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Introduction

Why is STEM important

What is STEM? STEM is an acronym for science, technology, engineering, and math. In recent times STEM has created quite the buzz among our schools; however, the various meanings of STEM can create confusion and misunderstanding. The increased attention for STEM in schools has been due to recent educational and political urging to improve students' overall performance in mathematics and science (Murphy, 2011). In order to peak students' interest in these areas, we must change the way that students view the STEM subject areas. In examining research, we find that an interdisciplinary or integrated curriculum provides students with a relevant, comprehensive, and more stimulating experience in the classroom (Bybee, Powell, & Ellis, 1991). It is our hope that these experiences will embed a knowledge base within our students that will continue to grow throughout their studies, eventually transforming into future careers in the STEM disciplines.

Our nation is currently experiencing a shortage of individuals pursuing STEM careers, and that demand is only expected to increase over the next few years. To answer the question of when we can expect relief in these fields, we look at the number of students enrolled in higher education STEM fields. This too also falls short of the demands for jobs (Rockland, et al, 2010). Therefore, the call for STEM programs at the elementary level is being pursued as the answer to our national problem.

Need for STEM programs and instruction in elementary

When looking at the characteristics of current elementary students, research suggests that students will have already developed a strong opinion about subject areas such as science and math before they reach middle school. Their ideas of these subjects and willingness to

investigate are not likely to change over the years (Archer, et al, 2012). This leads us to look at the way young students learn. Murphy (2011) summarizes the learning of children as discovery and exploration. He asserts that children are already young scientists and engineers, who have an innate tendency to touch, taste, build, dismantle, create, discover, and most importantly explore their surroundings. While educators say they are learning, the children view their behaviors as fun. In order to best educate this group of students, teachers will need to make learning both fun and relevant to the student's current interest and needs. In a study by Habashi, Graziano, Evangelou and Ngambeki (2008), researchers found that teachers were effective at directing elementary students' interest in STEM by targeting students' personal interests in objects. They discovered that the personal connection was a motivational influence for engaging in STEM activities. However, in this longitudinal study, the effect was strongest with third grade students when their interests were more "plastic", and diminished significantly by sixth grade. These results indicate that if more children are to enter the STEM pipeline, then teachers in early elementary grades need to be prepared to provide interesting and engaging lessons that focus on developing children's problem-solving and spatial ability while encouraging their intrinsic interest in STEM. This means that the current practices of lecture and worksheets will need to be modified to a more engaging style of teaching.

This information leads to the implementation of STEM and project based learning (PBL) in the elementary schools. While there have been attempts to define the results of a STEM curriculum, there has been little agreement about how this should be accomplished. It is agreed, however, that students engaged in STEM through PBL are exposed to problem-solving, innovation, logical thinking, and technological literacy (Lantz, 2009). In an evaluation of STEM programs, Dejarnette (2012) suggested that elementary STEM education should be used to help

foster an interest in STEM subject areas for continued interest among students. He linked students' involvement with STEM programs and learning with a higher likelihood of pursuing STEM fields and advanced study, stressing that reaching students at a younger age is of vital importance. Research also shows that early exposure to STEM initiatives and activities positively impacts elementary students' perceptions and dispositions (Bybee, & Fuchs, 2006). This positive attitude, coupled with the desire to learn, is what educators and elementary schools need to be achieving. Brotman and Moore (2008) studied elementary female students who were engaged in hands-on science projects. Their research showed that these girls were more likely to perform well in science and math, as well as inclined to engage in STEM fields at the collegiate level. A study by Marx, Blumenfeld, Krajcik, Fishman, Soloway, Geier, and Tal (2004) confirmed that PBL was successful at increasing students' tests scores when compared to traditional instruction. The researchers found that PBL creates an atmosphere where students feel compelled to conduct research, ask questions, and explore beyond the stated requirements of a given lesson. Through PBL our students will be able to develop a deeper meaning and understanding through their experiences, leading to a positive outcome and greater interest in STEM subjects. Students will become more actively engaged when they have to organize, structure, and then apply their newly developed knowledge.

With the federal and state push for new learning standards such as *Common Core State Standards, Framework for K-12 Science Education, and Technology for All Americans*, teachers will already be required to adapt their classroom instruction. STEM programs and learning which include the inclusion of engineering and technology can provide elementary students with the opportunity to be fully engaged and think critically about the problems society is facing. Students' exposure to the engineering design process will greatly benefit their future studies and

ability to think independently, collaborate with others, and solve problems in a variety of situations and fields. It is possible that with the added stress of new learning standards, STEM programs can be the answer to a successful and meaningful implementation.

There are several factors that should be addressed when looking to implement STEM programs in elementary schools. In a recent study, it was discovered that out of 315 STEM schools, only 3 to 4 percent were geared for elementary learning (Means, et al., 2008). This means that schools that understand the need for STEM learning will have to build their environments without a large template to choose from.

Importance of STEM lab space

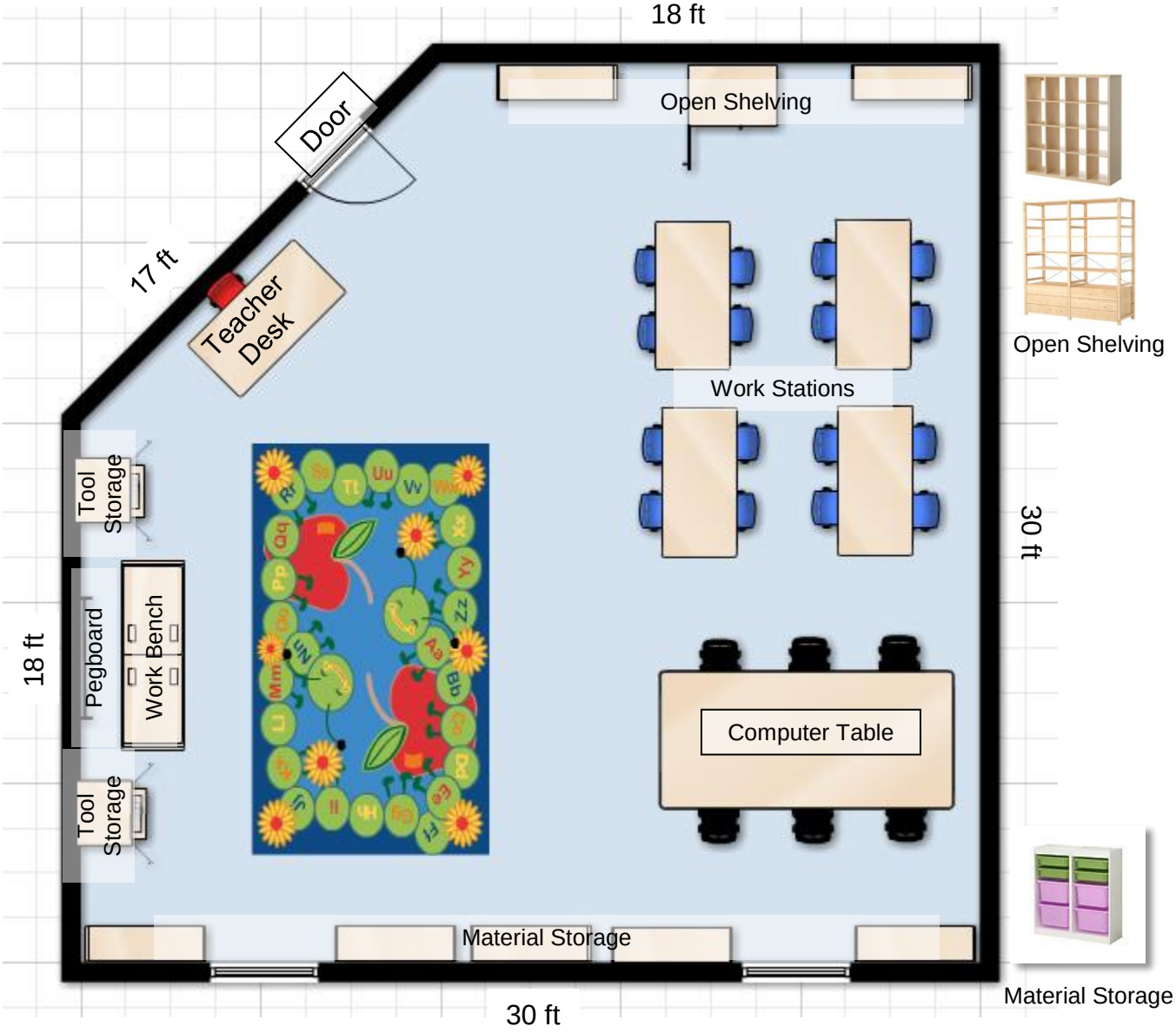
When looking at developing a STEM lab and space conducive to STEM project based learning, elementary schools throughout the nation seem to all be looking for assistance and guidance (Kelso, 2010). The following information will help to outline the importance in creating a STEM lab, as well as provide a rationale for learning and teaching. It is not uncommon for elementary teachers to feel apprehensive about teaching STEM lessons (Rittmayer & Beier, 2008), therefore we will need a highly skilled group of STEM teachers who can provide engaging lessons and professional development for other teachers within the elementary school. Kwan (2000) notes that despite the benefits of PBL and integrated STEM, many pre-service and current practicing teachers are reluctant to initiate PBL in their classrooms. This primarily involves concerns about classroom management, control over learning activities, and inability to answer students' questions. Several of these fears can be eliminated by having a designated STEM lab. The lab will be structured in a way that is conducive to exploration and project based learning. Most current elementary classrooms do not have the adequate space, storage, and materials that PBL learning requires. While the research is limited on STEM labs,

we can assert several key points that show the benefits of having one. It has been shown that student have a direct preference for environments that are characterized by work/life environments. This shows that not just the learning should be relevant to real life events, but also the space in which the students are working (DeFraine, et al, 2014). A separate study (Remmen & Froyland, 2014) showed that there was increased attention to material and excitement to learn when students were outside of their traditional classrooms. The study also recognized a deeper level of engagement and cooperative learning among the students. These characteristics directly correlate with integrated STEM and PBL. We feel that having an integrated STEM lab for the school will create a sense of space and confidence that will not just increase awareness, but continued interest in learning. As we move forward in our teaching practices, we want to make sure that our student's environment connects with their learning, therefore emphasizing the overarching need for a STEM lab.

STEM Lab Characteristics

The following pictorial models, visually shows the layout of our proposed STEM lab as well as rationales and descriptions.

Model STEM Lab and Description

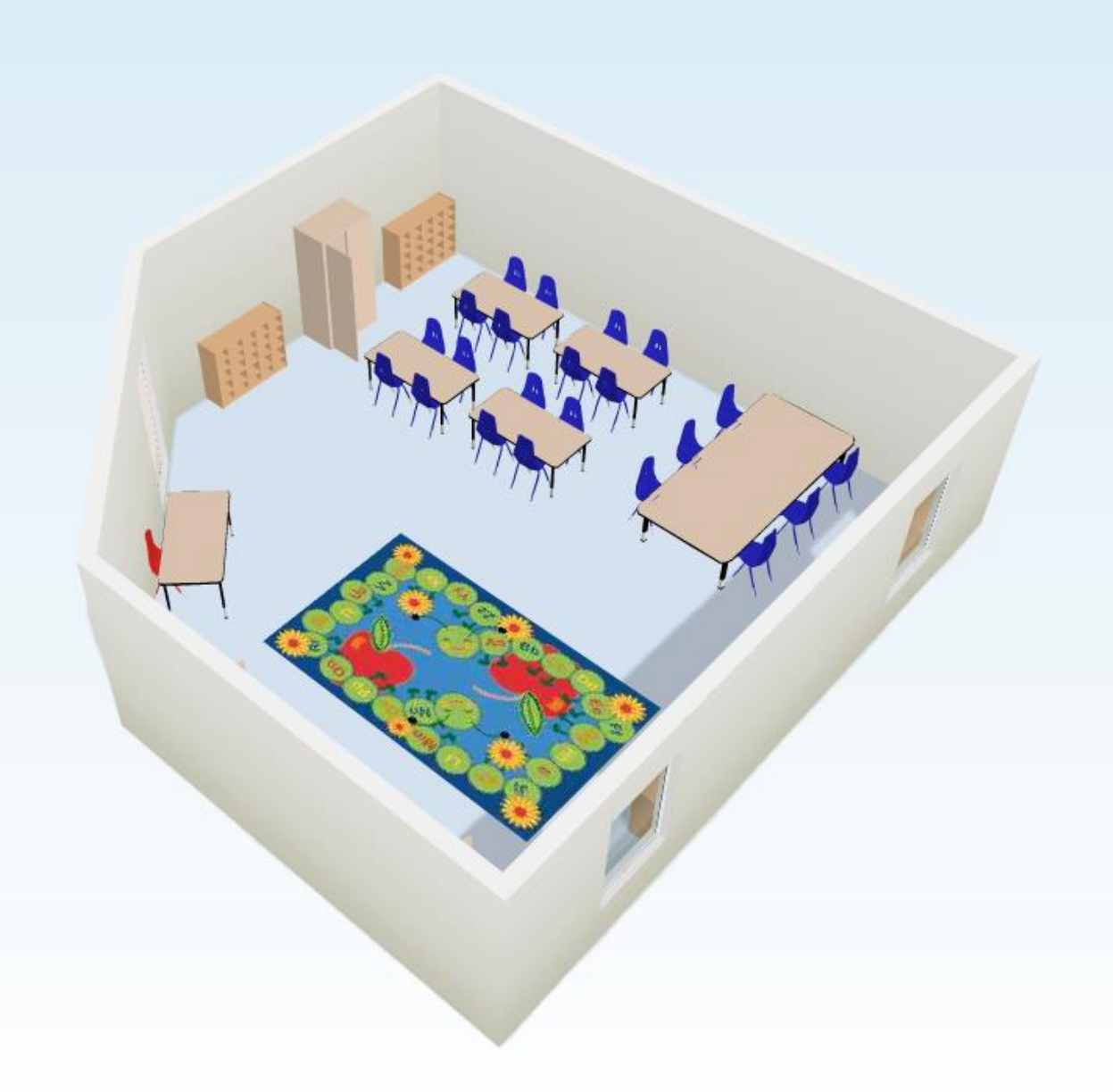


This is a 2-D overview of our STEM classroom. Immediately to the left of the doorway (as you enter) is a desk and chair for the STEM teacher. Against the West wall are two cabinets with doors to contain tools. Between the cabinets is a workbench with pegboard hanging over it to hold tools that stay out all of the time. There is a large carpet in front of this area that can be used for students to gather on. On the South wall are the Ikea Trofast storage bins. These run the entire length of the wall and hold materials to be used for projects. Additionally, the tops may be used to display student work. The East well contains one large table which houses six computers to be used for research. There are also four tables to be used by students during class. The North wall contains open shelving to display student work and store works in progress.

3-D overview of classroom

Here is a 3-D model of the West and South walls. On the West wall, you can see the two cabinets, which can be shut. These will contain tools that are not in use and that require supervision for use. In between these cabinets is a workbench, with a pegboard for hanging everyday tools over it. In front of this area is the carpet that will serve as a gathering area for students.

One the West wall, you can see the Trofast storage units lined up along the wall. These each contain four storage bins, which will hold materials to be used in design challenges. The tops may be used to display student work.



This is a 3-D model of the East and North walls. The East wall is home to a computer table with six computers, which students will use to research and brainstorm ideas during the design process. Additionally, there are four tables with chairs to be used daily by students as they work on their design challenges. The North wall contains open shelving to display student work and hold works in progress.

STEM Lab Budget

Essential tools

Essential Tools					
Item	**Cost**	**Per**	**Desired Number**	**Total Cost**	**Vendor**
Cutting Mats	$36.25	1	5	$181.25	Pitsco
Lumberjack Cutter	$44.95	1	1	$44.95	Pitsco
Miter Box Set (Metal)	$14.25	1	5	$71.25	Pitsco
Mini Easy Cutter	$17.50	1	4	$70.00	Pitsco
Retractable Utility Knife	$4.50	1	4	$18.00	Pitsco
Dual Temp Glue Gun	$16.95	1	1	$16.95	Pitsco
Fiberglass Handled Hammer	$22.00	1	2	$44.00	Pitsco
4" Quick Release Speed Clamp	$5.95	1	8	$47.60	Pitsco
30 Meter Wind Up Tape Measure	$15.95	1	1	$15.95	Pitsco
Quick Strip Wire Stripper	$4.25	1	2	$8.50	Pitsco
Safety Glasses	$1.95	1	30	$58.50	Pitsco
Drill Bit Set	$19.95	1	1	$19.95	Pitsco
Hand Drill	$16.00	1	4	$64.00	Pitsco
Long Nose Pliers	$7.75	1	4	$31.00	Pitsco
Stanley Measure Tape	$19.95	1	2	$39.90	Pitsco
Hand Drill Press	$89.00	1	2	$178.00	The Science Source
Lynx Joiner	$2.25	1	25	$56.25	The Science Source
Glue Gun Stand	$10.00	1	1	$10.00	The Science Source
			Total Cost:	**$976.05**	

Essential materials

Essential Materials					
Item	**Cost**	**Per**	**Desired Number**	**Total Cost**	**Vendor**
Balsa Wood Economy Bag	$9.00		5	$45.00	Pitsco
Art Straws for Structures	$49.95	1800	2	$99.90	Pitsco
Hot Melt Glue Sticks	$4.95	30	5	$24.75	Pitsco
Basswood Strips	$9.95	50	5	$49.75	Pitsco
Aluminum Foil	$1.75	1	5	$8.75	Pitsco
Dowel Rods	$0.40	1	200	$80.00	Pitsco
Electrical Tape	$1.25	1	10	$12.50	Pitsco
Foam Board	$1.45	1	50	$72.50	Pitsco
Duct Tape	$7.50	1	10	$75.00	Pitsco
Card Stock	$2.95	10	100	$295.00	Pitsco
Jumbo Craft Sticks	$3.50	75	50	$175.00	Pitsco
Construction Paper	$5.95	50	10	$59.50	Kelvin
Tissue Paper	$19.95	50	5	$99.75	Kelvin
Propulsion Bands	$1.80	100	10	$18.00	The Science Source
LED Light Bulbs	$0.65	1	50	$32.50	The Science Source
Sanding Block	$2.35	1	20	$47.00	The Science Source
Replacement Razor Saw Blade	$3.75	1	4	$15.00	Pitsco
			Total Cost:	**$1,209.90**	

Desired tools

Desired Tools					
Item	**Cost**	**Per**	**Desired Number**	**Total Cost**	**Vendor**
Electronic Digital Scale	$31.95	1	1	$31.95	Pitsco
10" Bench Drill Press	$250.00	1	1	$250.00	Pitsco
Test Leads	$8.25	10	10	$82.50	Pitsco
Diagonal Cutting Pliers	$14.00	1	4	$56.00	Pitsco
Calipers	$10.95	1	2	$21.90	Pitsco
Bottle Rocket Launcher and Luanch Pad	$72.50	1	1	$72.50	The Science Source
Clamp Pulley	$22.75	1	4	$91.00	The Science Source
Maglev Track	$200.00	1	1	$200.00	The Science Source
C Clamp Heavy Duty	$4.20	1	8	$33.60	The Science Source
			Total Cost:	**$839.45**	

Desired materials

Desired Materials					
Item	**Cost**	**Per**	**Desired Number**	**Total Cost**	**Vendor**
Maglev Ceramic Magnets	$9.95	12	20	$199.00	The Science Source
			Total Cost:	**$199.00**	

Storage and shelving

Storage / Shelving					
Item	**Cost**	**Per**	**Desired Number**	**Total Cost**	**Vendor**
Trofast Storage Combination Unit	$87.98	1	5	$439.90	Ikea
Trofast Small Storage Bin	$3.00	1	25	$75.00	Ikea
Trofast Medium Storage Bin	$4.00	1	25	$100.00	Ikea
Kallax Shelving Unit	$139.00	1	2	$278.00	Ikea
Ivar 2 sections shelving unit	$440.00	1	1	$440.00	Ikea
			Total Cost:	**$1,332.90**	

Tools and Materials Resources

Ikea: http://www.ikea.com/
Pitsco: http://www.pitsco.com/
The Science Source: http://www.thesciencesource.com/

STEM consent and safety

Major Considerations

Before beginning any STEM activity or design challenge, the rules and expectations should be presented. It should be incorporated that the mission of the school is to keep all students safe and that the STEM lab is no exception.

You may want to have the class write out a poster about the safety rules and hang it in the lab for the school year as a reminder. Having the students develop and construct the list will provide more meaning than the teacher making the list and talking through each rule.

There should be a designated area for a first aid kit. The students should understand the contents inside and when they should be used. It should be explained that anyone who is injured or hurt should notify their teacher immediately.

In reviewing the safety rules, it would be a good idea to have the students discuss about how real world occupations remain safe. For example: if your design challenge was to construct a bridge, you may talk about the different safety aspects of real construction workers and engineers. Such as hard hats, goggles, safety boots, tucked in shirts etc.

School and parental permissions

Teachers should make the students, parents, and school administration aware of the safety concerns of the STEM lab. It should be explained the different equipment in the lab and the importance of safety. STEM teachers should follow protocol for school rules and the submission of permission slips before the school year begins.

Sample consent letter

STEM Laboratory ~ Safety Information/Informed Consent

Dear Parent or Guardian:

This school year your child will have the opportunity to participate in supervised STEM class activities that involve the use and operation of various hand and power tools as well as equipment.

Appropriate instruction in the safe operation of assigned tools, equipment and procedures will be given that will include supervised student performance testing on each item. Precautions are taken to prevent accidents but a certain risk is involved due to the nature of the experience and the learning environment.

Working with tools and equipment in the STEM lab area requires proper eye protection. Safety glasses are available in the classroom for your child's use, or you may purchase them on your own. We ask your support in discussing with your child the necessity to observe safety policies that have been established. You are invited to visit our school program to discuss any of the course requirements. Please contact me to arrange for a visit. It is my goal to have a fun and educational learning experience for all students.

Thank you for your assistance.

Teacher's name

Teacher's Email

Teacher's Phone number

Please retain top portion for your records.

I have read this form and the safety precautions my child has brought home for me to read. I give permission for my child to participate in activities that may require them to use the various hand, power tools and equipment in the class. I will discuss with my child the safety aspect of the program.

Signature _____ **Date** _____
Parent

Phone Number: Primary Number _____ **Alternate Number** _____

Email _____

I agree to observe all safety rules and procedures for the safe operation and conduct in this course. I will wear approved eye protection.

Signature _____ **Date** _____
Parent

Signature _____ **Date** _____
Student

STEM Resources

Design Challenges, Lessons, Information

All of the resources listed below are free of charge, and accessible via the web.

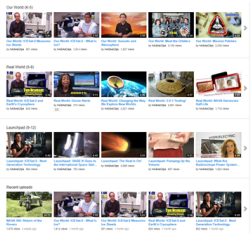
PBS: STEM Resource Center
http://aetn.pbslearningmedia.org

The PBS Teachers STEM Education Resource Center offers database of nearly 4,000 science, technology, engineering, and math resources for grades preK-12. Many of these activities are linked to familiar and well-known characters which will add to the excitement for our students.

Live Binders: Variety of Online Resources, Lessons, and Ideas
http://www.livebinders.com
Folder: The Common Core State Standards for Math

Live Binders is an excellent teacher resource for a variety of ideas, lessons, videos, and scholarly sources related to every topic. Live binders is completely free, and you do not have to set up an account to view materials shared. There is also an app for Apple and Android devices. You can post material as either a private or public folder. There is a way to contact the person who posts the folder for additional information or collaboration.

NASA eClips: NASA videos and design challenges
http://www.nasa.gov/nasaeclips

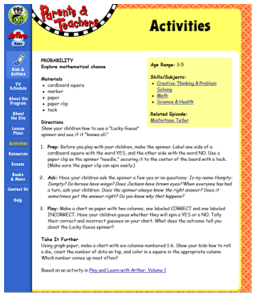


NASA eClips, is an exceptional resource to show your students how STEM is being used at NASA and in the world. NASA does a good job at showing how STEM is beneficial while attracting the interest of students. The eClips are short online videos that will typically lead into a design challenge involving STEM subject areas.

HowToons: Activities and Application
http://www.howtoons.com

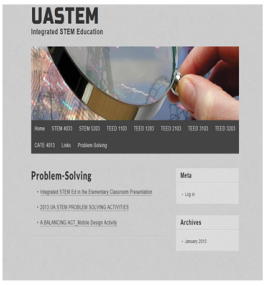
Introduces design challenges through a comic and colorful format.

PBS: Hands on Learning and Activities
http://www.pbs.org/parents/fun-and-games/pbs-kids-activity-search/

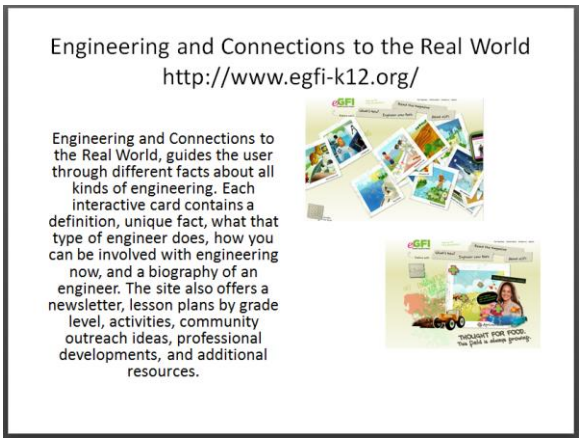


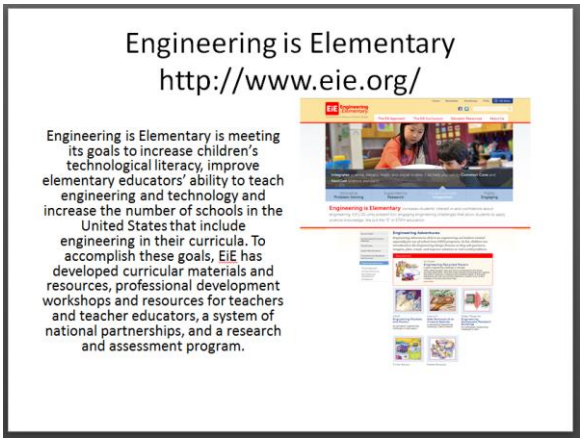
The PBS Hands on learning activities are equipped pre-made lessons. These lessons include the lesson objectives, material list, directions, and ideas for expanding the lesson. You are able to search for learning activities any or all of the following: Subject area, Grade level, or by character. Many of the lessons are linked to show clips or children's books.

University of Arkansas: STEM curriculum Activities
http://www.uastem.com/

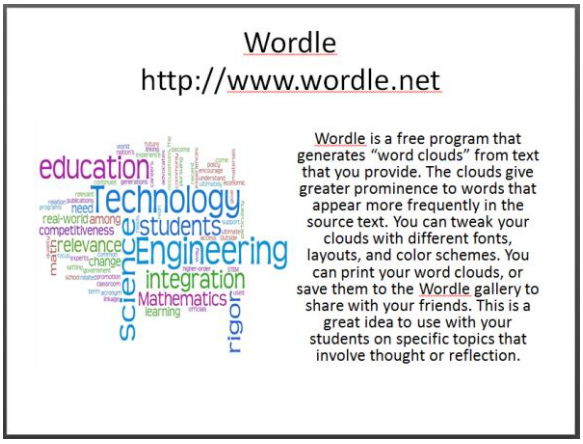


The University of Arkansas STEM certification program faculty and students have created a website to offer new and up to date lessons, design challenges, and resources for a variety of age levels. The lessons are linked to Common Core standards as well as National Science Education Content Standards and Standards for Technological Literacy. This site is constantly modified, so please check regularly for new ideas and resources from the University of Arkansas STEM certification program.





Activation Schema



Exemplary elementary STEM lab

Cooper Elementary STEM lab Hampton, VA

Joan Harper Neely was awarded the ITEEA teacher excellence award (2014) for her work, dedication, and contribution to the Cooper elementary STEM lab and programs. Joan is contributed for much of the success in taking Cooper Elementary students to a high achieving school for academics. She contributes this success to STEM and project based learning.

Computer stations for conducting research prior to design challenges

Work station tables are located at the back of the room, near the tool cabinets and materials.

Projector is at the front of the room, and is used to introduce design challenges and schema. Students sit on rug while activities are explained.

Display and schedule board. Projects ready to go home are placed on the table. There is also storage and teachers desk behind the partition.

Professional Development and Resources

STEM Organizations and memberships

Childrens Engineering Educators: http://www.childrensengineering.com/

ISEA: International STEM Education Association
http://www.isea-stem.org/

ITEEA: International Technology and Engineering Educators Association
http://www.iteaconnect.org/

NSTA: National Science Teachers Association
http://www.nsta.org/

Continued learning

Books:

Whiting, G. & Hickey, M. (2009) Children's engineering: A handbook for elementary educators. Richmond, VA: Children's Engineering Educators LLC.

Whiting, G. & Hickey, M. (2010) Beyond the basics: Highlighting the T & E in STEM education. Richmond, VA: Children's Engineering Educators LLC.

Asia Society report:

Teaching and Learning 21st Century Skills: Lessons from the Learning Sciences
http://asiasociety.org/files/rand-0512report.pdf

Learning Standards

Common Core Math Standards
http://www.corestandards.org/Math/

Common Core English Language Arts Standards
http://www.corestandards.org/ELA-Literacy/

Next Generation Science Standards (NGSS)
http://www.nextgenscience.org/next-generation-science-standards

Standards for Technological Literacy
http://www.iteea.org/TAA/PDFs/xstnd.pdf

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