natural systems, minerals, and weather

RATIONALE AND PURPOSE OF THE STUDY

Recent results of Jordanian students' performances in both TIMSS and PISA tests showed a serious decline in their academic abilities in both science and mathematics subjects since 2009 (National Center for Human Resources Development, 2013; Qablan, in press) (**Figure 1**).

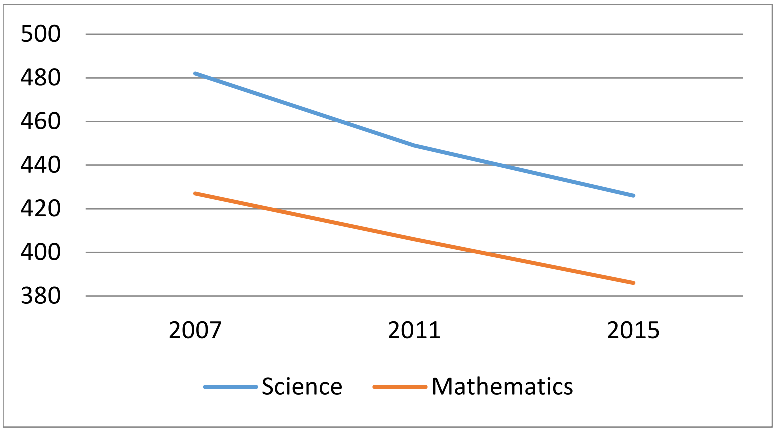

Figure 1. Jordan Students Academic Performance over years

In addition to that, a recent assessment of the newly released first three grades science textbooks revealed that the revised science textbooks do not provide students with sufficient science content knowledge and do not effectively create a deeper understanding of science content (Queen Rania Foundation, 2015).

Based on these results, several critiques from both educators and public advocates were posed against the reformed Jordanian science standards and curricula. Critiques were mostly revolved around the curricular insufficiency in providing students with the needed content knowledge, These critiques were strongly supported by the recent analysis of Jordan students' performances in the three major dimensions of TIMSS tests; content knowledge, knowledge application, and reasoning and analyzing (Ababneh, Al-Tweissi & Abulibdeh 2016; Qablan, in press) and by the Arab League for Education, Culture, and Science Organization (ALECSO) study that was conducted in 2014 to analyze science students' performances in three Arab countries including Jordan. (ALECSO, 2014).

Thus, this study came to address the need of comparing Jordan reformed science content standards with those of international benchmarks. NGSS science standards have been chosen to act as a reference to compare Jordan's science education standards with those of NGSS (NRC, 2012).

The value of comparing Jordan's science standards with NGSS science standards is that NGSS draw a comprehensive roadmap for future science teaching and learning at both levels, national and international (NRC, 2012). Another valuable addition of the NGSS is the progressions of disciplinary core ideas for students in Kindergarten through high school (NRC 2012). These progressions provide examples of the growth in the sophistication of students' thinking are addressed across grades in the Earth and Space Sciences, Life Sciences and Physical Sciences concepts. These progressions provide also a reference that depicts the content in each grade band.

Moreover, the NGSS provide a totally new dimension to science learning that builds the engineering capacities of students to play the role of engineers while learning science. According to NRC (2012), the rationale for providing students with a foundation in engineering design is based on the idea that engineering design allows students to engage in and solve major societal and environmental challenges and fulfills at the same time the forecasted future needs of more engineers and technicians, who will significantly contribute in resolving the future problems and challenges that will face humanity.

It is worth mentioning that the comparison is mainly focused on the first dimension of NGSS standards which is disciplinary core ideas in physical sciences, life sciences, and Earth and spaces sciences. According to NGSS, disciplinary core ideas are designed to focus on what students should know by the end of each grade or grade band, which satisfies the purpose of this study of determining whether Jordan science standards are providing students with the needed content knowledge that meets the international benchmarks and prepares students to perform well in international tests. However, that is not to neglect the importance of the other two dimensions of NGSS, these two dimensions support building other technical and engineering capacities in students, but they cannot work without reforming the first and making sure that students receive sufficient subject core content knowledge. It is hopeful that once Jordan science content standards are revised and align them to those suggested in NGSS, Jordanian students will have sufficient content and reasoning capacities to help them excel in international tests.

It is also expected that the results of this comparison might help identify the mismatch or grade band delay in addressing the Jordan science standards in order to see if that contribute in the decline of Jordanian students' achievement in international tests. MoE educators might also benefit from the results of this study in revising the national science education standards to help build the capacity of Jordan workforce and therefore contribute in advancing the economic status of the country.

RESEARCH QUESTION

The NGSS-JOR Standards Content Comparison Study intends to answer the following questions:

1. What are the degrees of match between science concepts in NGSS and Jordan's science concepts at the same grade?
2. What are the degrees of match between science concepts in NGSS and Jordan's science concepts with respect to content area?
3. What is the grade band shift in the Jordan's science standards Framework versus the NGSS?

It is important to note that this study focused only on science content standards because these were viewed to be most informative for MoE leaders concerned about potential changes to curriculum and instructional materials resulting from NGSS comparison. However, the study did not address similarities and differences in the science inquiry practices or performance expectations defined in Jordan's standards and in NGSS.

To answer these questions, we utilized "The Crosswalk Comparison Tool" developed by Connecticut Department of Education (Connecticut State Department of Education, 2013) to compare between Core Concepts in Next Generation Science Standards for K-8 (NRC, 2013) and concepts in the Jordan Science Curriculum Standards for kindergarten to Grade 8 Science (MoE, 2012).

METHODOLOGY

Content Crosswalk Process

This "Science Standards Content Crosswalk" is a process used to compare between Core Concepts in Next Generation Science Standards for K-8 (NRC, 2013) and concepts in Jordan Core Science Curriculum Framework and Curriculum Standards for K-8 Science (Mullis et al., 2016). A scale that describes the degree of match between each comparison (**Table 1**) was used to rate each comparison category.

Table 1. Criteria for rating the degree of match between the NGSS and JOR science standards

Criteria for Match Between Comparison Categories on Standards	Degree of Match Between Standard Categories	Example	
		NGSS	JOR
No identified match	No Match	All organisms have external parts that they use to perform daily functions.	Not Available
Several matches between concepts and terms	Moderate Match	Earth's orbit and rotation and the orbit of the moon around Earth cause observable patterns.	Moon rotates around the Earth.
Most concepts and terms match	Strong match	Most of Earth's water is in the ocean and much of Earth's fresh water is in glaciers or underground.	Water on Earth exists in Ocean, Glaciers, and underground (aquifers)

It is important to note that this study was specifically focused only on science content standards because these were viewed to be most informative for MoE curriculum leaders. The Content crosswalk did not address similarities and differences in the science inquiry practices or performance expectations defined in Jordan science standards and in NGSS.

Procedures of Standards' Analysis

An initial examination of each set of standards was conducted. The NGSS were examined using the Disciplinary Core Ideas (NRC, 2012), which are one of the three major dimensions of the NGSS; (Scientific and Engineering Practices, Crosscutting Concepts, and Core Ideas). Jordan's science standards were also examined using the Disciplines (Physical Sciences, Life Sciences, and Earth and Space Sciences) for grades K-8 as outlined in the Science Grade Level Content Expectations.

A committee of 5 science educators worked together to review each NGSS sub-concept (the bullets found in the NGSS Foundations Boxes) and determine whether there is a conceptual match for it in current Jordan's science standards. Two members of the committee are specialized in Biology and the other three are specialized in the other three fields of science (Physic, Geology, & Chemistry).

The 5 science educators were trained through an intensive training workshop to pay close attention to the specific concepts included in each content standard. During this workshop, several readings about NGSS and

Jordan's science standards were provided. Following to that, researchers were trained on how to use Science Standards Content Crosswalk to analyze both the NGSS and Jordan's science standards using the detailed procedures (See **Figure 2**).

Figure 2. Science Standards Content Crosswalk Procedure

Step I. Preparation

1. Choose your Disciplinary Core Idea (DCI): Disciplinary Core Idea (DCI) / Grade Band (You will keep picking the same one each time you go through the search).
2. Choose the NGSS DCI concept you are currently searching for in the Jordan's science curriculum framework (i.e, K-2 grade band "Living things have different structures and behaviors that allow them to meet their basic needs".
3. Look through the Content Standards, Supportive Concepts, and either the Grade-Level Concepts (GLCs) for K-8 or the Expected Performances for 9-10. You may need to look at multiple grades above and below. However, do not look through the Enrichment standards.

Structure and Function — How are organisms structured to ensure efficiency and survival? GRADE 1			
	1.2 — Living things have different structures and behaviors that allow them to meet their basic needs.		
Core Science Curriculum Framework	**Grade-Level Concepts** *Students should understand that…*	**Grade-Level Expectations** *Students should be able to…*	**Assessment**
1.2.a. Animals need air, water and food to survive. 1.2.b. Plants need air, water and sunlight to survive.	GRADE-LEVEL CONCEPT 1.2.a. 1. All living things (organisms) need air, water and food to stay alive and grow; they meet these needs in different ways. 2. Most animals move from place to place to find food and water. Some animals have two legs, four legs, six legs or more for moving. Other animals move using fins, wings or by slithering. 3. Animals get air in different ways. For example, humans breathe with lungs, while fish breathe with gills. 4. Animals get food in different ways. Some animals eat parts of plants and others catch and eat other animals. 5. Animals get water in different ways. Some animals have special body parts, such as noses, tongues or beaks that help them get water. 6. Fictional animals and plants can have structures and behaviors that are different than real animals and plants. GRADE-LEVEL CONCEPT 1.2.b. 1. Plants absorb sunlight and air through their leaves and water through their roots. 2. Plants use sunlight to make food from the air and water they absorb. 3. Plants have various leaf shapes and sizes that help them absorb sunlight and air. 4. Plant roots grow toward a source of water. 5. Plant stems grow toward sunlight.	1. Infer from direct observation and print or electronic information that most animals and plants need water, food and air to stay alive. 2. Identify structures and behaviors used by mammals, birds, amphibians, reptiles, fish and insects to move around, breathe and obtain food and water (e.g., legs/wings/fins, gills/lungs, claws/fingers, etc.) 3. Sort and classify plants (or plant parts) by observable characteristics (e.g., leaf shape/size, stem or trunk covering, flower or fruit). 4. Use senses and simple measuring tools to measure the effects of water and sunlight on plant growth. 5. Compare and contrast information about animals and plants found in fiction	A12. Describe the different ways that animals, including humans, obtain water and food. A13. Describe the different structures plants have for obtaining water and sunlight. A14. Describe the structures that animals, including humans, use to move around.

Step II. Analysis

1. Identify if there is a strong match (Captures the whole standard), moderate match (captures a piece of the standard), or no match (not available at all).

Step III: Documentation/Recording Analysis

1. Identify the level of match:
   a. Strong Match: List the one standard (and just the standard) that is the strongest match.
   b. Moderate Match: List the one or two standards (and just the standards) that are moderate matches. If there are more than two, just choose the best two.
   c. No Match: You will be sent back to the beginning of the survey. Begin again for the next NGSS DCI concept.
2. *Applicable for strong and moderate matches:* Identify where you found evidence of the alignment. Use GLCs for K-8 and expected performances for 9-10. If you only found evidence in the Content Standard or Supportive Concept and not in the GLCs or Expected Performances (See example below):

GRADE-LEVEL CONCEPT 1.2.a.

1. All living things (organisms) need air, water and food to stay alive and grow; they meet these needs in different ways.
2. Most animals move from place to place to find food and water. Some animals have two legs, four legs, six legs or more for moving. Other animals move using fins, wings or by slithering.
3. Animals get air in different ways. For example, humans breathe with lungs, while fish breathe with gills.
4. Animals get food in different ways. Some animals eat parts of plants and others catch and eat other animals.
5. Animals get water in different ways. Some animals have special body parts, such as noses, tongues or beaks that help them get water.
6. Fictional animals and plants can have structures and behaviors that are different than real animals and plants.

GRADE-LEVEL CONCEPT 1.2.b.

1. Plants absorb sunlight and air through their leaves and water through their roots.
2. Plants use sunlight to make food from the air and water they absorb.
3. Plants have various leaf shapes and sizes that help them absorb sunlight and air.
4. Plant roots grow toward a source of water.
5. Plant stems grow toward sunlight.

Record your result in a table as follows (**Appendix 1**).

NGSS Disciplinary Core Idea / Grade Band	Degree of Match in Jordan Science Standards			Evidence of Alignment
	Strong	Moderate	No	

Step IV: Identification of NGSS in Jordan Grade Level

1. Identify if there is a grade level (K-8) or grade band shift in the Jordan Framework versus the NGSS. Examples:
   a. The NGSS DCI concept is in grade 4. You find a match in grade 5 in Jordan's standards. Choose (JOR is) "at a higher grade/grade band than NGSS."
   b. The NGSS DCI concept is in the Middle School grade band. You find a match in grade 4 in JOR. Choose (JOR is) "at a lower grade/grade band than NGSS."
   c. The NGSS DCI concept is in the High School grade band. You find a match in grade 9 in JOR. Choose (JOR is) "at the same grade/grade band as NGSS."
   d. The NGSS DCI concept is in grade 5. You find matches in grades 3 and 7 in JOR. Choose (JOR is) "at grades/grade bands both above and below NGSS."

Step V: Starting New Analysis

Go back to step 1 and begin again for the next NGSS DCI concept.

Duration

The duration of comparing both standards lasts for 14 weeks during the second academic semester 2017/2018. Each week, the committer worked together for at least 5 hours to compare both sets of standards. The committee handled each subject alone by projecting the NGSS related standards for each grade band on the board and each of the committee opens the Jordanian standards document. The committee searched to find where each of the NGSS standard located/addressed in Jordanian science standards' document.

Validation

After finishing the first cycle of the comparison process, two additional cycles were conducted to validate to check the accuracy of the decisions made in the first cycle regarding the degree of match. The first validation cycle was conducted after four weeks of the first comparison and the second cycle was conducted after three weeks of the first validation cycle. Each of the validation cycles was performed by randomly selecting an NGSS standard and the committee double check their decision whether it is accurate or not. These two validation cycles resulted into no change to the main comparison results.

Once the validation process is completed, the number of matches were counted and percentages for each grade band and core subjects were calculated according to the following equation (# of matches/the total number of NGSS standards) *100%. Percentages were then used to draw the needed figures.

RESULTS

Match and Mismatch between NGSS and Jordan's Standards at the Same Grade

The greatest percentage (39%) of matched concepts between NGSS concepts and Jordan's national science standards was found in both K-2 and 3-5 grade bands. However, the lowest percentage (18%) of matched concepts was found in 6-8 grade band. Grade band 6-8 showed the highest percentage of moderate match followed by grade band 3-5 with a 16% moderate match and only 6% of moderate match in K-2 grade band (**Figure 3**).

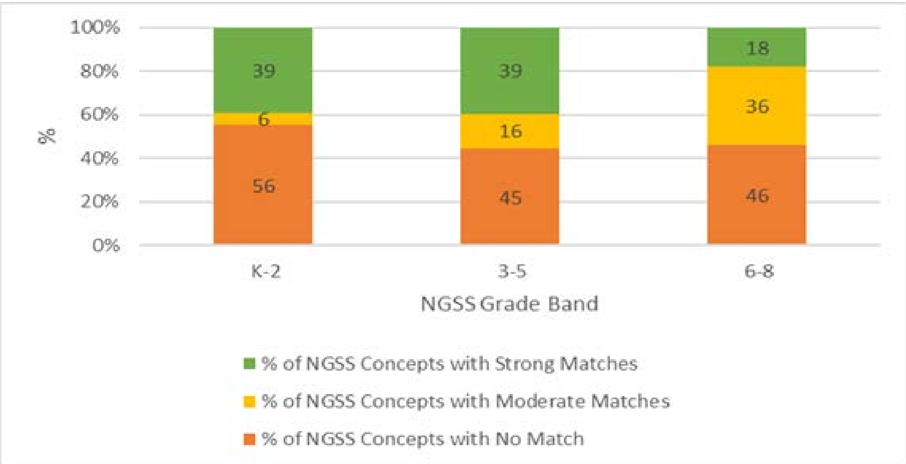

Figure 3. Percentages of NGSS Concepts (K-8) With and Without Matches in JOR Standards (K-8) Organized by NGSS Grade Band

Match and Mismatch between NGSS and Jordan's Standards at Each Discipline

The highest percentage (82%) of not addressed science concepts in K-2 grade band in Jordan science standards was found in Earth & Space Sciences (ESS) followed by Life Sciences concepts (LS) with a percentage of (62%) and Physical Sciences (PS) with a percentage of (27%), (**Figure 4**).

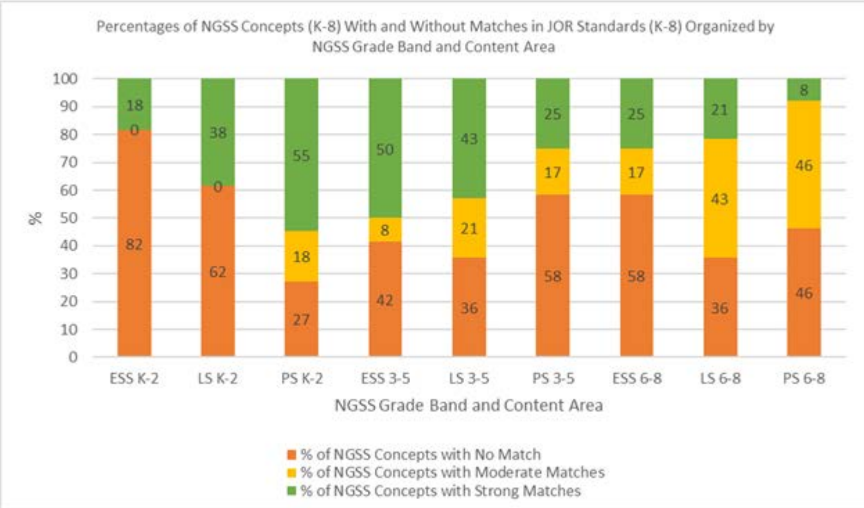

Figure 4. Percentages of NGSS Concepts (K-8) With and Without Matches in JOR Standards (K-8) Organized by NGSS Grade Band and Content Area

On the contrary, the highest percentage of not addressed science concepts in 3-5 grade band was found in Physical Sciences (58%) followed by Earth and Spaces Sciences (42%) and Life Sciences (36%).

With respect to 6-8 grade band, more than half of not addressed science concepts was found in Earth and Space Sciences (58%), followed by Physical Sciences (46%) and Life Sciences (36%).

The Grade Band Shift in Jordan's Science Standards Framework versus the NGSS

Around 70% of the matched NGSS science concepts in Grades K-8 were found within the same grade bands in both NGSS and Jordan science standards. Twenty-nine percent (29%) of NGSS science concepts of K-2 grade band were found in a later stage in Jordan science standards, however, 21% of NGSS science concepts in grade band 6-8 were found in a later stage in Jordan science followed by concepts of 3-6 grade band with a (19%) (**Figure 5**). However, the highest percentage (15%) of NGSS science concepts of grade band 3-5 were found in both at earlier and at a later stage in Jordan science standards followed by grades K-2. Only 7% of NGSS science concepts found in an earlier stage in Jordan science standards was found in grades 6-8. Appendix 1 demonstrates an availability comparison between NGSS and Jordan science standards across the three grade bands for the three core areas concepts.

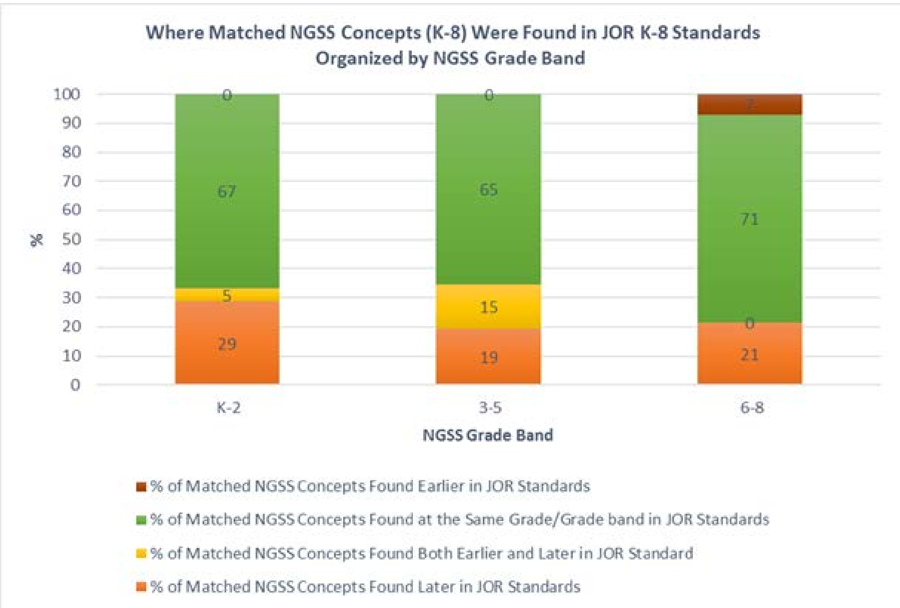

Figure 5. Where Matched NGSS Concepts (K-8) Were Found in JOR K-8 Standards Organized by NGSS Grade Band

The highest percentage of not addressed NGSS science concepts in grades K-2 that found in later stages in Jordan science standards was found in Earth and Space Sciences concepts (60%) followed by Life Sciences concepts (38%). However, for grades 3-5, the highest percentage of not addressed NGSS science concepts that found in later stages in Jordan science standards was found in Physical Sciences concepts followed by 13% for Earth and Space Sciences concepts. With respect to grades 6-8, the highest percentage of not addressed NGSS science concepts that found in later stages in Jordan science standards was found in Earth and Space Sciences concepts (38%) followed by Physical Sciences concepts (30%) (See **Figure 6**).

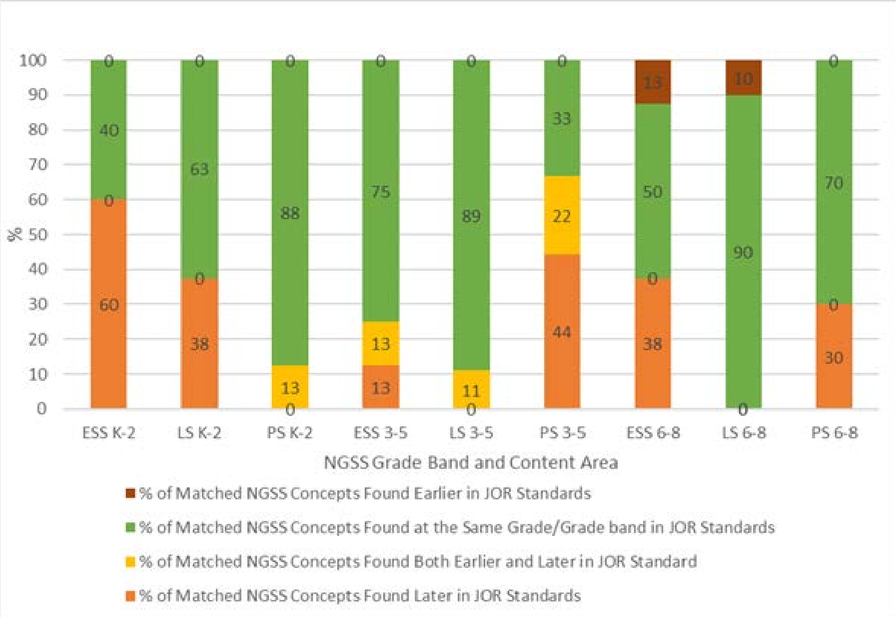

Figure 6. Where Matched NGSS Concepts (K-8) Were Found in JOR K-8 Standards Organized by NGSS Grade Band and Content Area

In the same line, the highest percentage of not addressed NGSS science concepts that found in both earlier and later stages in Jordan science standards was found in physical sciences in grades 3-5, followed by Earth and Space sciences (13%) in grades 3-5 and Physical sciences (13%) for grades K-2.

With respect to NGSS science concepts that found in earlier stages in Jordan science standards were found in Earth and Space sciences and Life Sciences for grades 6-8 with percentages of 13% and 10% respectively.

DISCUSSION

The purpose of this study was to compare the degree of alignment between NGSS science concepts and Jordan's science standards in K-8 grade bands. The results revealed a high percentage of science concepts in NGSS are not addressed in Jordan's science standards in all three grade bands defined by NGSS (NRC, 2013). This result indicates that there are significant misalignments between the science learning outcomes identified by NGSS and those of Jordan.

Results also showed that, Physical Sciences concepts had the highest percentage (58%) of not addressed concepts in 3-5 grade band followed by Earth and Space Sciences (42%) and Life Sciences concepts (36%). However, the highest percentage of not addressed concepts in grade band 6-8 were Earth and Space Sciences (58%) followed by Physical Sciences (46%) and Life Sciences (36%) concepts. These results confirm that Jordan science curricula are not providing students with sufficient subject content in all grade bands. Such misalignment indicates that Jordanian students are not provided with a coherent core science concepts during their school years that help them develop a deep understanding of various science concepts. Such misalignment also provides an explanation of the weak performance of Jordanian students against international benchmarks in the content dimension of international examinations such as TIMSS and PISA. According to IEA (2016), the highest percentage of devoted items in TIMSS 2015 test for 4th grade level was for Life Sciences (45%) followed by Physical Science concepts (35%) and Earth and Space Sciences concepts (20%). However, for 8th grade TIMSS test, the highest percentage of devoted items was for Life Sciences (35%) followed by Physical Sciences (45%) and Earth and Space Sciences (20%).

These conclusions encourage Jordan's national curriculum department to revise the national science standards in the light of NGSS standards in order to enhance Jordanian students' abilities in science and advance their performance in international benchmarking assessments. The significance of considering NGSS science standards in revising Jordan national science standards is that the NGSS draws a comprehensive roadmap for future science teaching and learning at both levels, national and international (NRC, 2012). NGSS science concepts were designed based on the content requirements of international tests including TIMSS and are internationally benchmarked against countries whose students typically perform well on the Program for International Student Assessment (PISA) or (TIMSS) (Achieve, 2010) and focuses on a limited number of core ideas in science that build coherently over time throughout K–12 in an effort to foster a greater depth of understanding on a few fundamental concepts within the constraints of the typical school year.

The results of this study also give MoE educators a comprehensive analysis and direction of which and where missed science concepts can be added and or moved. According to the previous analysis, more science contents in all three major domains (Earth and Space Sciences, Life Sciences and Physical Sciences) need to be included in both 3-5 and 6-8 grade bands. The inclusion of the identified learning concepts would also enable Jordanian students to engage in the learning process by understanding and utilizing the metalanguage of both science and education (Mortimer & Scott 2003).

According to the results of this study, most of not addressed science concepts in K-2 grade band were found in a later stage and mostly in 6-8 grade band level. Sixty (60) percent of those delayed science concepts in Jordan science standards were related to Earth and Space Sciences followed by Life Sciences (38%). Similarly, 38% of not addressed science concepts in 6-8 grade band were related to Earth and Space Sciences followed by Physical Sciences (30%) concepts. Such delay in concepts presentation supports the earlier explanation of the weakness in providing Jordanian students with the critical scientific content which also explain the serious decline of Jordanian students' performance in international tests. In this sense, several studies argue the significance of the progressive evolution of children's conceptions of science concepts during the school years (Brook & Driver 1989; Carey, 1985; Holding, 1987; Strauss & Stavy, 1982). For example, Nussbaum (1985) study of the development of children's ideas about the Earth in space revealed a sequence of conceptions; young children ascribe to a flat Earth notion, this is replaced by a notion incorporating a spherical Earth but with an absolute view of 'up and down', later the directions of up and down are construed in terms of movement away from or towards the Earth.

The findings of the study show lack of key science concepts in K-2 grade band and these concepts found in a later stage and mostly in 6-8 grade band level. This can influence negatively the progression of science concepts across three grade needed for developing the students' science concepts progressively. Baxter (1989) identified features in the progression of the science conceptions used by children between ages nine and 16 and indicates how these findings are being used to inform teaching in this domain. Baxter's study suggests that children may progress in their understandings by passing through a series of intermediate notions which, though they may not be correct from a scientific point of view, may however reflect progress in children's understanding. Baxter's study and other similar studies inform the longer-term sequencing of teaching topics and provide information about the range and prevalence of prior ideas that may need to be addressed within a teaching sequence. These studies could also inform science curriculum development across the school years.

Considering these views in designing the progression of science concepts across three grade bands identified in the NGSS is significant to help children understand science concepts at the suitable time. However, delaying the presentation of these concepts would adversely impact students' performance against international benchmarks.

NGSS INSIGHTS AND VALUES

While the science standards of both Jordan and NGSS overlap in some content areas, there are several values that can be achieved by following NGSS science standards. One of these values is the coherency that exists in NGSS. NGSS science concepts build coherently from grade to grade, while implementing crosscutting concepts that are integrated within core content (NRC, 2013). These crosscutting concepts and namely; Patterns, Cause and effect, Scale, proportion, and quantity, Energy and matter, Structure and function, and Stability and change, connect science concepts and content across all science disciplines and provide students with an enhanced understanding of how different science concepts are connected and utilized to explain different scientific phenomena. The NGSS Framework emphasizes that these concepts need to be explicitly stated for students in order to provide a schema for interrelating knowledge from various fields of science into a coherent and scientific view of the world (NRC, 2012).

Another valuable addition that NGSS provide is the progressions of disciplinary core ideas for students in Kindergarten through high school (NRC, 2012). These progressions provide examples of the growth in the sophistication of students' thinking are addressed across grades in the Earth and Space Sciences, Life Sciences and Physical Sciences concepts. These progressions provide a reference that depicts the content in each grade band.

Moreover, the NGSS provides a totally new dimension to science learning that builds the engineering capacities of students to play the role of engineers while learning science. According to NRC (2012), the rationale for providing students with a foundation in engineering design is based on the idea that engineering design allows students to engage in and solve major societal and environmental challenges and fulfills at the same time the forecasted future needs of more engineers and technicians, who will significantly contribute in resolving the future problems and challenges that will face humanity.

The engineering perspective that the NGSS provide is missing in Jordan science standards and curricula. It is important not to confuse engineering practices with integrating technological applications in science curricula. Jordan science curricula provide several technological applications for students at the end of some lessons or units. But that does not give students an opportunity to determine the problem and think of resolving it utilizing their understanding of different science concepts. According to the NGSS, the difference between scientific inquiry and engineering design is that the first involves the formulation of a question that can be answered through investigation, while the later involves the formulation of a problem that can be solved through engineering design. By integrating engineering design and thinking into the science education curricula, the NGSS provide students with the tools to engage in solving future environmental and societal problems (NRC, 2012).

CONCLUSION AND IMPLICATIONS

Findings indicate a significant mismatch between the NGSS and the Jordan's Science Grade Level Content Expectations for K-8. Although this result appears negative, but it is of most significance to Jordan as a country that strives to advance its science education system. The results provide a clear direction for the newly established national center for curricula in Jordan to revise the national science standards and curricula and depart from the traditional approach of designing science curricula to other innovative pathways (i.e., NGSS).

The findings of this study are also useful for identifying the effects of an NGSS adoption on the science curriculum currently taught in Jordanian schools. This knowledge can support projections of the needs for new instructional materials and for subject-specific teachers' professional development.

The NGSS represent the culmination of years of collaboration and effort by several science educators and experts from across the United States (NRC, 2012). The standards were built based on an exhaustive review of the previous science education literature and experiences from around the world to enhance the US students' science learning. Based on the NGSS Framework, the NGSS, when implemented with fidelity, have the potential to fundamentally alter the landscape of American science education and prepare students for college, careers and life in the 21st century (NRC, 2012).

However, it is worth mentioning that adopting the NGSS framework is no small tasks for several reasons. One of these reasons is that the NGSS require several shifts in the way that science is taught (NRC, 2012), which will require engaging students in a series of science and engineering practices that enable them to be prepared to face and resolve the new challenges of the future. Students need to acquire several science concepts and be able to apply their understanding in designing useful tools and technologies to make their life easier. They need to see how different fields of science are connected and used to analyze diverse science phenomena.

To that end, we hope that this study will enlighten science educators in Jordan and the world to advance the way we teach science for students that simulates the recent innovations in international science education. Finally, we hope that revising the national science standards and curricula will help Jordanian students performs better in international tests and regain their leading position in science achievement in the region and the world.

ACKNOWLEDGEMENT

The author would like to thank the following people (Mohammad Zohdi, Dyala Nofal, Rawan Amroo & Asmaa Mohammad) for their help and support provided during the data collection stage of this study.

REFERENCES

Ababneh, E., Al-Tweissi, A., & Abulibdeh, K. (2016). TIMSS and PISA impact – the case of Jordan. *Research Papers in Education, 31*(5), 542–555. https://doi.org/10.1080/02671522.2016.1225350

Abd-El-Khalick, F., Boujaoude, S., Duschl, R., Lederman, N. G., Mamlok-Naaman, R., & Hofstein, A. (2004). Inquiry in science education: International perspectives. *Science Education, 88*, 397–419. https://doi.org/10.1002/sce.10118

Achieve. (2010). *International Science Benchmarking Report: Taking the Lead in Science Education: Forging Next-Generation Science Standards*. Retrieved on April 16 from https://www.achieve.org/files/InternationalScienceBenchmarkingReport.pdf

Aldahmash, A., Mansour, N., & Alshamrani, S., (2016). An Analysis of Activities in Saudi Arabian Middle School Science Textbooks and Workbooks for the Inclusion of Essential Features of Inquiry. *Research in Science Education, 26*(6), 879–900. https://doi.org/10.1007/s11165-015-9485-7

ALECSO. (2014). *Analyzing the results of international TIMSS for the year 2011 in Arab States*. Tunisia.

Baxter, J. (1989). Children's understanding of familiar astronomical events. *International Journal of Science Education*, *11*(Special issue), 502-513. http://doi.org/10.1080/0950069890110503

Brook, A., & Driver, R. (1989). *Progression in Science: The development of pupils' understanding of physical characteristics of air across the age range 5-16 years.* Children's Learning in Science Project, University of Leeds.

Carey, S. (1985). *Conceptual Change in Childhood.* Massachusetts: MIT Press.

Chambliss, M. J., & Calfee, R. C. (1989). Designing science textbooks to enhance students' understanding. *Educational Psychologist, 24*(3), 307-322. https://doi.org/10.1207/s15326985ep2403_5

Chiappetta, E., & Fillman, D. (2007). Analysis of five high school biology textbooks used in the United States for inclusion of the Nature of Science. *International Journal of Science Education, 29*(15), 1847-1868. https://doi.org/10.1080/09500690601159407

Clement, P. (2008). Critical analysis of school science textbooks. *Science Education International, 19*(2), 93- 96.

Connecticut State Department of Education. (2013). *Science Standards Content Crosswalk Report*. Connecticut, USA.

Holding, B. (1987). *Investigation of schoolchildren's understanding of the process of dissolving with special reference to the conservation of matter and the development of atomistic ideas* (Unpublished PhD thesis), University of Leeds.

IEA. (2016). TIMSS 2015 International Results in Mathematics and Science. Boston College. USA.

Koppal, M., & Caldwell, A. (2004). Meeting the challenge of science literacy: Project 2061 efforts to improve science education. *Cell Biology Education*, *3*, 28–30. https://doi.org/10.1187/cbe.03-10-0016

Mansour, N. (2010). The representation of scientific literacy in Egyptian science textbooks. *Journal of Science Education, 11*(2), 91-95.

Mortimer, E., & Scott, P. (2003). *Making Meaning in secondary science classrooms*. Maidenhead, Philadelphia: Open University Press.

Mullis, I. V. S., Martin, M. O., Goh, S., & Cotter, K. (Eds.) (2016). *TIMSS 2015 Encyclopedia: Education Policy and Curriculum in Mathematics and Science*. Retrieved from Boston College, TIMSS & PIRLS International Study Center website: http://timssandpirls.bc.edu/timss2015/encyclopedia/

National Center for Human Resources Development. (2013). *Jordan Students Performance on international TIMSS and PISA tests*.

National Research Council. (2012). *A Framework for K-12 Science Education: Practices, Crosscutting Concepts, and Core Ideas. Committee on a Conceptual Framework for New K-12 Science Education Standards. Board on Science Education, Division of Behavioral and Social Sciences and Education*. Washington, DC: The National Academies Press.

National Research Council. (2013). *Next Generation Science Standards: For States, By States*. Washington, DC: The National Academies Press. https://doi.org/10.17226/18290.

Nussbaum, J. (1985). The earth as a cosmic body. In R. Driver, E. Guesne, & A. Tiberghien (Eds.), *Children's ideas in science* (pp. 170-192). Milton Keynes, UK: Open University Press.

Qablan, A. (in press). *Continuous Decline of Jordanian Science Students' Academic Performance in TIMSS: Reasons and Resolutions*. Mutah Lil -Buhuth Wad-dirasat

Queen Rania Foundation. (2015). *Comparative Curricular Review of the Old and Revised Science Textbooks in Jordan, Grades 1-3* (Unpublished report). Amman: Jordan.

Royal Hashemite Court. (n.d.). The Education Reform for Knowledge Economy (ERfKE). Retrieved on 31 July, 2016 from http:// www.kingabdullah.jo/index.php/en_US/initiatives/view/id/81.html

Schmidt, W. H., McKnight, C. C., & Raizen, S. A. (1996). *Splintered vision: An investigation of U.S. science and mathematics education: Executive summary*. Lansing, MI: U.S. National Research Center for the Third International Mathematics and Science Study, Michigan State University.

Strauss, S., & Stavy, R. (1982). *U-shaped Behavioral Growth*. Academic Press: New York.

UNESCO. (2014). *Global Citizenship Education: Preparing learners for the challenges of the twenty-first century*. Paris, France.

APPENDIX 1

EARTH AND SPACE SCIENCES PROGRESSION

	K-2		3-5		6-8	
	NGSS	**JOR**	**NGSS**	**JOR**	**NGSS**	**JOR**
ESS1.A The universe and its stars		NA Available in G4.Part 2 Page77	Stars range greatly in size and distance from Earth, and this can explain their relative brightness.	Available in G3. Part 1 Page72	The solar system is part of the Milky Way, which is one of many billions of galaxies.	G8. Part 2 Page138
ESS1.B Earth and the solar system	Patterns of movement of the sun, moon, and stars as seen from Earth can be observed, described, and predicted.	NA	Earth's orbit and rotation and the orbit of the moon around Earth cause observable patterns.	Moderate G2. Part 1 Page68 G3. Part 1 Page77 G3. Part 1 Page79 G3. Part 1 Page75	The solar system contains many varied objects held together by gravity. Solar system models explain and predict eclipses, lunar phases, and seasons.	G4. Part 2 Page73,74,78 Four seasons and their cause
ESS1.C The history of planet Earth	Some events on Earth occur very quickly; others can occur very slowly.	NA G4. Part 2 Page180 G3. Part 2 Page22,28	Certain features on Earth can be used to order events that have occurred in a landscape.	NA	Rock strata and the fossil record can be used as evidence to organize the relative occurrence of major historical events in Earth's history.	G7. Part 2 Page110 G8. Part 2 Page104
ESS2.A Earth's materials and systems	Wind and water change the shape of the land.	NA G3. Part 2 Page32-37	Four major Earth systems interact. Rainfall helps to shape the land and affects the types of living things found in a region. Water, ice, wind, organisms, and gravity break rocks, soils, and sediments into smaller pieces and move them around.	G4. Part 2 Page88 G4. Part 1 Page22	Energy flows and matter cycles within and among Earth's systems, including the sun and Earth's interior as primary energy sources. Plate tectonics is one result of these processes.	G6. Part 2 P54-56 Fossil energy is addressed.
ESS2.B Plate tectonics and large-scale system interactions	Maps show where things are located. The shapes and kinds of land and water in any area can be mapped.	NA	Earth's physical features occur in patterns, as do earthquakes and volcanoes. Maps can be used to locate features and determine patterns in those events.	NA	Plate tectonics is the unifying theory that explains the movements of rocks at Earth's surface and geologic history. Maps are used to display evidence of plate movement.	G8. Part 2 Page90 G7. Part 2 Page108
ESS2.C The roles of water in Earth's surface processes	Water is found in many types of places and in different forms on Earth.	G1. Part 2 Page 6,8	Most of Earth's water is in the ocean and much of Earth's fresh water is in glaciers or underground.	G3. Part 2 Page10 G5. Part 2 Page 9	Water cycles among land, ocean, and atmosphere and is propelled by sunlight and gravity. Density variations of sea water drive interconnected ocean currents. Water movement causes weathering and erosion, changing landscape features.	NA G9. Part 2 Page14 (Water cycle is mentioned) G10. Part 2. P60 (ocean currents are mentioned) G9. Part 1 Page35 (rain and water movement are mentioned)
ESS2.D Weather and climate	Weather is the combination of sunlight, wind, snow or rain, and temperature in a particular region and time. People record weather patterns over time.	NA	Climate describes patterns of typical weather conditions over different scales and variations. Historical weather patterns can be analyzed.	G5. Part 2 Page21	Complex interactions determine local weather patterns and influence climate, including the role of the ocean.	NA G10. Part 1 Page 9-17. (weather patterns and influence climate)
ESS2.E Biogeology	Plants and animals can change their local environment.	NA	Living things can affect the physical characteristics of their environment.	G4. Part 1 Page 22,24,32	[Content found in LS4.A and LS4.D]	NA
ESS3.A Natural resources	Living things need water, air, and resources from the land, and they live in places that have the things they need. Humans use natural resources for everything they do.	NA	Energy and fuels that humans use are derived from natural sources and their use affects the environment. Some resources are renewable over time, others are not.	NA G6. Part 2 Page 53	Humans depend on Earth's land, ocean, atmosphere, and biosphere for different resources, many of which are limited or not renewable. Resources are distributed unevenly around the planet as a result of past geologic processes.	NA
ESS3.B Natural hazards	In a region some kinds of severe weather are more likely than others. Forecasts allow communities to prepare for severe weather.	NA	A variety of hazards result from natural processes; humans cannot eliminate hazards but can reduce their impacts.	NA	Some natural hazards can be predicted by mapping the history of those natural hazards in a region and understanding related geologic forces.	NA G10. Part 1 Page 66 (earthquick prediction)
ESS3.C Human impacts on Earth systems	Things people do can affect the environment, but they can make choices to reduce their impacts.	G2. Part 2 Page 64	Societal activities have had major effects on land, ocean, atmosphere, and even outer space. Societal activities can also help protect Earth's resources and environments.	G4. Part 1 Page22 G5. Part 2 Page100	Human activities have altered the biosphere, sometimes damaging it, although changes to environments can have different impacts for different living things. Activities and technologies can be engineered to reduce people's impacts on Earth.	NA
ESS3.D Global climate change	NA	LEFT BLANCK	NA	NA	Human activities affect global warming. Decisions to reduce the impact of global warming depend on understanding climate science, engineering capabilities, and social dynamics.	NA

LIFE SCIENCES PROGRESSION

	K-2		3-5		6-8	
	NGSS	**JOR**	**NGSS**	**JOR**	**NGSS**	**JOR**
LS1.A Structure and function	All organisms have external parts that they use to perform daily functions.	**NA** Available in G3. Part 1 Page28 G4. Part 1 Page 40	Organisms have both internal and external macroscopic structures that allow for growth, Survival, behavior, and reproduction.	Available in G3. Part 2 Page44 G3. Part 1 Page 28 G5. Part 2 Page 84	All living things are made up of cells. In organisms, cells work together to form tissues and organs that are specialized for particular body functions.	Available in G7. Part 1 Page 40
LS1.B Growth and development of organisms	Parents and offspring often engage in behaviors that help the offspring survive.	Available in G2. Part 1 Page8 G2. Part 2 Page10	Reproduction is essential to every kind of organism. Organisms have unique and diverse life cycles.	Available in G5. Part 1 Page10 G4. Part 2 Page 47	Animals engage in behaviors that increase the odds of reproduction. An organism's growth is affected by both genetic and environmental factors.	Available in G8. Part 2 Page6 G8. Part 2 Page 28
LS1.C Organization for matter and energy flow in organisms	Animals obtain food they need from plants or other animals. Plants need water and light.	Available in G1. Part 2 Page33 G1. Part 2 Page48 G2. Part 2 Page 8	Food provides animals with the materials and energy they need for body repair, growth, warmth, and motion. Plants acquire material for growth chiefly from air, water, and process matter and obtain energy from sunlight, which is used to maintain conditions necessary for survival.	**NA**	Plants use the energy from light to make sugars through photosynthesis. Within individual organisms, food is broken down through a series of chemical reactions that rearrange molecules and release energy.	Available in G7. Part 1 Page 69
LS1.D Information processing	Animals sense and communicate information and respond to inputs with behaviors that help them grow and survive.	**NA** Available in G4. Part 1 Page 43,45	Different sense receptors are specialized for particular kinds of information; animals use their perceptions and memories to guide their actions.	Available in G4. Part 1 Page 43	Each sense receptor responds to different inputs, transmitting them as signals that travel along nerve cells to the brain; the signals are then processed in the brain, resulting in immediate behavior or memories.	**NA** Available in G5. Part 2 Page49 (superficially mentioned)
LS2.A Interdependent relationships in ecosystems	Plants depend on water and light to grow and on animals for pollination or to move their seeds around.	**NA**	The food of almost any animal can be traced back to plants. Organisms are related in food webs in which some animals eat plants for food and other animals eat the animals that eat plants, while decomposers restore some materials to the soil.	G8. Part 1 Page13 G4.1 Page 9 G5. Part 2 Page83 (Decomposers are not mentioned)	Organisms and populations are dependent on their environmental interactions with both other living things and non-living factors, any of which can limit their growth. Competitive, predatory, and mutually beneficial interactions vary across ecosystems, but the patterns are shared.	G8. Part 1 Page 8 (mutual relationship is not available)
LS2.B Cycles of matter and energy transfer in ecosystems	[Content found in LS1.C and ESS3.A]	**NA**	Matter cycles between the air and soil and among organisms as they live and die.	**NA**	The atoms that make up the organisms in an ecosystem are cycled repeatedly between the living and non-living parts of the ecosystem. Food webs model how matter and energy are transferred among producers, consumers, and decomposers as the three groups interact within an ecosystem.	**NA**
LS2.C Ecosystem dynamics, functioning, and resilience	NA	**NA**	When the environment changes some organisms survive and reproduce, some move to new locations, some move into the transformed environment, and some die.	Available in G3. Part 2 Page 68	Ecosystem characteristics vary over time. Disruptions to any part of an ecosystem can lead to shifts in all of its populations. The completeness or integrity of an ecosystem's biodiversity is often used as a measure of its health.	**NA**
LS2.D Social interactions and group behavior	NA	**NA**	Being part of a group helps animals obtain food, defend themselves, and cope with changes.	**NA**	NA	**NA**
LS3.A Inheritance of traits	Young organisms are very much, but not exactly, like their parents and also resemble other organisms of the same kind.	Available in G2. Part 1 Page12 G3. Part 2 Page 50	Different organisms vary in how they look and function because they have different inherited information; the environment also affects the traits that an organism develops.	Mod Available in G5. Part 1 Page38 G5. Part 1 Page 27	Genes chiefly regulate specific proteins, which affect an individual's traits.	Available in GG8. Part 1 Page 6 (mutations and gene translation are not available) G7. Part 1 Page 54
LS3.B Variation of traits		Available in G5.1 Page 30		Available in G5.2Page84 G3. Part 2 Page 70-73	In sexual reproduction each parent contributes half the genes acquired by the offspring, resulting in variation between parent and offspring. Genetic information can be altered because of mutations, which may result in beneficial, negative, or no change to proteins in or traits of an organism.	Available in G8. Part 2 Page 6 (Mutations are not mentioned)
LS4.A Evidence of common ancestry and diversity	NA	**NA**	Some living organisms resemble organisms that once lived on Earth. Fossils provide evidence about the types of organisms and environments that existed long ago.	**NA**	The fossil record documents the existence, diversity, extinction, and change of many life forms and their environments through Earth's history. The fossil record and comparisons of anatomical similarities between organisms enable the inference of lines of evolutionary descent.	Available in G7. Part 1 Page 114 (comparisons of anatomical similarities between organisms enable the inference of lines of evolutionary descent are not available)

	K-2		3-5		6-8	
	NGSS	JOR	NGSS	JOR	NGSS	JOR
LS4.B Natural selection	NA	**NA**	Differences in characteristics between individuals of the same species provide advantages in survival and reproduction.	**NA**	Both natural and artificial selection result from certain traits giving some individuals an advantage in survival and reproduction, leading to predominance of certain traits in a population.	Available in G8. Part 2 Page 38 (Natural selection is not mentioned) G10. Part 1 Page 60 G10. Part 1 Page 44
LSG4.C Adaptation	NA	**NA** Available in G3. Part 2 Page 70-73	Particular organisms can survive only in particular environments.	Available in G5. Part 2 Page 84	Species can change over time in response to changes in environmental conditions through adaptation by natural selection acting over generations. Traits that support successful survival and reproduction in the new environment become more common.	**NA**
LS4.D Biodiversity and humans	A range of different organisms lives in different places.	Available in G2. Part 1 Page 7 G2. Part 2 Page 54	Populations of organisms live in a variety of habitats. Change in those habitats affects the organisms living there.	Mod Available in G5. Part 2 Page 94	Changes in biodiversity can influence humans' resources and the ecosystem services they rely on.	Available in G8. Part 1 Page 9-33. (Changes in biodiversity and genetic materials for each species as well as the influence of changes in biodiversity on human resources

PHYSICAL SCIENCES PROGRESSION

	K-2		3-5		6-8	
	NGSS	JOR	NGSS	NGSS	JOR	NGSS
PS1.A Structure of matter (includes PS1.C Nuclear processes)	Matter exists as different substances that have observable different properties. Different properties are suited to different purposes. Objects can be built up from smaller parts.	Available in G2. Part 2 Page16	Matter exists as particles that are too small to see, and so matter is always conserved even if it seems to disappear. Measurements of a variety of observable properties can be used to identify particular materials.	NA	The fact that matter is composed of atoms and molecules can be used to explain the properties of substances, diversity of materials, states of matter, phase changes, and conservation of matter.	Available in G6. Part 1 Page45 G8. Part 1 Page88 G6. Part 1 Page49 G7. Part 1 Page25 G7. Part 1 Page 28
PS1.B Chemical reactions	Heating and cooling of substances cause changes that are sometimes reversible and sometimes not.	Available in G2. Part 2 Page 26-29	Chemical reactions that occur when substances are mixed can be identified by the emergence of substances with different properties; the total mass remains the same.	NA	Reacting substances rearrange to form different molecules, but the number of atoms is conserved. Some reactions release energy and others absorb energy.	Available in G7. Part 1 Page 25 (features of chemical interaction (type of interaction, conservation of mass) are not available.
PS2.A Forces and motion	Pushes and pulls can have different strengths and directions, and can change the speed or direction of an object's motion or start or stop it.	Mod Available in G1. Part 2 Page 62 G3. Part 1 Page 58 G5. Part 1 Page 60 G3. Part 1 Page 54-62	The effect of unbalanced forces on an object results in a change of motion. Patterns of motion can be used to predict future motion. Some forces act through contact; some forces act even when the objects are not in contact. The gravitational force of Earth acting on an object near Earth's surface pulls that object toward the planet's center.	Available in G5. Part 1 Page 56-57	The role of the mass of an object must be qualitatively accounted for in any change of motion due to the application of a force.	NA Available in G9. Part 1 Page 90
PS2.B Types of interactions		NA		Available in G5. Part 1 Page 54	Forces that act at a distance involve fields that can be mapped by their relative strength and effect on an object.	NA Available in G10. Part 2 Page 21
PS2.C Stability and instability in physical systems	NA	Available in G1. Part 2 Page 59	NA	G5. Part 1 Page 56 G5. Part 1 Page 62-63	NA	NA
PS3.A Definitions of energy	NA	Left Blank	Moving objects contain energy. The faster an object moves, the more energy it has. Energy can be moved from place to place by moving objects or through sound, light, or electrical currents. Energy can be converted from one form to another.	NA Available in G6. Part 2 Page 45 G6. Part 1 Page 24 G8. Part 2	Kinetic energy can be distinguished from the various forms of potential energy. Energy changes to and from each type can be tracked through physical or chemical interactions. The relationship between the temperature and the total energy of a system depends on the types, states, and amounts of matter.	Available in G6. Part 2 Page 43 (kinetic energy and factors that influencing it are mentioned)
PS3.B Conservation of energy and energy transfer	[Content found in PS3.D]	Available in G2. Part 1 Page 45		NA Available in G6.2 Page 48		Available in G6. Part 2 Page 47 G7. Part 2 Page 88
PS3.C Relationship between energy and forces	Bigger pushes and pulls cause bigger changes in an object's motion or shape.	NA	When objects collide, contact forces transfer energy so as to change the objects' motions.	NA	When two objects interact, each exerts a force on the other, and these forces can transfer energy between them.	NA
PS3.D Energy in chemical processes and everyday life	Sunlight warms Earth's surface.	NA	Energy can be "produced," "used," or "released" by converting stored energy. Plants capture energy from sunlight, which can later be used as fuel or food.	NA Available in G6. Part 2 Page 42, Page 59, Page 60, Page 66	Sunlight is captured by plants and used in a reaction to produce sugar molecules, which can be reversed by burning those molecules to release energy.	Available in G7. Part 1 Page 70 G7. Part 1 Page 71
PS4.A Wave properties	Sound can make matter vibrate, and vibrating matter can make sound.	Available in G2. Part 2 Page 3	Waves are regular patterns of motion, which can be made in water by disturbing the surface. Waves of the same type can differ in amplitude and wavelength. Waves can make objects move.	Available in G5. Part 2 Page 63 G8. Part 1 Page149 G8. Part 2 Page110	A simple wave model has a repeating pattern with a specific wavelength, frequency, and amplitude, and mechanical waves need a medium through which they are transmitted. This model can explain many phenomena, including sound and light. Waves can transmit energy.	NA Available in G9. Part 1 Page 38-168
PS4.B Electromagnetic radiation	Objects can be seen only when light is available to illuminate them.	Available in G2. Part 1 Page 62	An object can be seen when light reflected from its surface enters our eyes.	Available in G4. Part 1 Page 59 G6. Part 2 P12 G6. Part 2 P21.	The construct of a wave is used to model how light interacts with objects.	Available in G6. Part 2 Page 7-37
PS4.C Information technologies and instrumentation	People use devices to send and receive information.	Available in G1. Part 1 Page 4	Patterns can encode, send, receive, and decode information.	NA Available in G6. Part 2 P30	Waves can be used to transmit digital information. Digitized information is comprised of a pattern of ones and zeros.	Available in G8. Part 1 Page156