Science Newsletter

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Middle School Edition

What does the Big Idea of The Earth and the Universe (E&U) look like in the middle school (6-8) classroom?

According to the Kentucky Program of Studies:
The Earth system is in a constant state of change. These changes affect life on Earth in many ways. Development of conceptual understandings about processes that shape the Earth begin at the elementary level with understanding what Earth materials are and that change occurs. At the middle level, students investigate how these changes occur. An understanding of systems and their interacting components will enable students to evaluate supporting theories of Earth changes. The use of models and observance of patterns to explain common phenomena is essential to building a conceptual foundation and supporting ideas with evidence at all levels. In middle school, students begin to look beyond what can be directly observed as they explore the Earth-sun-moon system, as well as the rest of our solar system, employing the concept of scale within their models. Patterns play an important role as students seek to develop a conceptual understanding of gravity in their world and in the universe.

What does this mean to students?

In student-friendly terms, some of the basic ideas underlying E&U at the 6-8 grade level include:

Grade 6	Grade 7	Grade 8
The earth is constantly moving, but since we are moving at the same speed it appears motionless to us. Movements of the sun, earth, moon are responsible for such things as day/night, years, eclipses, moon phases and seasons. The movements of the earth, sun and moon are repeatable and predictable. Barring an extreme catastrophe, we will always be able to predict their relative positions.	Predictable motion is not limited to the earth, sun and moon. Predictable rules of motion apply to the universe beyond our solar system, and those rules can be used to predict and then discover previously unknown objects. The effect of gravity on masses is known and predictable. Understanding the rules of gravity and motion help us	The earth and the solar system are believed to be about 4.6 billion years old. Many of the processes that are happening on earth are extremely slow. Observing the speed of these processes supports the idea that the earth is quite old. There are several different methods used to find the age of earth materials. Each of them has limitations and applies only to materials within a certain age range.

The relative motion of the sun, earth and moon can be predicted and demonstrated with both physical and conceptual models. The idea of Conservation of Matter applies to the earth system: the amount of matter on earth is relatively constant. A rock of one type may not remain the same forever. Rocks are not necessarily permanent, even though the matter inside them is. Processes within the earth may rearrange the elements in rock material into a new configuration. This process is referred to as the rock cycle. The earth's surface looks different today than in the distant past, and it will be different in the future than today. The processes that shape the surface can create new landforms (constructive) or destroy existing ones (destructive). The surface undergoes changes because of processes that both erode material from one place and deposit it in another. The processes that shape the surface range from extremely slow (e.g., wind erosion) to relatively fast (e.g., volcanic	understand how the universe works Gravitational attraction is the force controlling tides. Our solar system does not exist in isolation. It is a very small part of the Milky Way galaxy. The interior of the earth is not uniform in composition: it is arranged in distinct layers with varying properties. Evidence from earthquakes provides insight into the composition of the earth, even though we cannot directly observe it. The earth's outer layer is neither solid nor uniform: it is broken into plates which can move slowly over the material below it. Observing processes that are happening on the earth or in the atmosphere today provides the data needed to make predictions about some future changes. Not all changes/processes/phenomena happening on earth can be predicted given our current level on knowledge. Some changes happen suddenly and without warning.	Some methods of dating earth materials are based on calculating the rate of radioactive decay of isotopes contained in rocks. The arrangement of rock layers can be used to determine their relative ages. One method of dating earth materials relies on the use of fossils that lived for only a short period of time (index fossils). The movement of crustal plates is caused by the flow of molten rock below the crust. Movement of molten rock is caused by heat flow through convection currents. The movement of crustal plates can result in earthquakes, volcanoes, hot spot island formation and continental drift. All scientific models have flaws and limitations, but they can still be useful to help better understand the earth and the universe.

eruptions). Observations of processes and landforms existing today provide the data needed to make predictions about future changes. Technology (both for measurement and data processing) helps us understand the earth and solar system.		

What are some common misconceptions about E&U?

According to Operation Physics http://amasci.com/miscon/opphys.html these are some of the common misconceptions students have regarding The Earth and the Universe:

- Rocks must be heavy.
- Soil must have always been in its present form.
- Mountains are created rapidly.
- Earth is molten, except for its crust.
- Earth's gravitational attraction is drastically reduced on mountaintops.
- Continents do not move.
- Boiling or burning radioactive material can reduce radiation.
- All radioactivity is man-made.
- Stars and constellations appear in the same place in the sky every night.
- The sun rises exactly in the east and sets exactly in the west every day.
- The sun is always directly south at 12:00 noon.
- The tip of a shadow always moves along an east-west line.
- We experience seasons because of the earth's changing distance from the sun (closer in the summer, farther in the winter).
- The earth is the center of the solar system. (The planets, sun and moon revolve around the earth.)
- The moon can only be seen during the night.
- The moon does not rotate on its axis as it revolves around the earth.
- The phases of the moon are caused by shadows cast on its surface by other objects in the solar system.
- The phases of the moon are caused by the shadow of the earth on the moon.
- The phases of the moon are caused by the moon moving into the sun's shadow.
- The shape of the moon always appears the same.
- The earth is the largest object in the solar system.
- The solar system contains only the sun, planets and the moon.
- Meteors are falling stars.
- Rain comes from holes in clouds.

- Rain comes from clouds sweating.
- Rain falls from funnels in the clouds.
- Rain occurs when clouds get scrambled and melt.
- Rain occurs when clouds are shaken.
- Clouds move because we move.
- Clouds come from somewhere above the sky.
- Empty clouds are filled by the sea.
- The sun boils the sea to create water vapor.

(*NOTE:* many misconceptions related specifically to weather and stars were omitted from this list)

What are some resources available to help my students understand (and help me teach) E&U?

Related Lessons/Activities

AAAS Science NetLinks- How Sedimentary Rocks are Formed:

http://www.sciencenetlinks.com/lessons.cfm?Grade=6-8&BenchmarkID=4&DocID=174

Soil Erosion:

http://www.sciencenetlinks.com/lessons.cfm?Grade=6-8&BenchmarkID=4&DocID=454

Satellite Orbits:

http://www.sciencenetlinks.com/lessons.cfm?Grade=6-8&BenchmarkID=4&DocID=338

The Four Seasons:

http://www.sciencenetlinks.com/lessons.cfm?Grade=6-8&BenchmarkID=4&DocID=256

Scholastic Science Interactives- Scholastic.com and MSNBC present interactive activities on a variety of topics. Animations include demonstrations of how eclipses happen, finding extrasolar planets and how earthquakes occur. You will need to have the Flash player plug-in installed on your computer to view the animations. http://teacher.scholastic.com/activities/science/index.htm

Fear of Physics- a set of simple animated simulations that demonstrate the relative motion of the earth, sun and moon, as well as a simulation of why moon phases occur and how the system might look from the sun or moon. http://www.fearofphysics.com/SunMoon/sunmoon1.html

Moon Phases- a set of simple moon phase simulations in Spanish.
http://sunshine.chpc.utah.edu/espanol/labs/moon/lunar_phases_main.html

A controllable moon phase demonstrator with multiple views (in English):

http://jove.geol.niu.edu/faculty/stoddard/JAVA/moonphase.html

Mountain maker, Earth Shaker- this interactive simulation lets you manipulate tectonic plates. Pull the plates apart and push them together and watch what happens to the Earth. This page also links to an illustrated tutorial on plate tectonics and continental drift. The Shockwave plug-in is needed to use the simulation. http://www.pbs.org/wgbh/aso/tryit/tectonics/#

Teacher's Domain- The *Teachers' Domain* Earth and Space Science Collection is collaboration between WGBH Educational Foundation (WGBH Educational Productions, the WGBH Media Library, and WGBH Interactive) and University Corporation for Atmospheric Research (UCAR), Digital Library for Earth System Education Program Center (DLESE Program Center). This page contains links to an extensive collection of resources for teaching E &U, including video segments and interactive lessons. http://72.32.11.171/sci/ess/index.html

ForgeFX- interactive 3D simulations created for Prentice Hall's middle grades science program called Science Explorer This page has 10 sample projects including eclipses, seismic waves and the solar system. The Shockwave plug-in is required.
http://www.forgefx.com/casestudies/prenticehall/

Online Resources

Kentucky Science Support Network- Has a student ever asked a science question you didn't have the content background to answer confidently? Fortunately, there is a free online resource that lets you tap into a wealth of knowledge. The Kentucky Science Support Network (KSSN) is designed to provide classroom teachers in Kentucky a direct link to "experts" across the Commonwealth.

Teachers can select an area of expertise and instantly generate a list of contacts who are willing to provide content information, consultation on research/projects, and/or suggestions and information regarding equipment and/or materials primarily through the use of email. This is a collaborative effort between the Kentucky Department of Education, the Kentucky Science and Engineering Fair and the Kentucky Science Teachers Association.
http://oapd.kde.state.ky.us/kssn/FMPro

What is critical vocabulary in science?

In his book *Building Background Knowledge for Academic Achievement*, Dr. Robert Marzano provides estimates of the number of terms that can be taught at various grade levels. Marzano suggests that while students in 1st grade can only be taught one new word per week, this number rises to five words/week in 4th grade, to 20 words/week by 7th grade and peaks at 25 words/week in high school. These numbers are cumulative across all subjects and not just limited to science. In essence Marzano, who is a supporter of direct vocabulary instruction, has determined that 3 to 4 new terms per week are the maximum (for middle school) that can be successfully introduced in any subject area. This requires teachers to identify terms that are truly 'essential' rather than those that are only 'supplemental' and to focus on the essential.

For example, consider this list of terms from a chapter on earth history from a general science text:

cast	Cenozoic era	fossil	geologic time	geologic time scale
Mesozoic era	Mold	Paleozoic era	petrification	Precambrian era

Marzano suggests that a viable option for schools to separate the essential terms from the supplemental ones is to identify only those that are essential for all students to learn regardless of their aspirations after high school. Using this criterion, not all of these 10 words can be truly considered essential. The list could potentially be reduced to as few as two terms: fossil and geologic time.

It is important to remember that students can often recall the definitions of new terms from working memory, yet be unable to apply the true meaning of those terms to new and unfamiliar situations. Narrowing the number of terms they are required to learn allows us to teach for understanding rather than for simple recall that never rises beyond DOK 1.

Finally, it is important to realize that there is no vocabulary list for the KCCT. Several districts/individuals have created lists, but the KDE and the Content Advisory Committees for Science do not have or use any such list. In fact, the following example is routinely shared with the Content Advisory Committees during training for item development:

Basic vs. Technical Vocabulary
•Use simple, basic vocabulary instead of technical vocabulary unless you are assessing the students' knowledge of the *meaning* of the technical word/phrase.

Example

When you plant a seed, the roots grow downward. This is called geotropism. Which factor is responsible for geotropism?

vs.

When you plant a seed, the roots grow downward, and the stem grows upward. Which factor is responsible for the roots growing downward?

What might a potential assessment item for a Core Content standard related to E & U look like?

The Science Core Content for Assessment, version 4.1 includes this statement related to E&U in 6th grade:

SC-06-2.3.3
Students will compare constructive and destructive forces on Earth in order to make predictions about the nature of landforms.

Landforms are a result of a combination of constructive and destructive forces. Collection and analysis of data indicates that constructive forces include crustal deformation, faulting, volcanic eruption and deposition of sediment, while destructive forces include weathering and erosion.
DOK 2

The 2004 Annotated Released Form of the 7th grade KCCT contains this item:

Changes in Landforms

Scientists have evidence that the landforms we see on Earth, such as mountains, islands, and canyons, as well as the shapes of continents, are the result of constructive and destructive forces at work over a long period of time.

Describe in detail **two** pieces of evidence that show that landforms on Earth are constantly changing. Provide a specific example for each piece of evidence.

Scoring Guide

Score	Description
4	Student clearly describes, in detail, two pieces of evidence that show that landforms on Earth are constantly changing. A specific example is given for each piece of evidence.
3	Student generally describes two pieces of evidence that show that landforms on Earth are constantly changing. A specific example is given for at least one piece of evidence.
2	Student provides a limited description of two pieces of evidence that show that landforms on Earth are constantly changing. Examples may or may not be given. **OR** Student generally describes one piece of evidence that shows that landforms on Earth are constantly changing. A specific example is given for this piece of evidence.
1	Student demonstrates minimal understanding (e.g., student provides a limited description of one piece of evidence that shows that landforms on Earth are constantly changing, **or** student names an example of a specific landform or type of landform that changes but does not describe how this provides evidence that landforms on Earth are constantly changing).
0	Student's response is totally incorrect or irrelevant.
Blank	No student response.

Note: The question asks for evidence that landforms are constantly changing. It does not distinguish between slow change over time and rapid change— either is acceptable.

Examples of possible answers choices:

- Shapes of continents "fitting" from the breakup of Pangea (shape of Africa fits with shape of South America)

- Fossil distribution of the same species across continents as evidence of plate movement (similar dinosaurs existed on several continents)
- Mountain building as a result of plate movement pressures—different ages of mountain ranges as shown by erosion shapes (old Appalachians vs. young Rockies)—uplift measured by modern satellites (such as change in height of Mt. Everest, rise of Santa Monica Mountains by over a foot in Northridge earthquake)
- Tectonic activity at plate boundaries (the "Ring of Fire" in the Pacific)
- New surface created by lava flows from active volcanoes (many recent examples, also historical ones such as Vesuvius burying Pompeii)
- New volcanic island formation (near Iceland)
- Water erosion resulting in river delta formation (Mississippi), canyon formation (Grand Canyon), changes in the course of rivers (many examples including rivers in KY), and cave formation (Mammoth Caves, including recent changes as well as former)
- Wind-caused sand dune movement (Sahara Desert changes, White Sands dunes), natural arch formation (in deserts in Utah and Arizona, and by water and wind at Natural Bridge)
- Magnetic variations found along the sea floor (magnetic striping and polar reversals along mid-ocean ridges)

Sample 4 point student response:

Land forms on Earth are constantly changing in many ways. For example: the process of Erosion. If there is a mountian with lose pieces of rock on it, when it rains the rain water is going to wash downward breaking away bits of rock as it flows.

Another change we have experienced in the past, and are still experiencing is Plate Techtonics. Plate Techtonics is how the Earth's continents have shifted over the years. A long time ago there was one big continent called the Pangea. But over time parts of the Pangea have broken off and moved away which have formed the continents we see today. But a little at a time the continents are still shifting.

NOTE: this was a student response that was given a score of 4 on the 2004 KCCT. Three errors related to writing skills are highlighted, but they have no impact on the score because the student response is still understandable. Overall, the student demonstrates appropriate understanding of how landforms change. The student clearly describes two pieces of evidence that show that landforms on Earth are constantly changing. A specific example, with details, is given to support each piece of evidence.

This item, rubric and annotated student responses are available from http://education.ky.gov/KDE/Administrative+Resources/Testing+and+Reporting+/District+Support/Link+to+Released+Items/2004+Kentucky+Core+Content+TestKCCTAnnotated+Released+Items.htm

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