PreK-8 STEM Design Principles

- K-8 STEM School will ensure opportunities for all students to be academically challenged while appropriately supported. There will be no academic admission criteria for any students.

- K-8 STEM School will start and stay small but have a "large district footprint".

- K-8 STEM School will use multiple metrics to measure success. Students will be expected to demonstrate mastery of curriculum in multiple ways and no one single measure of achievement alone will be considered an appropriate demonstration of mastery.

- K-8 STEM School’s instructional program will reflect the need for all STEM work to be trans-disciplinary in nature. Students will be expected to master core literacy skills of writing, reading, speaking, listening, viewing, and presenting and STEM literacy skills of design, inquiry, invention, and teamwork through highly differentiated instructional programming.

- K-8 STEM Schools will ensure a regular culture of discovery, collaborative learning, content integration, and workforce relevance using a problem/project based approach.

- K-8 STEM Schools will provide at least 4 hours of common planning time per week for all teaching teams, grade level teams and leadership within the teaching day or, with permission, after school.

- K-8 STEM School will serve as a microcosm of the global STEM community. All STEM school partners, including students, parents, faculty, and staff, and community participants will be engaged in an array of opportunities to work collaboratively in leadership, internship/fellowship, advisories, mentorships, and service learning roles.

- K-8 STEM School will recognize the importance of citizenship and will ensure ongoing outreach opportunities that promote the strength of the school community and that ensure parents are actively engaged in their child’s education in relevant meaningful ways.

...a teacher of mathematics has a great opportunity. If he fills his allotted time with drilling his students in routine operations he kills their interest, hampers their intellectual development and misuses his opportunity. But if he challenges the curiosity of his students by setting them problems proportionate to their knowledge, and helps them to solve their problems with stimulating questions, he may give them a taste for, and some means of, independent thinking.

George Polya, How to Solve It, 1946
Prek-8 STEM Initiative and the Ohio STEM Learning Network

What is STEM Education?

STEM stands for Science, Technology, Engineering and Math. While originally designed to encourage more students to pursue careers in these specific areas, STEM education has evolved into a unique approach to teaching and learning that fosters creativity and innovative thinking in all students. STEM education is a direct response to the realization that other states and nations are gaining competitive advantage by asserting their scientific and technological leadership, and that Ohio’s future will be built on its own capacity for innovation, invention and creative problem solving. STEM education produces exactly the kind of thinkers, innovators and problem solvers such a world demands.

How is STEM education different from a traditional approach to education?

STEM schools are centers of creativity and innovation that provide challenging, student-centered, inquiry-based educational experiences that are cross-disciplinary in nature and relevant to the real world. Unlike traditional school experiences in which different subject areas are treated as separate “silos,” STEM education emphasizes the technological-design process and integrates subjects in ways that emphasize connections across disciplines. In a STEM classroom, students develop analytical and creative skills through investigation and problem solving – STEM moves beyond an emphasis on simple test performance and focuses instead on developing higher-level thinking skills. STEM education also typically features strong levels of collaboration among education, business and community partners to help develop relevant curriculum and provide internships, mentorships and co-operative education opportunities to help students connect classroom learning to the real world.

Is it true, as some people suggest, that STEM education is only for a small, select number of students interested in careers in math and science fields?

No. While increasing the number of our young people who choose careers in STEM fields is certainly one objective driving STEM education, it is only part of the story. STEM education develops skills that have much broader application than just areas such as math and science. STEM education emphasizes collaboration, communication, research, problem solving, critical thinking and creativity – skills that all students must have to be successful in today’s world, no matter what their specific interests or career goals are. STEM education also places a strong emphasis on personalizing educational experiences to best suit students’ individual learning styles and interests – which means STEM education has something to offer to every student.

Ohio STEM Learning Network

The Ohio STEM Learning Network (OSLN) is an unprecedented collaborative aimed at building and connecting STEM (Science, Technology, Engineering and Mathematics) teaching and learning capacity in regions across the State of Ohio. At its core, the OSLN is focused on student and teacher success, built from a slate of committed partners from Pre-K-12 education, higher education and business and industry.

Designed from a systems engineering approach, the OSLN will help develop and connect a state-wide system of innovative STEM schools and Programs of Excellence, leveraging the ongoing work of regions across the state, along with a $12 million grant from the Bill & Melinda Gates Foundation and an initial $2.8 million investment from Battelle. This will be done through a state-level public-private partnership that includes Battelle, Ohio Partnership for Continued Learning, Ohio Business Roundtable, Ohio Business Alliance for Higher Education and the Economy, Cleveland Foundation, and the Teaching Institute for Excellence in STEM (TIES). Locally, many partners across the state are involved in this work.

The OSLN upholds three overarching objectives:

a) Enhancing STEM teaching and learning capacity that is closely aligned with state-level guiding principles as specified in Am. Sub. H.B. 119, Ohio’s biennial budget.

b) Accelerating existing and emerging STEM initiatives such as STEM start-up schools and related K-8 STEM Programs of Excellence.

c) Creating a network-based infrastructure that promotes and connects innovative, scalable and sustainable STEM initiatives.
Fact Sheet:
What STEM Education Is & What STEM Education Isn’t

What STEM education is:

- **STEM education is a teaching philosophy that fosters creativity and innovation in Ohio’s students.** STEM schools are centers of creativity and innovation that provide challenging, student-centered, inquiry-based educational experiences. Unlike a traditional curriculum, STEM education teaches students to integrate skills from different subject areas to help them develop innovative solutions to real-world problems.

- **STEM education is designed to prepare students for success in college, in careers, and as responsible citizens.** STEM education develops Ohio’s students’ creative, analytical, teamwork, communication and problem-solving skills – all essential to success in today’s world, no matter what students’ interests or career goals are.

- **STEM education is a direct response to the realization that Ohio’s future will be built on technological leadership, knowledge creation and innovation.** Ohio, along with the rest of the nation, has fallen behind in the global market as other states and nations have gained competitive advantage by asserting their scientific and technological leadership. STEM will elevate Ohio’s position in the global economy and give our students the skills they need to successfully compete with talent from around the world.

- **STEM education is the key to Ohio’s economic turnaround.** STEM education unleashes students’ creativity and gives them the skills needed to conceive and develop the revolutionary products and processes that will shape Ohio’s economic future. A STEM-literate workforce will attract investment and jobs to Ohio, while good jobs and economic opportunity will attract world-class talent.

What STEM education isn’t:

- **STEM education is not highly specialized education for an elite group of students.** When fully realized, STEM will serve all students in public schools across Ohio.

- **STEM education is not only for those interested in science, engineering, technology or math.** STEM education goes beyond training scientists, engineers and technology professionals. It helps all students develop and apply essential skills through a rigorous and diverse curriculum, a college-ready and work-ready culture, personalized learning opportunities, and a top-flight teaching force. These skills will serve students in all areas of their future education and careers.

- **STEM education is not beneficial only to those enrolled in STEM schools or STEM Programs of Excellence.** All students benefit from a strong STEM infrastructure. STEM schools share curricular and teacher professional development tools and best practices, impacting surrounding traditional schools. Furthermore, regional STEM centers will develop STEM curriculum and instructional tools, train STEM teachers, share STEM best practices and provide STEM distance-learning experiences for students across the state.

- **STEM education is not one-size-fits-all.** STEM is highly personalized education that caters to students’ individual learning styles and interests through individual student and faculty interaction. STEM students have the opportunity to build upon their strengths and learn in ways that are most meaningful and beneficial to them. Students are active in internships and are often earning college credit while still in high school.
Capstone = PBL

Capstone: A capstone experience is defined as a culminating student experience in which students apply the STEM concepts that they learn to solve an open-ended, preferably real-life, problem.

**Project-Based vs Problem-Based Learning**

**Project-based learning** is an instructional strategy in which students work cooperatively over time to create a product, presentation, or performance. The two essential components of project-based learning are an engaging and motivating question and a product that meaningfully addresses that question.

Important characteristics of project-based learning, according to The Road Ahead Background Papers, a report prepared by ISTE, include the following:

- Students can shape the project to fit their own interests and abilities.
- Students collect and analyze information, make discoveries, and report their results.
- Students conduct research using multiple sources of information.
- The project cuts across a number of disciplines.
- Students must draw on a broad range of knowledge and skills.
- The project extends over a significant period of time.
- The project involves the design and development of a product, presentation, or performance that can be used or viewed by others.
- The context for the subject matter is larger than the immediate lesson.
- The instruction and facilitation is guided by a broad range of teaching goals.

**Problem-based learning** is an instructional strategy in which students work cooperatively to investigate and resolve an ill-structured problem based on real-world issues or situations. The steps involved in problem-based learning include:

- determining what the problem is;
- creating a specific statement of the problem;
- identifying the information needed;
- identifying the resources to be used to find that information;
- developing a possible solution;
- analyzing and refining the solution;
- presenting the final solution, orally, in writing or as a demonstration, product of performance.

**Project-based learning and problem-based learning** have a great deal in common.

- involve realistic problems and situations.
- are based on authentic educational goals.
- include formative and summative evaluation.
- are learner centered and teacher facilitated.
- are intrinsically engaging and motivating.
- are frequently multidisciplinary.
- Improve students’ research and problem-solving skills, as well as their ability to work cooperatively with their peers.

The difference between the two lies largely in their application: Problem-based learning focuses on the problem and the process, while project-based learning focuses on the product.
**Rigor/Relevance Framework®**

The Rigor/Relevance Framework is a tool developed by staff of the International Center for Leadership in Education to examine curriculum, instruction, and assessment. The Rigor/Relevance Framework is based on two dimensions of higher standards and student achievement.

First, there is the Knowledge Taxonomy, a continuum based on the six levels of Bloom's Taxonomy, which describes the increasingly complex ways in which we think. The low end involves acquiring knowledge and being able to recall or locate that knowledge. The high end labels the more complex ways in which individuals use knowledge, such as taking several pieces of knowledge and combining them in both logical and creative ways.

The second continuum, known as the Application Model, is one of action. Its five levels describe putting knowledge to use. While the low end is knowledge acquired for its own sake, the high end signifies use of that knowledge to solve complex real-world problems and to create unique projects, designs, and other works for use in real-world situations.

The Rigor/Relevance Framework has four quadrants. Each is labeled with a term that characterizes the learning or student performance at that level.

The Rigor/Relevance Framework is easy to understand. With its simple, straightforward structure, it can serve as a bridge between school and the community. It offers a common language with which to express the notion of a more rigorous and relevant curriculum.

The Rigor/Relevance Framework is versatile; it can be used in the development of instruction and assessment. Likewise, teachers can use it to measure their progress in adding rigor and relevance to instruction and to select appropriate instructional strategies to meet learner needs and higher achievement goals.

HTTP://WWW.LEADERED.COM/RRR.HTML

© 2011 International Center for Leadership in Education
Levels of Inquiry

<table>
<thead>
<tr>
<th>Inquiry Level</th>
<th>Name</th>
<th>Description</th>
<th>Example</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Confirmation, Validation, or</td>
<td>Students confirm a principle already learned in class by following step-by-step</td>
<td>“In this investigation, you will confirm the concept learned yesterday that</td>
</tr>
<tr>
<td></td>
<td>“Cookbook”</td>
<td>instructions.</td>
<td>temperature increases reaction rate. Follow the procedure below and record</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>your data in the charts given.&quot;</td>
</tr>
<tr>
<td>2</td>
<td>Structured Inquiry</td>
<td>Students investigate a principle that they have NOT learned yet through a</td>
<td>“In this investigation, you will determine the relationship between</td>
</tr>
<tr>
<td></td>
<td></td>
<td>prescribed procedure.</td>
<td>temperature and reaction rate by following the procedure below and</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>recording your data in the charts given.</td>
</tr>
<tr>
<td>3</td>
<td>Guided Inquiry</td>
<td>Students investigate a principle that they have NOT learned yet through a</td>
<td>“Design an investigation to answer the question: ‘What effect will</td>
</tr>
<tr>
<td></td>
<td></td>
<td>teacher-generated question using their own procedure and data.</td>
<td>water temperature have on reaction rate?’ Develop a hypothesis,</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>determine a procedure, collect data, and present your conclusion based</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>on that data. Your procedure must be approved before implementation.”</td>
</tr>
<tr>
<td>4</td>
<td>Open Inquiry</td>
<td>Students formulate a question and design the procedure to answer that</td>
<td>“Design an investigation to explore a chemistry topic or answer a</td>
</tr>
<tr>
<td></td>
<td></td>
<td>question.</td>
<td>chemistry question related to what we have been studying. Your</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>procedure must be approved before implementation.”</td>
</tr>
</tbody>
</table>

What is inquiry?

The *National Science Education Standards* characterize inquiry instruction as involving students in a form of active learning that emphasizes questioning, data analysis, and critical thinking.

"Students at all grade levels and in every domain of science should have the opportunity to use scientific inquiry and develop the ability to think and act in ways associated with inquiry, including asking questions, planning and conducting investigations, using appropriate tools and techniques to gather data, thinking critically and logically about relationships between evidence and explanations, constructing and analyzing alternative explanations, and communicating scientific arguments" (NRC 1996, p. 105).

At its heart, inquiry is an active learning process in which students answer research questions through data analysis. One might argue that the most authentic inquiry activities are those in which students answer their own questions through analyzing data they collect independently. However, an activity can still be inquiry based when the questions and data are provided, as long as students are conducting the analysis and drawing their own conclusions. Furthermore, most students need substantial scaffolding before they are ready to develop scientific questions and design effective data collection procedures to answer these questions. The deal plan for inquiry instruction recognizes this fact and seeks to help students progress to greater inquiry skills through a series of graduated steps, as described later in this article.

THINK, PAIR, SHARE

1. Generate a central idea, theme or topic in the center bubble
2. Discuss possible extensions of the main idea with identifying standards and benchmarks from multiple disciplines.
3. Align benchmarks to each activity and develop an assessment tools for measuring student demonstration of the benchmarks through the activities, projects, or presentations.

SCIENCE       MATH       READING       ENGLISH       SOCIAL STUDIES
VISUAL & PERFORMING ARTS TECHNOLOGY ENGINEERING LANGUAGE
Benchmarks:

Essential Questions Brainstorm:

Project Brainstorm:
## Rubric for Capstone Development

Check your Capstone and Unit against this development rubric

<table>
<thead>
<tr>
<th>Score</th>
<th>Category</th>
<th>4 Advanced Exemplary Yes Plus</th>
<th>3 Proficient Accomplished Yes</th>
<th>2 Basic Developing No, but</th>
<th>1 Novice Beginning No, not yet</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>The big idea of the capstone is clearly articulated in one of the following forms: concept, theme, theory, issue, problem, process, paradox, perspective</td>
<td>The big idea of the capstone is so powerful and so clearly articulated that students are able to remember it three years or more after the capstone experience</td>
<td>Needs more clarity, needs to be stated more succinctly</td>
<td>Idea not ‘big’ enough, needs to be a synthesis that transcends and includes all that will be learned</td>
</tr>
<tr>
<td></td>
<td></td>
<td>The essential question for the capstone is designed to engage students in inquiry and exploration</td>
<td>The essential question is so well-designed that it sustains engagement throughout the capstone</td>
<td>Needs more of a ‘hook’ for engaging adolescent learners</td>
<td>Question is not ‘essential’, not one that requires uncovering and discovery</td>
</tr>
<tr>
<td></td>
<td>Transdisciplinary academic content benchmarks are identified for the capstone and further chunked together into units and unit projects</td>
<td>Transdisciplinary units seamlessly flow through the entire capstone period and the capstone project(s) connect together or are one transdisciplinary project</td>
<td>Transdisciplinary academic content benchmarks are identified for the capstone and further chunked together into units and unit projects</td>
<td>Unit projects need to be more inclusive of all content disciplines</td>
<td>Units are not adequate to hold the benchmarks identified as capstone; do not cohere w/ big idea</td>
</tr>
<tr>
<td></td>
<td>The capstone’s mastery learning goals are deconstructed and represented in a rubric that describes clear, scaffolded performance criteria for the demonstration of mastery learning, as well as, learning that goes beyond mastery, approaches mastery, or is basic to mastery</td>
<td>The rubric so clearly describes scaffolded performance criteria for each mastery learning goal that every student sees and understands what is expected of him/her to be successful beyond mastery</td>
<td>The capstone’s mastery learning goals are deconstructed and represented in a rubric that describes clear, scaffolded performance criteria for the demo of mastery learning, as well as, learning that goes beyond mastery, approaches mastery, or is basic to mastery</td>
<td>Needs more clarity in the description of the criteria for each level of performance</td>
<td>The rubric does not present scaffolded performance criteria</td>
</tr>
<tr>
<td></td>
<td>The learning activities within the capstone (including their sequence and pacing) provide adequate scaffolding/differentiation to facilitate successful performance of the mastery learning goals during both project time and class time</td>
<td>Differentiation of learning activities within the capstone is so prevalent that every student is not only meeting the mastery learning goals but is reaching their individual potential as well</td>
<td>The learning activities within the capstone (as well as their sequence and pacing) provide adequate scaffolding / differentiation to facilitate successful performance of the mastery learning goals in both project time and class time</td>
<td>The pacing/amount of time allotted for learning activities in either or both project time and class time need adjustment to facilitate successful performance of the learning goals</td>
<td>The learning activities do not provide adequate scaffolding / differentiation to facilitate successful performance of the mastery learning goals in both project time and class time</td>
</tr>
<tr>
<td></td>
<td>Formative assessments of student performance on learning activities are designed into the capstone and units to provide data that determines learning activities and their pacing, as well as, the provision of remediation/extension opportunities - to insure successful performance of the mastery learning goals</td>
<td>Multiple different learning activities, pacing options and remediation/extension activities triggered by different possible formative assessment data</td>
<td>Formative assessments of student performance on learning activities are designed into the capstone and units to provide data that determines learning activities and their pacing, as well as, the provision of remediation/extension opportunities - to insure successful performance of the mastery learning goals</td>
<td>Does not indicate how data from formative assessments would impact decisions re: learning activities and their pacing or the provision of remediation/extension</td>
<td>Does not include description formative assessments of student performance on learning activities</td>
</tr>
<tr>
<td></td>
<td>The capstone and units as a whole and the learning activities contained within have a high degree of rigor and relevance</td>
<td>Across the board, the learning activities in this capstone exceed the rigor and relevance of the Ohio benchmarks</td>
<td>The capstone as a whole and the learning activities contained within have a high degree of rigor and relevance</td>
<td>Some learning activities not in Quadrant D could become Quadrant D activities with a little tuning</td>
<td>The learning activities contained within the capstone and units are not getting students to perform in Quadrant D</td>
</tr>
</tbody>
</table>