Science Connection
KENTUCKY DEPARTMENT OF EDUCATION
A Collaborative Resource for Teachers
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In This Issue

Another look at formative assessment

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HS

As we begin implementing the NGSS, the need for the effective use of formative assessment is greater than ever. I, along with a group of teachers in various grade levels and content areas, have had the opportunity to interact with formative assessment expert, Shirley Clarke. This interaction included four days of instruction and feedback provided by Clarke and hosted by the Partnership Institute for Math and Science Education Reform (PIMSER) at the University of Kentucky's College of Education. The instruction was powerful because it helped me tie together so many pieces to make the classroom experiences richer for my students.

While I have always used formative assessment strategies, these sessions helped me focus on how to make them more real to my students. For students to understand what is meant by formative assessment and how it improves their learning, time must be spent developing the learning culture within the classroom. This means we have to teach our students who they are as learners.

To begin this process, I used an excerpt from Clarke's book, Active Learning through Formative Assessment, which focuses on fixed and growth mindsets. It is interesting to listen to students discuss their views on grading, learning and intelligence. While doing this at the beginning of a new course is powerful, the learning culture must be maintained on a daily basis. It is important for students to reflect on their mindset – is it becoming more growth oriented and how does it impact their learning?

This lays the foundation for talking with students about formative assessment. Since I teach high school students, my approach to this is different than if I were teaching elementary or middle school students. I use the l formative assessment language with them and explain how I will use it to guide my instruction and they will use the feedback they receive to help them deepen their understanding. In doing this we talk about the role of feedback. The feedback they receive will not only be from me but from each other as the role of peer-assessment takes on new meaning. As a class we worked

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Springing forward with the KCAS for science

Editor's note by Christine Duke

As I engage with Kentucky teachers, as well as those in other states that have adopted the Next Generation Science Standards (NGSS), I marvel at the fortitude that is apparent in all who are embracing the new science standards. We know that affecting change in what is known and comfortable can be a challenging. Yet through my experiences, I have observed a level of determination to better pedagogical practices and content understanding that is nothing short of impressive.

Teachers are discarding their old favorite lessons and replacing them with more rigorous, student led, learning opportunities. They are reflecting on current science instruction to self-assess their strengths and growth areas. Colleagues are taking on the role of critical friends and pushing back against methodology that does not align with the vision of the Framework. Although these changes often test our mettle, they do propel us forward. Are you growing in your understanding and implementation of our new standards? Can you support your claim with defensible evidence?

NEXT GENERATION SCIENCE STANDARDS

Practice	DCI	Crosscutting Concept
Asking questions and defining problems	LS1 from molecules to organisms: structure and function	Patterns

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together to develop success criteria (or simply "What Makes Good?") that we use for providing feedback. As we develop the success criteria, we talkabout how it helps us to focus on improving the quality of the work – that our comments are about the work and not the person.

One formative assessment strategy that we use for providing feedback is called "One Book on Top of Another". In this, students work in pairs to provide feedback on each person's work. As the name suggests, one person's work is placed on top of the other person's work. Using the success criteria, together they provide feedback. At this point, they may work together to cooperatively improve the piece. Next, they will repeat the process for the other person's work. This strategy is valuable as it requires the student to both self-assess and peer-assess. In doing so, the student develops a deeper understanding of the content.

An example of this is seen in a lesson focused on the Science and Engineering Practice of Constructing Explanations and Designing Solutions. Earth Science students were given climate data from two major U.S. cities. They were asked to analyze the data and write an explanation using evidence from their findings. As they began to review the work and provide feedback, students used the language of the success criteria and were focused on the content of the explanations. From doing this, I have seen an increase in the correct use of scientific terminology and students are more eager to receive feedback from both their peers and myself. Madison M., a 12th grade student said:, "When you put a lot of time and effort into your work, it can become increasingly difficult to recognize your mistakes. Peer assessment allows you to have someone with a fresh perspective review your work, help you identify these problems and provide constructive criticism."

The most exciting part of this is that students begin making the connections between what we do in the class and how it impacts them as learners. We often talk about how our mindsets are changing and what we can do to better understand what we study.

Deciding on a course model?

Sean Elkins, *OVEC Instructional Specialist*

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The adoption of new science standards creates both a need and an opportunity to revisit how high school science courses are configured. The revised high school graduation regulation that included the new Kentucky Core Academic Standards(KCAS) for Science (http://www.lrc.state.ky.us/kar/704/003/305.htm) requires students to complete "*three (3) credits that shall incorporate lab-based scientific investigation experiences and include the content contained in the Kentucky core academic standards for science*"

Decisions regarding how the KCAS standards are distributed among courses are subject to local control, meaning that individual high schools and districts will need to revisit their course syllabi to ensure students will have the opportunity to learn all of the performance expectations contained in the KCAS regardless of the course sequence in which they are enrolled.

Achieve, Inc., the publisher of the Next Generation Science Standards (NGSS) has created a guidance document to assist schools in making decisions about high school course design. NGSS Appendix K, Model Course Mapping in Middle and High School, contains several suggested models high schools may consider when redesigning courses to align to the new science KCAS. Appendix K explains the origin of those models and their relative strengths/weaknesses in great detail, but their major features are summarized as follows.

Conceptual Progressions model (Appendix K, pp. 7-12; Table 2, p. 12)

Description: This is an integrated model designed to present the Disciplinary Core Ideas (DCI) in a progression based on a scaffolded progression of learning. This model is presented as a defined sequence, so Course 1 should be taken before Course 2, etc. Concepts in Course 1 were determined to be foundational ideas students should learn first in order to obtain the background knowledge and skills required to fully engage with the concepts contained in Course 2. Course 2 likewise is organized around those concepts that will contribute to student success with those conceptually demanding ideas in Course 3. The full set of Engineering Design standards are incorporated into every course in all models. Positive considerations of this course model include the fact that it was designed with progression of student learning in mind and that it tells a story of developing concepts over time.

Course codes, descriptions and a list of certification permissions for courses created from this model are being created by the Education Professional Standards Board (EPSB) and will be listed under the content area of Conceptual Progressions Science. These codes will be available for scheduling courses for the 2014-2015 school year.

Science Domains model (Appendix K, pp. 22-26; Table 5, p. 24)

Description: This is a relatively simple model based around the three domains of science. Performance expectations are sorted into three courses: Physical Science, Life Science and Earth/Space Science. The full set of Engineering Design standards are incorporated into every course in all models. An important consideration to remember is that these three courses do not imply a defined sequence. This course sequence matches relatively well to existing certifications.

Modified Science Domains model (Appendix K, pp. 27-31, Table 6, p.28)

Description: This model is a variation of the Science Domains model (above) that groups courses into the traditional courses of biology, chemistry and physics. The physical science performance expectations are divided into chemistry or physics while the life science performance expectations are all included

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in biology. The Earth/Space Science performance expectations are distributed across all three courses in a way that best connects those concepts with related ideas in the three courses. For example, standards related to biogeology are integrated into biology while astronomical standards are included in physics. This model aligns well with existing certifications and traditional course models. As with the Science Domains model, the Engineering Design standards are included in every course, and the models do not imply a course sequence.

Modified Science Domains model-four courses (Appendix K, pp. 31-33, Table 7, p.33)

Description: This model is a variation of the Modified Science Domains model (above) that groups courses into the traditional courses of biology, chemistry and physics and adds an Earth/Space Science course. Rather than integrating the Earth/Space science standards they are separated into a distinct course of their own. Only districts wishing to require an additional fourth course beyond the three required by statute would likely use this model.

It is important to consider these models as only first steps in course planning. Districts and schools are encouraged to consider the best features of each model and perhaps make curricular decisions that modify, blend or revise them. Appendix K contains significantly more detailed guidance on how to use these models to guide course development and curriculum planners are urged to download and read it in its entirety.

The joy of a challenge versus the fear of failure

Sondra Jones & Kristin Baker, *Teachers of Jackson County Public Schools*

ELEMENTARY

Four teachers from Sand Gap Elementary School in southeastern Kentucky recently engaged in an action research project designed for teachers interested in assessment for learning. The action research project was created as a part of their participation in the Outstanding Formative Assessment workshop sponsored by the University of Kentucky and the Partnership Institute for Math and Science Education Reform (PIMSER). The workshop was led by Shirley Clarke, a leading scholar in formative assessment strategies. The participating teachers were classroom math and science teachers, who taught 1st, 2nd, 3rd, and 4th grades. As a component of the project, the four teachers formed a learning team. They also agreed to experiment with formative assessment in their classrooms and to share feedback with other project participants.

One of the principle components of Shirley Clarke's work is establishing an ideal learning culture. When applying this principal in the classroom, the learning team found that fostering an active learning culture is fundamental in implementing effective formative assessment in the classroom. During the action research project, teachers learned that Clarke's work is based on the principle of growth/fixed mindset. Individuals with a growth mindset believe that there is always the potential for learning more. In theory, students with a growth mindset will choose the harder problems and be more inclined to try new and challenging concepts. Individuals with a fixed mindset are more likely to adhere to the philosophy that you cannot teach old dogs new tricks, believing that there is a limit on the mind's ability to learn new things. In the classroom, students with a fixed mindset will choose the easier problems and communicate that certain work is "too hard." In addition, students with a fixed mindset believe that effort is a waste of time, whereas a student with a growth mindset will adhere to the belief that effort leads to mastery of a concept. As part of the action research project, the teachers' goal was to guide students with a fixed mindset toward having more of a growth mindset.

The participating teachers implemented several strategies during the project that focused on establishing a growth mindset learning culture. At the onset of the project, two of the participating teachers read aloud the book, *My Fantastic Elastic Brain,* written by J. Deak This picture book, teaches that individuals have the ability to stretch and grow their own brains. It also relates the knowledge that mistakes are an important part of learning. According to the author, if we are not failing, we are not learning.

Another way the learning team introduced the project to their students was to show several videos suggested by Clarke, one of which outlined failures of various famous figures. These figures had to overcome failures and obstacles before achieving their ultimate success. After watching the video, one student responded by saying, "So, it's okay to be wrong as long as we keep trying." Teachers also displayed videos that demonstrated how the brain has potential to make new neuron connections when learning new concepts. In response to the video and discussions, students began to relate that they sometimes felt their own neuron s firing. The classes also adopted the motto, "I can't do it… yet." This motto is based on Clarke's idea that students constantly seek improvement in their learning, and that they are only in competition with themselves, not other students.

One of Clarke's strategies utilized in all four classrooms was the incorporation of the 8 Characteristics of Highly Effective Learning. One class adopted a growth mindset classroom character whom they named "Spidey Spider." The participating teacher used a spider on an anchor chart and wrote each of the eight characteristics on the legs of the spider: Concentrate, Don't Give Up, Be Cooperative, Be Curious, Have a Go, Use Your Imagination, Keep Improving, and Enjoy Learning. During the course of the project, the class brainstormed and listed what they thought each of the characteristics meant. One little girl related that Be Cooperative meant, "Listen to each other." Another student stated that Don't Give Up meant, "Keep trying and practicing."

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Through the process of this action research project, the participating teachers gained insight into the importance of establishing positive learning cultures to create effective formative assessment. They are beginning to see that the use of strategies that promote a growth mindset in their classrooms encourage their students to enjoy challenges and are focused less on fear of failure.

Earth and Space Science web resources for elementary teachers

William Thornburgh,
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University of Louisville

ELEMENTARY

The goal of the Next Generation Science Standards (NGSS) Disciplinary Core Ideas (DCI) is to focus science curriculum, instruction and assessments on the most important aspects of science. If an idea is to be considered core, it must meet certain criteria, two of which are concepts related to students' life experiences and concepts that are teachable and learnable over multiple grade levels at increasing levels of depth and sophistication (Quinn, Schweingruber, & Keller, 2012).

One of the four domains of the NGSS DCIs is Earth and Space Sciences (ESS). This domain investigates processes that operate on Earth and also address its place in the solar system, which involve phenomena that range in scale from the unimaginably large to the invisibly small (Quinn et al., 2012). Within this domain, weather, climate, water, and human impacts on Earth are key topics. Students have daily experience with each and they can be taught and learned about at some level over many years, making them most relevant to our students.

The following Internet resources focus specifically on these four key topics and will be useful for teachers at the elementary school level. A short description follows each website, with some general ideas for how teachers could use them in the classroom.This sample represents only a few of the many great resources available to teachers, so be sure to do your homework and find websites that will be most useful for you and your students.

http://studyjams.scholastic.com/studyjams/jams/science/ecosystems/water-cycle.htm - A short, child-friendly video explaining the hydrologic cycle (water cycle). Teachers can use this video as an introduction to weather, knowing that water is a key feature of the weather and climate in various locations around the world. (K-3)

http://www.cotf.edu/ete/modules/k4/online/Wonline1.html - A fun trivia review game for younger students. This resource can be projected and used for entire class review, used individually by students with classroom computers, or teachers can borrow questions for their own review of weather. (K-3)

http://www.wildwildweather.com/index.html - This website provides valuable information on many types of weather. Additionally, each page lists learning activities directly related to each weather event that teachers could incorporate into their classroom. All activities could be adapted to be appropriate for younger or older students. Getting students involved in thinking, building, and experimenting at young ages is vital to establishing a strong science background. (K-5)

http://www.scholastic.com/kids/weather/ - An interactive resource where students can manipulate temperatures and humidity to observe the changes that would occur in the weather. With each alteration made, students will visibly see the changes and receive an explanation of the changing conditions. This resource could be used as an inquiry tool by having students ask questions and make predictions before changing the conditions. (3-5)

http://climatekids.nasa.gov - This interactive website gives students the necessary background to learn about weather and climate. Teachers can also use this resource to lay the foundations for our changing climate, what that means for our planet, and how humans can help this issue. (3-5)

http://www.fi.edu/weatherED/ - Older elementary students could use this site as an introduction to weather or use as a review. Teachers could divide the students into groups and assign each group one of the many topics that make up this website. The resource includes the everyday elements of weather, wintry weather conditions, steamy weather conditions, dirty weather, and weather forces. There are also a number of links provided for teachers and students if further research is desired. (3-5)

Reference:

Quinn, H., Schweingruber, H., & Keller, T. (Eds.). (2012). A framework for K-12 science education: Practices, crosscutting concepts, and core ideas. National Academies Press.

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The art of explanation

Chris Crouch, Instructional Specialist

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"If I'm going to explain this theory, the question is, are you going to understand it? Will you understand the theory?"
Richard Feynman, 1979 Douglas Robb Memorial Lectures

At the heart of being a scientist is the persistent compulsiveness to seek questions that have yet to be answered. There is a desire to piece together observations, clues, evidence, and data into an ever-evolving articulation of the universe around us. By nature, we seek understanding of our world through explanation and as the complexity of the phenomena increase, so do the explanations. Feynman's idea is that the goal of effective explanations is to convey understanding.To articulate an understanding through explanation in order to clearly demonstrate so that others can also understand is the primary objective.

The skill of explanation is clearly one we take for granted, but is also one that can be learned. The Kentucky Core Academic Standards (KCAS) establish explanation as a key disciplinary skill and with careful scaffolding, students can create explanations that not only demonstrate their understanding, but can also help others come to greater insight.

To successfully scaffold instruction that enables students to build clear and meaningful explanations, we must first come to a common understanding at what is at the heart of explaining. What does it mean to explain within the disciplines of science? The KCAS for Science establishes when students should explain, but what does a written or verbal response look like that fully does explain an understanding? Students who are able to make explanations that demonstrate understanding build upon an intentional perception of the relationships between observations, clues, evidence and data. By empowering students with the language of relationships, students will be able to better articulate meaningful explanations.

Some commonly seen relationships from the science disciplines are: cause and effect, contrast, define, and process. There are more likely others, depending upon the specific discipline, but these four seem to be universal. Each of these relationships have nuances of language that clearly demonstrate understanding and create robust explanations. Scaffolded instruction that allows students to access the language of a specific relationship in terms of content will create student performances that are more insightful and analytical. The language of the relationship typically embodies two important components: transitions and verbs.

Below is a chart illustrating the types of language that students need intentional instructional practice with in order to create robust explanations (by no means is this list exclusive):

	Cause and Effect	Contrast	Define	Process
Transitions	therefore, hence, for this reason, since, for, because, as a result, due to, thus, so, if	in contrast, on the contrary, although, even though, similarly, however, on the other hand, as opposed to, whereas, instead, in spite of, different, differs from	can be defined as, the same as	after, afterward, at last, at that time, before, during, immediately, now, presently, shortly, since, until, while
verbs	leads to, creates, yields, stems from, produces	opposes, differs, contrasts, juxtaposes	means, like, defines, clarify, determine	stepped, force from, progress

Along with having mastery of the language of scientific explanation, Cassandra Volpe Horii, Director of Teaching and Learning Programs at the California Institute of Technology (Caltech) outlines the "anatomy" of explanation by creating an analogy of the structure for a clear explanation. The complete article can be found here: http://podnetwork.org/content/uploads/V20-N-6-Horii.pdf

In short, Horii suggests a three-part view of the anatomy of explanation.

1. Head and Neck

According to Horii, "effective scientific explanations begin by revealing exactly what" should be understood by the end. This sounds straight-forward enough but communication instruction in the science disciplines needs to stress this to students.

2. Limbs for Locomotion

After establishing the direction of a scientific explanation, Horii describes "the details of an explanation" as the component that "requires movement from one step to the next"

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and the manipulation of evidence, observations, and data as the "hands" of explanation.

3. Torso for Digestion

After deciding direction and the details necessary for movement and manipulation, "effective explanations of science end in the gut." Horii's analogy is that this is where meaning is extracted and students provide insight and conclusions for their explanations.

So, by scaffolding student experiences that allow students to access content through the language and anatomy of explanation, we will empower students to achieve Feynman's vision of enabling our future scientists to explain the mysteries of the universe so that we all can understand.

Horii, Cassandra. "Anatomy of a Scientific Explanation" 2008-09. 22 March 2014
<http://podnetwork.org/content/uploads/V20-N-6-Horii.pdf>

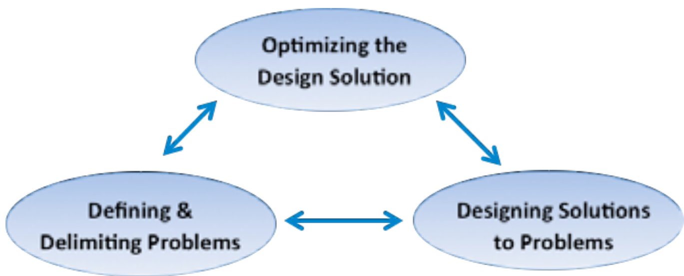
Engineering Design: Do canned engineering experiences meet the intent of science KCAS?

Mindy Curless, *KDE STEM Consultant*

ALL

Uneasy about teaching engineering design to your K-12 students? There are hundreds, if not thousands, of engineering design experiences available on the internet, advertised as appropriate for K-12 classrooms. Some of them even cite "alignment" to the NGSS engineering design PEs. Would one of these be appropriate? How do you know if these experiences meet the intent of our Kentucky Core Academic Standards for Science (NGSS)?

Of course a teacher will want to use the appropriate grade banded engineering design PEs for the grade he teaches.



In addition, Appendix I of the NGSS is a great resource for understanding the intent of engineering design in our standards http://www.nextgenscience.org/sites/ngss/files/Appendix%20I%20-%20Engineering%20Design%20in%20NGSS%20-%20FINAL_V2.pdf. Developed based on the NRC Framework for K-12 Science Education, this appendix broadly defines engineering design to include a cycle of three components, noting that these components do not always follow in order:

In fact, the NRC *Framework* explicitly states that "from a teaching and learning point of view, it is the *iterative cycle of design* that offers the greatest potential for applying science knowledge in the classroom and engaging in engineering practices" (NRC 2012, pp. 201-2) (emphasis added). Hence, we should appreciate that these iterative design experiences will help our students learn both science content and the engineering practices.

But how can you evaluate if some of the existing engineering experiences meet the intent of the NGSS and NRC *Framework* with respect to engineering design? Consider using the table below as a tool to help with a first look at an existing engineering experience. This table, synthesized from the information in NGSS Appendix I to reflect the intent of engineering design for each grade band, can be used as a rubric for initial evaluation. This website, eGFI: http://teachers.egfi-k12.org/, specializes in engineering for K-12, and offers lesson plans and other resources at varying grade levels. Take a moment to explore the site, and use the rubric for a quick evaluation for how closely the resources align with NGSS intent. Do they meet the intent? Could some be modified to better align with the intent?

	K-2	3-5	6-8	9-12
DEFINE & DELIMIT	Identify situations that people want to change as problems that can be solved through engineering	Specify criteria and constraints that a possible solution to a simple problem must meet	Attend to precision of criteria and constraints and considerations likely to limit possible solutions	Attend to a broad range of considerations in criteria and constraints for problems of social and global significance
DEVELOP SOLUTIONS	Convey possible solutions through visual or physical representations	Research and explore multiple possible solutions	Combine parts of different solutions to creat new solutions	Break a major problem into smaller problems that can be solved separately
OPTIMIZE	Compare solutions, test them and evaluate each	Improve a solution based on results of simple tests, including failure points	Use systematic processes to iteratively test and refine a solution	Prioritize criteria, consider trade-offs and assess social and environmental impacts as a complex solution is tested and refined

A final word of caution: Research by Custer and Daugherty (http://www.nae.edu/Publications/Bridge/16145/16204.aspx) suggests that recent engineering curricula reflect a "strong preference for hands-on activities with little emphasis on learning," and that too often, the focus is on implementation of the task, rather than developing a conceptual basis. In short, engineering experiences can become focused on simply doing the task, rather than the thinking and learning within the task. Thus, as we build our capacity to teach engineering design, we need to keep focus on the intent of the standards, not simply doing engineering activities. The table above can be an efficient tool to get started.

Science for All

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ALL

The Kentucky Department of Education (KDE) will be working with World-Class Instructional Design and Assessment (WIDA) to present online training on the WIDA English Language Development (ELD) Standards. The webinar is April 28 from 10-12 AM ET. Registration is through CIITS. Webinar log in information will be emailed to those who register.

The introduction to the WIDA ELD Standards Framework is based on a student-centered, teacher-focused approach to engage English Language Learners (ELLs) in academic language development. WIDA has designed the training for K-12 teachers of all subject areas, language specialists, administrators, and support staff. All educational staff that works with ELL students will benefit from the webinar.

WIDA standards framework was first developed and introduced in 2004 with the WIDA English Language Proficiency (ELP) Standards. WIDA has continued to work on advancing academic language development and academic achievement for English language learners (ELLs) and released revised ELP Standards Framework in 2007. WIDA released the 2012 Amplification of the WIDA ELD Standards with the goal of making the framework more meaningful to educators who work with ELLs.

The 2012 WIDA standards framework is connected to state content standards. WIDA's Amplification of the ELD Standards can be downloaded free at http://www.wida.us/standards/eld.aspx#2012. The downloaded standards booklet provides example topics and connections to content standards. The standards are drawn from the Common Core State Standards (CCSS), the Next Generation Science Standards (NGSS), and content standards from other states, including the KCAS.

Those who participate in the April 28 training will be able to describe the "academic language within the WIDA English Language Development Standards, the components of the WIDA ELD Standards Framework (Guiding Principles, Can Do Philosophy, Features of Academic Language, Performance Definitions, and standards matrices), the features of the amplified matrix and the elements of model performance indicators (MPIs)".

KDE will build on the *Introduction to WIDA ELD Standards webinar by providing WIDA facilitated professional development workshops to further assist educators in using the ELD Standards. ELD Standards in Action: Unit Planning and ELD Standards in Action: Lesson Planning workshops will be provided in the 2014-2015 school year.*

The webinar will be archived in the WIDA Download Library and available for Kentucky educators to review throughout the school year. It also gives new teachers the opportunity to view the webinar so they can participate in the Unit Planning and Lesson Planning workshops.

Be in the Know

CIITS Update

Jackie Rogers, *KDE Consultant*

Finding Instructional Resources in CIITS

CIITS has a wide array of resources: units, lesson plans, videos, labs, presentations, articles, and graphic organizers. Finding just the right material in an every growing system can be a challenge, but not if you understand the general rules of its navigation.

Once you log into CIITS and choose the Classrooms tab, then Instructional Materials, you will have several options for searching. The first search filter is by subject. If you leave this field blank, it will search all subject areas including Professional Development. Sometimes this is the best option if you want to cast a wide net to see what's available. Same thing is true for the second filter, grade. This can narrow a search drastically. It is recommended to begin searching without selecting a specific grade and then narrow if necessary.

The main filter has a default of Materials. This is normally the best route to find any resource available that relates to your intended search. Leaving the subject and grade fields empty and by choosing Materials, enter a topic. This topic search gives the most flexibility for searching.

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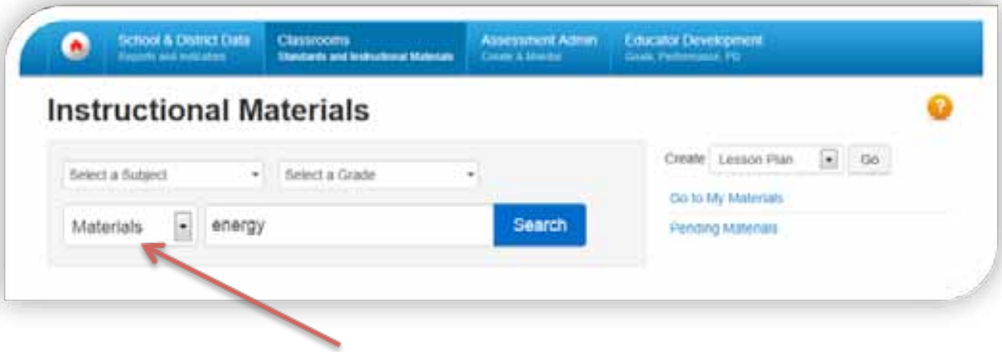

In my topic search for "energy" I found 30 different materials related to energy. They included PowerPoints, units, lessons, labs, virtual labs, lab learning logs, and handouts. If any of those materials meet your needs, click on "Save" to add to your materials. Many of the materials (those that aren't PDFs) can be edited to meet your needs and resaved in your materials.

CIITS is intended to be a one-stop shop for educators, but also a place to share instructional materials. If you have a resource that would be beneficial for other teachers, just create that material or upload it to CIITS and submit it to your district and the state level.

In the next addition of this newsletter, there will be more information on how to submit your materials to CIITS to help ensure quality resources get in the hands of all Kentucky teachers.

Assessment

Whole class questioning: Are we maximizing the potential for rich formative assessment?

Melissa L. Shirley, *Ph.D., College of Education and Human Development, University of Louisville*

ALL

Formative assessment. Assessment for learning, not assessment of learning. Bellringers. Exit slips. Diagnostic quizzes. Worksheets. Thumbs-up/thumbs-down. Asking students questions. We've been hearing about formative assessment for years now. What makes an instructional strategy be formative assessment? And more importantly, how can we integrate formative assessment into our instruction without losing significant instructional time?

Here's how I determine if something is formative assessment: Formative assessment is using any instructional means possible to find out what our students know about a topic or concept and using that information to help them learn more. Formative assessment is more about the quality of the data that we collect and how we use it to help student learning, and less about the strategies we call formative assessment, how frequently we use it, and whether or not we grade it. I propose three key factors to consider whether a formative assessment is of high quality:

1. How well does the formative assessment strategy/prompt probe for the learning we want to measure?
2. How well does the formative assessment strategy/prompt help us know what students are really thinking?
3. To what extent can the collected data help us to make instructional decisions?

If we aren't assessing what we want to assess, the results don't make a difference for instruction. If the assessment isn't getting to the heart of what students understand, we are limited in our ability to interpret what they know. If it takes too long to review the results and students have gone on to the next concept, we can't use the data to make appropriate and timely instructional decisions.

Particularly in upper grades, a large portion of instruction occurs through whole-group instruction. And teachers often engage students in informal questioning during whole-group instruction. Carried out with skill and intentionality, questioning holds great potential for informing teachers of what students really understand and meets the three criteria above. If not, we may be missing some great opportunities for rich formative assessment.

Effective questioning helps a teacher get a snapshot view inside a student's mind: it lets the teacher know what the student is thinking. And knowing what students know (or don't know) is the first step in carrying out formative assessment. If we don't know what our students think about a specific science concept, we can't make good decisions about how to correct misconceptions or extend students' learning to result in increased student achievement.

Here's an activity I ask of the pre-service teachers I work with so they can self-reflect, with evidence, on how well

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they are engaging in whole-class questioning – and I suggest that you try it also. I encourage you to pick a day when you will be doing a significant amount of whole-class instruction and audio-record your lesson. If you have a smart phone or tablet computer, you can use an app to help record the lesson. Your school's media center may also have a video or audio recorder that you can borrow.

Choose a 10-minute segment from your recorded lesson to focus on. If you transcribe all the questions and student responses during that 10-minute lesson segment, you'll have some real evidence of your own questioning practices. Think of a way in which you would like to improve your own questioning practice, then use the transcript to give you real evidence of how you are currently questioning and help you identify areas for change or areas where you are already doing well. You might even wish to do this as part of your PLC activities or with a group of colleagues with whom you feel safe sharing your teaching practice and growth.

Over the next few months, I'll share some ideas you can use to examine different aspects of classroom questioning. Each article will include specific examples of that month's questioning topic, aligned to the Next Generation Science Standards.

You might wish to analyze your transcribed lesson segment with respect to each of these aspects of questioning as they come up (even if it's on a different topic than the examples I use!).

These are the four aspects we will address in this series:

1. Questions that stretch students' thinking
2. Eliciting deep student responses
3. Extended, focused cycles of questioning
4. Hearing from many student voices

Whole class questioning: Questions that stretch students' thinking

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This is the second entry in a series of articles about how to increase the effectiveness of whole-class questioning to support informal formative assessment. In the first article I encouraged you to record a 10-minute excerpt of a science lesson in which you carried out a significant amount of class discussion. If you did that, you can follow along with your own excerpt to reflect on how well your questions stretch students' thinking. If you don't have a recorded excerpt, I encourage you to think of an upcoming lesson and consider how you might apply these ideas to the topic you will teach. In this article, we're going to take a closer look at the kinds of questions teachers can ask and how those help us know what students think about a science concept. They are arranged in order from questions that give us the least information about student thinking to the questions that give us the most.

Many of us, myself included, resort to rhetorical or leading questions during class discussions. Rhetorical questions occur when we either answer the question ourselves or give the answer in our question, like in this example:

Teacher: And what do we call this part of the water cycle? (points to the diagram) Precipitation.

Does the teacher really want or expect a contribution from the class? Perhaps not. Why do we use rhetorical questions? Often, they help us to pace a lecture and keep the information from sounding like a lecture. Or they make us think that students are following along when they nod in agreement as we give them the answer. (I asked two rhetorical questions in this paragraph alone!) When we ask rhetorical questions, we don't have any idea what students are really thinking. They give us no information we can use for formative assessment. So clearly, we need a better set of questions to ask.

I use a compressed version of Bloom's Taxonomy (see Bloom, 1956; Anderson, 2001; Krathwohl, 2001) to categorize my questions. The next-richer type of question would be knowledge, and it makes up most of the questions many teachers ask. Knowledge questions ask students to respond with memorized or rote information, or to articulate an observation.

Teacher: Someone tell me, what is the name of the process where liquid water turns into vapor?

Student: Evaporation.

When students answer knowledge questions, we can be sure they have memorized a definition, but we aren't sure to what extent they understand, for example, what evaporation is or why it is important in the water cycle. We have some formative assessment information, but it is very limited.

The next-richest types of questions are comprehension or application questions. Students have to manipulate information in some way – describing, interpreting, giving steps in a process, solving a simple calculation, reading data directly from a graph.

Teacher: And what happen to the rate of evaporation if the temperature of the surrounding air is increased?

Student 1: It will go up.

Student 2: More water will evaporate.

This type of question allows the teacher to get a deeper glimpse into student thinking because students are not only recalling information but understanding the meaning of their knowledge or using a process.

The highest level of question includes those classified as analysis, evaluation, or synthesis. In all of these types of question, students have to use multiple steps to break apart a concept, judge a result, or understand how the parts of a system relate to the whole. Here's an example of a higher-level question that requires students to relate knowledge from several different topic areas to construct a possible explanation.

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Teacher: The season for dangerous hurricanes in the southeastern coastal U.S. is typically June through August. Based on what we know about the water cycle, what are some reasons that stronger hurricanes would form during this time?

Student: Well, that's summer, so it's hotter. If the air is hot, more water evaporates so there would be more water in the air to come down as precipitation.

From a formative assessment perspective, if we want to know what our students know, we should ask as many higher level questions as we can. Of course, we also need to ask lower levels of questions, too, but if we don't ask higher levels we are missing some great opportunities for rich formative assessment!

If you're including a good range of question types in your lessons, you might prefer to focus on a different area of professional growth. But if this is an area where you would like to work on your practice, here are some suggestions that might help you increase your skill in this aspect of questioning.

During lesson planning, write out a certain number of higher-level thinking questions to ask students.

Make a list of high-level question starters that you can quickly apply to specific content. Carry it around on a clipboard, on an index card, or taped to your desk. As you are carrying out whole-class discussion, modify the end of the question to apply to your lesson.

Set a goal for what percent of your questions you want to be higher-level. After a few weeks, record your lesson again and see if you have met your goal.

You may also need to train your students in how to interpret and respond to your higher-level questions, or the depth of their responses might frustrate you – but that's the topic of next month's article!

References

Bloom, B. S. (1956). Taxonomy of Educational Objectives, Handbook I: The Cognitive Domain. New York: David McKay Co Inc.

Anderson, L.W. (Ed.), Krathwohl, D.R. (Ed.), Airasian, P.W., Cruikshank, K.A., Mayer, R.E., Pintrich, P.R., Raths, J., & Wittrock, M.C. (2001). *A taxonomy for learning, teaching, and assessing: A revision of Bloom's Taxonomy of Educational Objectives (Complete edition).* New York: Longman.

Krathwohl, D.R. (2002). A revision of Bloom's taxonomy: An overview. *Theory into Practice, 41(4), 212-218.*

Professional Learning Opportunities

Next Generation Science Standards Professional Development Opportunities Presented by PIMSER at the University of Kentucky College of Education

PIMSER
Partnership Institute for Mathematics & Science Education

NGSS Short Courses for Teachers

One-day short courses for elementary, middle, and high school teachers focused on strengthening content understanding, developing and using models, and using mathematics and computational thinking. Teachers will leave with a deeper understanding of the NGSS, both content and practices, along with sample activities that can be used with students.

$125 per session

Date	Topic	Grade Level
June 16	Light	1 and 4
June 23	Force and Motion	K and 3
June 30	Properties of Matter	2 and 5
July 21	Developing and Using Models	6 through 8
July 25	Using Mathematics and Computational Thinking	9 through 12

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Complete details on each course here: http://www.rsvpbook.com/ngssshortcourses
Find all of PIMSER's professional development opportunities at www.uky.edu/p12mathscience

The Kentucky Writing Project and the Kentucky Department of Education present two Summer 2014 workshops on Science Literacy through Science Journalism

July 7, 8, 9 8:30-3:30 Eastern / Louisville, KY

July 22, 23, 24 8:30-3:30 Eastern / Ashland, KY

18 hrs. PD credit

What: This three-day workshop will support you in engaging students in meeting the new Common Core Standards for research through the SciJourn process (www.scijourn.org). The process is based on a four-year NSF-funded research project demonstrating that teaching science journalism using reliable data sources and science-specific writing standards improves students' understanding of and literate engagement in science. Participants are invited to join the KWP SciJourn Network to receive follow-up support and share their students' experiences with like-minded teachers.

Who: Middle and high school science teachers and language arts teachers interested in authentic writing experiences for their students. Facilitated by the Kentucky Writing Project SciJourn Leadership Team.

Cost: $250 per person (Early Bird price, $200 by June 1). Registration includes text: Front Page Science: Engaging Teens in Science Literacy (NSTA Press) For more information please contact Marsha Buerger, KWP SciJourn Director and Co-Director of the Louisville Writing Project: marsha.buerger@jefferson.kyschools.us, 502-727-6933.

Kepler Art of Discovery –Art Contest Announcement (March 10 – May 5, 2014)

As part of the celebration of, and to help commemorate, the 5th Anniversary of NASA's Kepler Mission, (which launched in March 2009), this art contest will be open to artists from the age of 13 through adult. They will be encouraged to submit their creative artwork that depicts, or relates to, the exciting discoveries made possible by the Kepler Mission space craft and its team of scientists and engineers.

The best artwork, selected by a combination of participants' votes and expert judges' scores, will be displayed as the Top 100 in the Gallery of the Art of Discovery website. For more information about the art contest, visit:http://keplerart.seti.org/

Contact information: Gary Nakagiri, EPO specialist, SETI Institute/Kepler Mission gnakagiri@seti.org

Collaboration and Connections:

The Science Connections Newsletter offers a forum for science professionals across Kentucky to collaborate and share classroom experiences. You are encouraged to share instructional strategies, resources and lessons that you have learned with colleagues across the state. Note that your entries should relate to one, or all, of the topics for the next month as noted below.

Below are the upcoming SCN focus dimensions:

Coming up:	Science and Engineering Practice	Disciplinary Core	Crosscutting Concept
May	Engaging in Arguments From Evidence	PS2: Motion and Stability: Forces and Interactions	Stability and Change
June	Using Mathematics and Computational Thinking	LS3: Heredity: Inheritance and Variation of Traits	Structure and Function

E-mail your contributions to christine.duke@education.ky.gov.

All submissions are needed by the 25th of the month.

KDE Revised Consolidated Compliance Plan for Non-Discrimination Available

Please be advised that the Kentucky Department of Education has revised its Consolidated Compliance Plan for Non-Discrimination. The revised plan has been posted on the Legal and Legislative Services page on KDE's website and includes a Discrimination Complaint Form that can be filled out by anyone alleging discrimination against KDE staff and/or KDE program areas.