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Evaluation of RI Middle School Science Kits in Regards to the RI Grade Span Expectations

Melissa L. Wetzel
University of Rhode Island, melissa_wetzel@my.uri.edu

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Faculty Advisor: Professor Jay Fogleman, Department of Education

Abstract

The Rhode Island Department of Education provides a set of Grade Span Expectations (GSEs) that outline major ideas in science, including physical, life, and earth and space science. Students in Rhode Island schools are expected to be able to demonstrate understanding of each GSE in order to graduate high school with proficiency in science. Educators do not always have the time to "unpack" the GSEs that line up with the grade level they teach. Unpacking a GSE refers to determining what prior knowledge students should possess, what misconceptions students my have, and what students need to be able to do in order to demonstrate understanding of the material the particular GSE covers.

Rhode Island middle school science teachers are provided with kits that contain all the materials needed for a particular unit. These kits have lessons designed to engage students in mostly teacher directed activities that address each GSE for that particular grade level. However, many kits do not address the misconceptions students may have about a certain topic or provide enough background information about the material being taught. Therefore teachers must supplement these kits with filler lessons that address these issues. Experienced teachers can do this easily and almost naturally, but relatively new science teachers may struggle with deciding what sorts of instruction to intertwine within the lessons of the kits. I have taken a common middle school science kit entitled "Ecosystems" and unpacked each of the five separate GSEs aligned with it to determine what information is missing from the kits that students should be exposed to.

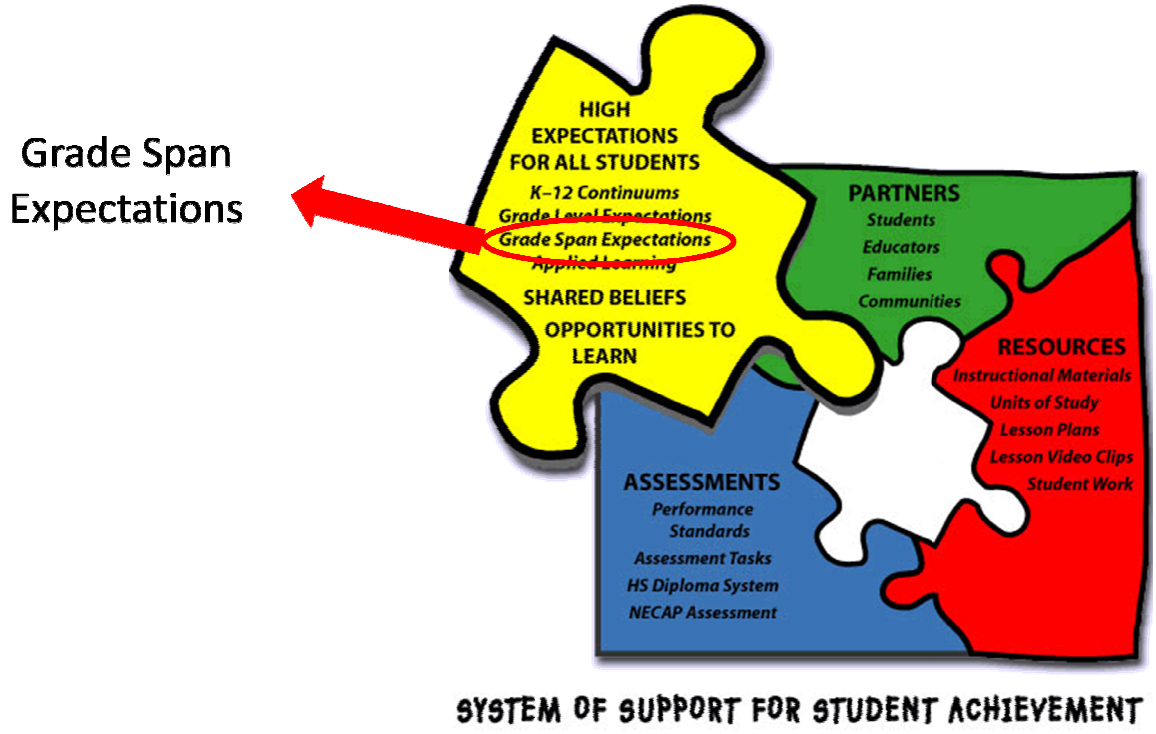
The second portion of my project examines the effectiveness of the Ecosystems kit in preparing students for the New England Common Assessment Program (NECAP) exam. This exam tests thirteen progressive levels of inquiry and I have found that the Ecosystems kit is lacking in regards to exposing students to a wide range of inquiry-based activities to adequately prepare them for this particular assessment. I have compiled lessons that can be added to the Ecosystems kit to more effectively address each of the thirteen levels of inquiry.

The products and results of this project will be displayed on the Rhode Island Science Teacher wikispace. My hope is that this work will be useful to both current and incoming science teachers.

Summary of Results

The Rhode Island Department of Education (or more commonly referred to as RIDE) has developed a statewide curriculum that includes four broad categories of goals that all teachers, students, and the rest of the community should aim towards. These categories include high expectations for all students, collaboration between students, educators, families and communities, use of high quality instructional materials, and use of multiple assessments to track student learning. I am focusing on the high expectations for all students aspect of this structure of learning. The state has defined a set of grade span expectations for all subjects that students should have an understanding of before moving on from school and entering either the workforce or higher level education. It is important for teachers to design instruction that helps students reach the level of understanding asked for by these grade span expectations.

Rhode Island Department of Education statewide curriculum:



Before moving on, it is important to understand the purpose and goals of grade span expectations (GSEs), specifically focusing on the science GSEs. GSEs are a set of science concepts that capture the major ideas of science. They attempt to focus a science curriculum without restricting it, so teachers still have the ability to go more in depth with certain material or add additional enrichment activities or information. According to the Rhode Island Department of Education, GSEs describe the knowledge and abilities that students should be able to demonstrate at the end of each grade span. There are GSEs for the three major areas of science: physical science, life science, and earth and space science.

As of the 2014 – 2015 school year, Rhode Island will be implementing common core standards as defined by the Common Core Standards Initiative that is moving its way across all states in the country. Schools and teachers have been slowly adapting to these new, more specific standards in the subjects of math and reading. As of today, the science common core standards

have not been released to the public, so teachers are asked to apply literacy standards to their instruction. When these standards are put in place in Rhode Island's educational system, learning progressions will be more apparent throughout elementary, middle, and high schools across the nation.

It is important to discover what a learning progression actually is and how it develops. The book, *Taking Science to School,* a research based text developed by the National Research Council, explicitly describes what a learning progression is, how it is applied, and why it is important. As students make their way through elementary, middle, and high school, there shouldn't be any gaps in their knowledge of a topic. Every subject in science can be learned in simple terms and then slowly expanded to discover more and more specific information. As students move through school, they learn material, revisit the material, and continue to look deeper and learn the material in a more complex way. Students should be able to use their prior knowledge about topics to expand their learning and go more in depth with the material as they revisit the topic in later years.

Learning progressions require students to learn specific skills and knowledge that they will need to use later on in their educational career. This depends on instructional strategies implemented by teachers. The job of a teacher is to use multiple styles of resources such as videos, demonstrations, activities, and readings that allow students opportunities to learn. Specifically applying this information to science classes, teachers should allow students opportunities to participate in the main activities that help develop scientific knowledge. These include gathering data through observation, representing data, experimenting, reasoning about data, and applying information learned to new situations.

The book describes four key characteristics of a learning progression. The first is the use of current research base on children's learning to suggest how students' conceptual understanding can develop.

The second characteristic of a learning progression is the use of interconnected strands of scientific proficiency. These four strands describe learning goals and a framework for curriculum design. Strands include knowing, using, and interpreting scientific explanations of the natural world, generating and evaluating scientific evidence and explanations, understanding the nature and development of scientific knowledge, and participating productively in scientific practice and discourse. Teachers need to plan instruction that allows students to participate in each one of these strands of scientific proficiency.

The third key component of a learning progression is the organization of conceptual knowledge around core ideas. The science GSEs are the core ideas that provide a base for structuring a learning progression around. When these core ideas are extended to explain a particular phenomenon, then a concept is formed.

The fourth and final characteristic of a learning progression is the recognition of multiple sequences and web-like growth. All students come to school with different experiences and cultural backgrounds, so students may follow a different path in their learning progression and arrive at a slightly different point by the time they graduate high school.

Overall, we have the prior knowledge that students come to school with at one end, and the knowledge that society expects students to leave school with at the other end. In the middle lies the learning progression.

The challenge of learning progressions arises from the lack of standardization of subjects throughout the country. Learning progressions are designed so that even if a student changes

location in the middle of their educational career, they are still on track with the progression. This problem may be if not solved, improved with the execution of common core standards in a few years. The Rhode Island GSEs follow a progression of knowledge that could flow smoothly if teachers provide the correct instruction throughout the year to keep students on track with the progression.

Most Rhode Island high schools are now beginning to administer department-wide activities or projects that attempt to measure students' understanding of a certain GSE so that all students will graduate with proficiency in science. For example, Westerly High School requires students to show proficiency on a number of assignments, or "common tasks". All of the rubrics for these assignments are uploaded onto a portfolio website, and students must have all rubrics uploaded before receiving a diploma. This is a way of standardizing science instruction throughout the state.

At the middle school level, GSEs are addressed in similar ways. Rhode Island middle school science teachers are provided with kits that cover an entire unit of study. The kits come equipped with all lesson plans and lab materials teachers will need to teach this unit. Most grades in middle school cover three to four kits in a year-long curriculum. For example, Broad Rock Middle School in Wakefield, RI covers three kits in one year: *Measuring Time*, *Ecosystems*, and *Magnets and Motors.* Guiding Education in Mathematics and Science Network (GEMSNET) coordinates the distribution of kits in eight school districts in Rhode Island, including South Kingstown. GEMSNET uses resources mostly from two different kit companies called Full Option Science Kits (FOSS) and the National Science Resource Center (NSRC). These kits are professionally developed and reviewed, but do they go the full lengths to make sure students demonstrate understanding of all GSEs the kits are said to align with?

Teachers rarely get the time or the opportunity to sit down either individually or with colleagues to discuss what grade span expectations are asking of students. In other words, what prior knowledge students need to possess, what preconceptions or misconceptions students have about the topic, or what students need to be able to do in the end in order to demonstrate understanding of the material. This process can be referred to as "unpacking" a GSE.

The goal of my project was to look at one middle school science kit created in collaboration of the National Science Resource Center and Science and Technology for Children entitled *Ecosystems*. I wanted to determine whether these kits align fully with the GSEs that it's supposed to as well as give students enough opportunity to demonstrate understanding of the material. It is full of mostly teacher-directed, inquiry based instruction that allows students to create an ecocolumn that contains their own terrarium and aquarium to use for studying the properties of ecosystems. I have first unpacked all seven of the Grade Span Expectations that align with this kit. The results of my unpacking have been posted on the RI Science Teachers Wikispace, which is a shared website where teachers can share any knowledge or resources for the benefit of other teachers.

Before unpacking these GSEs, I have researched what it means to teach science for understanding. The textbook, *Teaching Science for Understanding,* clearly outlines the dimensions of what it means to understand something and what students should be able to do to demonstrate their full understanding of phenomena. This is especially important when studying the GSEs because each expectation begins with the phrase "students demonstrate understanding of…". According to the text, there are six elements of understanding, or six tools that can be used to understand material. They are facts, beliefs, or opinions; images (mental representations);

episodes (memories); intellectual skills; strings (mnemonics, acronyms); and motor skills (riding a bike).

In order to understand a main idea or concept, perhaps outlined by a GSE, you first need to have been exposed to each of the constitute parts that when put together, form the concept as a whole. There are six facets of understanding, or six progressive levels of ways you can show your understanding of a concept. The first is explanation based on observations or data. The next is interpretation or making sense of data. Application is using knowledge to solve new problems. Having perspective is realizing that there could be multiple ways of interpreting the concept and knowing the importance of an idea (valuing the discipline is required for understanding). The fifth facet is empathy for the subject, or accepting ideas that seem strange or against what they believe is correct and a struggle to validate their current hypotheses about a subject. The final facet is self knowledge. This requires students to be aware of what they know, what they don't know, and always be questioning their understanding.

When unpacking a GSE, one of the questions to answer is "what can students do to demonstrate understanding of the GSE?". Teachers can easily apply the six facets of understanding outlined in this book to the topic they are teaching about. I have gone through and applied these six facets to each of the seven GSEs aligned with the Ecosystems kit as part of the unpacking process. This information can be found on the Rhode Island Science Teacher Wikispace.

I will provide an example of an unpacked GSEs to show the thought process that goes along with unpacking. This GSE is LS1 (5-6) – 1, or the first middle school GSE for life science. "Students demonstrate understanding of biodiversity by recognizing that organisms have different features and behaviors for meeting their needs to survive (e.g., fish have gills for

respiration, mammals have lungs, bears hibernate).” As stated before, there are six questions that need to be answered about the GSE in order to unpack it. This work was posted on the Rhode Island Science Teachers Wikispace, and this format is what is shown on the website:

What do these GSEs mean? What subtopics do students need to address to understand these GSEs?

- Characteristics of living things- made up of cells, obtain and use energy, grow and develop, reproduce, respond and adapt to their environment- understand that organisms must continually change to meet these needs in the environment they live in.
- Could happen over generations, or within the same generation (understanding of evolution, natural selection)
- What does an organism need in order to survive?
- Water, shelter, food
- Reproduction of species needed for survival of species
- Distingush and provide evidence between living and nonliving things
- Should be able to group animals and plants together based on similar features
- Definition of biodiversity- variability of life forms in a given area
- Adaptations- definition (adjustment of a trait that helps an organism survive in its environment)

What ideas to students need to understand before they can address the topics described above?

- Adaptations
- Organisms' needs for survival

What misconceptions are students likely to have about these topics?

- An organism is given the traits it needs for survival.
- Natural selection does not produce perfection.
- Natural selected is sometimes viewed as a random process, which is not true. Genetic variants that are more likely to aid an organism’s survival are selected for more often.
- Transmitted characteristics are acquired during the life time of the animal.
- Students believe animals consciously plan their reproductive strategies.

What phenomena and representations help students understand these topics?

- Observations of organisms in their natural environments

What activities or activity sequences can be used to address these GSEs?

- Inquiry activities:

  - Bird beaks- match the beak with the type of food the bird might eat
  - Observation of organisms, such as crickets, to discover which adaptations help in their reproductive process
  - Body coverings, animal defenses, bird feet, bones and feathers activity with play-doh. Change the environmental conditions and have students create adaptations to help their play-doh animal.

How can students show that they understand this GSE?

- Six Facets of Understanding:
  1. Explanation- based on data, experiments, observations.
  After an inquiry activity such as the bird's beak investigation, students can write an explanation of how organisms have special features for survival based on the observations and conclusions they made about the bird beaks.

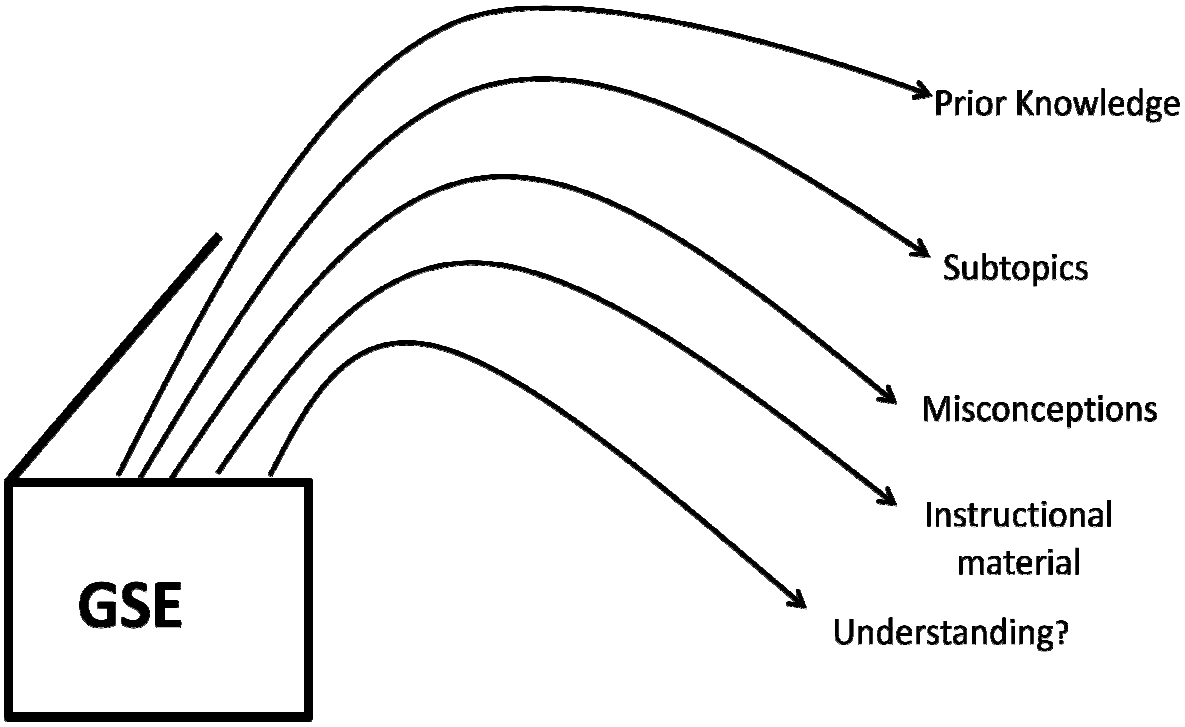
  2. Interpretation- the means by which scientists make sense of data, making connections.
  Before an explanation piece- students interpret reasons why certain birds' beaks are shaped the way they are. Also can be used with the crickets- students observe to see which how physical characteristics on a cricket contribute to its survival in their terrarium ecosystem.

  3. Application- using knowledge to solve new problems
  - Do not give the answer.
  - Present a related, but challenging task to explain
  - Point towards use of prior knowledge
  - Hints to provide a scaffold
  Playdoh activity- students change features on their playdoh animal as the environmental conditions change.

  4. Perspective- recognizing that multiple interpretations are possible, not jumping to conclusions and consider all alternatives, **knowing the importance of an idea-** teachers should design their lessons so that students come away knowing the importance
  - "Valuing the discipline is required for knowing and understanding the discipline"
  Why is it important that organisms have these special features? So they can survive.

  5. Empathy- Four levels:
  1. Struggle to validate the ideas and theories that they're learning
  2. Understand and appreciate the ways that science has changed people's ways of thinking over time about the natural world.
  3. Teachers need to grasp how and why students are thinking as they do
  4. Open- mindedly embrace ideas that seem strange
  6. Self-knowledge- examination of one's own ideas and reasoning in order to advance them

The six other grade span expectations that are associated with the Ecosystems kit are unpacked and all of the information is displayed on the Rhode Island Science Teachers Wikispaces. This is a simple model to show what six questions need to be answered about that one general sentence when unpacking GSEs.



After unpacking all seven of the GSEs that align with the Ecosystems kit, I went back to the actual kit and dissected each of the sixteen lessons in the teacher's guidebook. I determined what information was missing from the kit in order to make sure each student has an opportunity to develop an understanding of the material. This information allowed me to add activities, videos, and other instructional material to fill in the gaps of the Ecosystems kit.

The second portion of my project involved looking at the level of inquiry present in the Ecosystems kit. Scientific inquiry can be defined as "a student-driven exploration of phenomena which utilizes critical thinking and scientific processing skills to further develop knowledge and understanding on how the world works. Fueled by curiosity, students assume the role of

scientists by making observations, questioning the phenomena, selecting a statement to test, designing an experiment, collecting data, and communicating their findings." Rhode Island Science Teacher Wikispace. Inquiry involves learning by doing and it is a way of engaging students in the material by instilling interest because they are answering their own questions.

Inquiry isn't just a fun way of learning science in classrooms, it is actually assessed through high stakes state testing. In fourth, eighth and eleventh grade, students participate in the New England Common Assessment Program (referred to as the NECAP) for science. This exam used to just test math and reading abilities, but a science section has recently been added. A portion of the science NECAPs is inquiry based.

As students progress through middle school, they should be exposed to inquiry-based learning in order to be prepared for this NECAP exam. The NECAP covers thirteen what we call constructs of inquiry that vary in depth of knowledge. For example, the first construct of inquiry includes analyzing information in order to formulate a hypothesis or prediction. The constructs progress to include designing an experiment to test a hypothesis, collecting data, summarizing and analyzing results, and forming a conclusion. I wanted to see whether or not the lessons in this kit allowed students to practice their inquiry skills.

The second portion of the Ecosystems kit involves students adding certain chemicals to a few ecocolumns such as vinegar (to simulate acid rain), fertilizer, and salt to study the effects of pollution on an ecosystem. All of these eight lessons are semi inquiry-based. I have gone through and added suggestions as to how to increase the inquiry component of the kit to maximize student learning. For example, teachers can have students make a prediction of what will happen with pollutants in their ecocolumn based on their prior knowledge of pollution. Also, students could make a decision of what data they will need to collect to test their predictions, and also

how they want to record their information in a chart. The more practice students have with this under teacher guidance and supervision, the better they will be able to perform on this portion of their NECAP exams.

All of the work that I've done for this project is displayed on the Rhode Island Science Teachers Wikispace. It is my hope that both incoming and present science teachers will be able to use my additional lessons that I've added to the kit as well as the research about how teachers can know when their students are actually understanding the material that is being presented to them.

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