Communities In Schools of North Carolina is leading the national network in providing the most effective student supports and wraparound interventions and supports directly in schools to support students and teachers. Working collaboratively with 400 schools across North Carolina, Communities In Schools impacts the lives of more than 230,000 youth each year. Driven by research-based practices surrounding the best predictors of student success – attendance, behavior, coursework and parent and family engagement – Communities In Schools is changing the picture of education for students across North Carolina. Learn more about Communities In Schools of North Carolina at www.cisnc.org.

The Nonprofit Evaluation Support Program (NESP) is a collaborative effort between two University of North Carolina Greensboro organizations – The SERVE Center and The Office of Assessment, Evaluation, and Research Services (OAERS). NESP's mission is to provide program evaluation services and program evaluation capacity building support to nonprofit and community-based organizations while providing authentic learning experiences for future leaders in the field of program evaluation.

The SERVE Center at The University of North Carolina Greensboro is a university-based research, development, dissemination, evaluation, and technical assistance center. For more than 24 years, SERVE Center has worked to improve K-12 education by providing evidence-based resources and customized technical assistance to policymakers and practitioners.

The University of North Carolina Greensboro (UNCG) is one of the sixteen university campuses of The University of North Carolina. UNCG holds two classifications from the Carnegie Foundation for the Advancement of Teaching, as a "research university with high research activity" and for "community engagement" in curriculum, outreach, and partnerships.

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Overview

CISNC Introduction

In the 2014-2015 school-year, Communities In Schools of North Carolina (CISNC) introduced a framework that aligns site and student metrics and interventions and supports to four areas that have been shown to have the greatest impact on student success: attendance, behavior, coursework, and parent involvement, or ABC+P. Both combined and individually, attendance, behavior, and coursework are among the best predictors of a student's academic success and on-time graduation. While collecting data around ABC+P is critically important to understanding the school and student, it is even more important to use the data to drive high impact intervention and support delivery to empower each student to reach their full potential. To this end, Communities In Schools of North Carolina has partnered with the SERVE Center at the University of North Carolina at Greensboro to design curricula specifically for CIS within the ABC+P framework to enhance student outcomes in school and success in life. This document is one of more than 50 modules developed to support local CIS staff and most importantly the students that are served. We encourage you to explore all of the modules available online at www.cisnc.org.

Using Evidenced-Based Strategies

There are a multitude of strategies that claim to address attendance, but there are few that actually do so for all students. We suggest that schools use an evidence-based, decision-making model to ensure that high quality information informs the decisions made.

The Institute of Education Sciences (IES) at the U.S. Department of Education defines evidence-based decision making as routinely seeking out the best available information on prior research and recent evaluation findings before adopting programs or practices that will demand extensive material or human resources (including both funding and teacher time) and/or affect significant numbers of students (Whitehurst, 2004).

Evidence-based practice means delivering interventions and supports to students (clients) in ways that integrate the best available evidence from data, research, and evaluation; professional wisdom gained from experience; and contextual knowledge of the particular classroom, school, district, or state that might impact the design or implementation.

This document will focus on one easy to implement STEM strategy intended to engage students and support science process skills; it can also be extended to link science and language arts.

Problem/Rationale

Whether we stop to think of it or not, STEM drives everything around us, from the time we get up in the morning to the time we go to bed at night. Science, technology, engineering and math (STEM) are an inescapable part of the 21st Century world; to have a place in that world, our young people must have a strong STEM background. Current information confirms the importance of STEM education. According to the US Department of Commerce (Langdon, McKittrick, Beede, Kahn, & Doms, 2011), STEM is where the jobs are—and STEM related jobs are on track to grow faster than any other jobs in the next few years. Those in STEM related occupations will earn more than non-STEM workers and will experience less risk of job loss. There is more at stake than our young peoples' success—reports indicate that continued scientific leadership and economic growth in the United States is linked to STEM (National Research Council, 2011). Yet, our students have lost ground. Twenty-five years ago, the United States led the world in high school and college graduation rates; today, the US ranks 20th and 16th. In addition, the World Economic Forum ranks the U.S. as No. 48 in quality of math and science education. In 2009, 34% of 4th grade students and 21% of 12th grade students performed proficiently in science; in 2013, only 42% of 4th graders and 35% of 8th graders performed proficiently in math (National Math and Science Initiative, 2014). To compete, and to ensure our students have a place in the world of the 21st century, we must provide them the advantage that a world class STEM education offers.

Research tells us a great deal about what comprises effective STEM education. Broadly, successful STEM education

- Takes advantage of students' early interests and experiences,
- Identifies and builds on existing knowledge, and
- Provides students with engaging experiences that involve them in the practices of science and sustain their interest (National Research Council, 2011).

STEM can play a key role in learning for middle school students. The world our students live in sees technological advances almost daily; routine tasks are rapidly becoming computerized and educational and career paths increasingly require individuals who can think critically, solve problems and communicate effectively. Students' success builds on skills and abilities developed through high quality STEM education that begins early (National Academy of Sciences, 1997). Middle school is often where students begin to consider career paths. Middle school is also where students may lose interest in STEM and lack academic motivation (Rothwell, 2013). Opportunities to participate in well-conceived and implemented STEM courses can be a key to engaging students, keeping them in school and setting them on a productive education path. Middle school students often point to boredom as a reason for poor academic performance and sporadic attendance; the connections to students' lives, authentic instruction and choices integral to STEM can support student motivation (Maday, 2008). Research points to a set of key overarching ideas and practices that support effective STEM education:

- Consistent standards and curriculum,
- Teachers who are well prepared to teach in their subject area,
- A supportive system of assessment and accountability that does not limit what is taught based on assessment, and focuses on teacher practices as well as student outcomes,

- Adequate instruction time across disciplines, and
- Equal access to high quality STEM learning opportunities.

Research also identifies school level practices that support effective STEM instruction:

- A supportive school culture and learning and teaching conditions,
- School leadership that drives change,
- High quality teachers and staff, capacity of staff to work together, and effective professional development,
- A student centered climate that is safe, welcoming, stimulating and focused on the learning of all students, and
- Support for instruction that incorporates the nature of the curriculum, academic demands and challenges to instruction and the tools supplied to teachers (National Research Council, 2011).

Districts and schools can examine their practice to incorporate these elements and provide students with high quality STEM education.

Purpose

A strong grounding in science, technology, engineering and math is critical to assuring that students will be successful in K-12 and beyond. The active learning and relevance that are built in to good STEM coursework support positive student attitudes. Students who learn to solve problems, work with others, manage their time and communicate effectively have an advantage not only in school, but also as they move into post-secondary education and a career (Bertram & McDonald, 2013). The purpose of this guide is to provide teachers with information and activities that they can use to engage students and support science, technology, engineering and math learning.

Objectives: Students design, construct, and launch paper rockets.

Skills: This activity supports the following content skills:

- Number and operations
- Geometry
- Measurement
- Data analysis and probability

As well as these process skills:

- Problem Solving
- Reasoning and Proof
- Communication
- Connections
- Representations

Implementation Plan

This activity incorporates a number of content areas and concepts important to mathematics and science learning. Students will learn about change, constancy and measurement, positions, motions, and forces. They will also use scientific inquiry skills and technological design. The customization possible in the design process will help students understand how different structural choices impact the success of their design.

Uses

Through the activity below, teachers will help students learn to understand and apply STEM concepts.

Audiences

The primary audience for the lesson is sixth through eighth grades.

Activities

The activity is designed to provide students with a hands-on activity that incorporates a range of science and math skills and processes. Teachers can use it to teach problem solving and critical thinking, as well as other skills applicable in a variety of situations. It supports the North Carolina State curriculum for Science as Inquiry.

Materials/Equipment/Space

Activity One: Pop Rockets

- Pop Rocket Patterns (found in the Resources section)
- Card-stock paper
- Glue stick
- Cellophane tape
- Scissors
- Optional: Computer with an illustration program and printer Crayons or colored markers
- Ruler
- Pop! Rocket Launcher
- Penny
- 30 cm-long pieces of 1/2" PVC pipes

Activity Two: High Powered Paper Rockets

- Pop Rocket Launcher Paper 8 1/2 X 11 (white or color)
- Cellophane tape
- White glue
- Overhead projector transparency sheets
- Ruler
- Protractor

- Scissors
- 1/2” PVC pipe 24” long for each rocket
- builder or team
- Eye protection
- Mission Report sheet
- Other construction materials as required by the team missions

Time

Activity One: Pop Rockets

- Preparation Time: 10 minutes
- Lesson Time: 30 minutes

Activity Two: High Powered Paper Rockets

- Varies, but a minimum of two to three class periods

Lesson Plan of Activity

In this lesson, students will build two rockets to learn how structure impacts rocket flight. The activity is designed to provide students with a hands-on activity that incorporates a range of science and math skills and processes. Teachers can use it to teach problem solving and critical thinking, as well as other skills applicable in a variety of situations. It supports the North Carolina State curriculum for Science as Inquiry.
Additionally, the activity can be extended to help students understand the important role clear written communication plays in STEM.

Sample Lesson – *STEM Strategy in Middle School*

Activity	Process Notes
Activity 1: Pop Rockets	
Review the Rockets Educator Guide for resources for discussing concepts and suggestions for extending the lesson. Before beginning this activity with students, make one or more Pop Rocket Launchers.	*http://www.nasa.gov/audience/foreducators/topnav/materials/listbytype/Rockets.html#.VbeVKvlViko* *Refer to the Resource section for a link to instructions for building Pop Rocket Launchers.*
Introduce the lesson and key concepts – Using Rockets to explore change, constancy and measurement, positions, motions, and forces. Let students know that you will be using scientific inquiry during this lesson. Read "What is a Rocket?" information from NASA with your students. Share a video of a rocket launch.	*Review key concepts.* *Teachers may want to use a template to have students record their notes during the activity to apply the scientific inquiry method. Some samples can be found in the "Rockets Away with Newton's Laws of Motion" unit guide – see link in the Resources section.* *Tell students," I'm going to share with you some information about rockets. We will learn somethings about the history of rockets, and get some information about how rockets work. Then, you will each apply what we learn by making a rocket https://www.nasa.gov/audience/foreducators/rocketry/home/what-is-a-rocket-k4.html#.VXiHDvlVikr* *Rocket Launch Video http://www.nasa.gov/multimedia/videogallery/index.html*
Show students a completed Pop Rocket	*Tell students, "Here is a rocket like we will make." Pattern and directions found in Resources below.*
Discuss with students the parts of a rocket. Explore with students aspects of the rocket that may influence aspects of performance.	*Give students a copy of the diagram found at http://exploration.grc.nasa.gov/education/rocket/rockpart.html* *Tell students, "Let's look at this diagram of the parts of a rocket." Use the information provided with the diagram, and your completed Pop Rocket, to discuss the parts of a rocket.* *Ask students about what aspects of the rocket they think will influence speed, trajectory, distance, etc.*
Provide students with a Pop Rocket pattern, and with instructions for assembling their rocket.	*Go over the directions for making a Pop Rocket with students. Circulate around the class to provide any needed help.* *Pattern and instructions found in Resources below.*
Give each student a sheet of paper.	*Ask students to write their name on the paper.*

Activity	Process Notes
Allow students to launch their rockets, using the Pop Rocket Launcher	*As each rocket is launched, mark where it lands, using the paper with their name on it. Measure and record the distance each rocket travels.*
Optional Activity 1 Follow Up	*Collect the rockets; look at them and compare differences.* *Ask students, "Why do you think some rockets went further than others?" Ask students about their initial predictions.* *Record students' theories.*
Discuss Newton's Laws of Motion with students. Allow students to make modifications and retest their rocket designs.	*Use the information found at http://exploration.grc.nasa.gov/education/rocket/newton1r.html* *Follow up by allowing students to make changes to their rockets.* *Launch the rockets again and determine if they fly farther than before.* *Have students record changes in design, reasons for change, and new flight data. Have students record whether changes to their design resulted in predicted changes in speed, distance, and trajectory, and why.*
Activity 2: High Powered Paper Rockets	
	Students, working individually or in small groups, select a flight mission (what they want their rocket to do) and design and construct a high powered paper rocket to achieve the mission. *They will construct their rocket, predict its performance and the chance of mission success, fly the rocket, and file a post-flight mission report.*
Introduce the activity: Show students pictures of various rockets. Discuss design differences students see. A Google search on "pictures of NASA rockets" provides many good images.	*Say: "Every space rocket ever built was constructed with a specific mission in mind. The Bumper Project back in the 1950s combined a small WAC Corporal rocket with a V2 to test rocket staging, achieve altitude records, and to carry small payloads for investigating the space environment. The Saturn V was designed to carry astronauts and landing craft to the Moon. The space shuttle was designed as a payload and laboratory carrier for low orbit missions. NASA's new missions into the solar system will require designing rockets with heavy lifting capabilities." (NASA, 2011)* *Ask students to point out differences between the rockets. Examples can be found at: http://exploration.grc.nasa.gov/education/rocket/gallery.html*

Activity	Process Notes
Demonstrate ways of making heavy duty rockets.	*Show students how to roll and strengthen a paper tube with white glue.* *Note: Rockets made with glued body tubes require a couple of days for several applications of glue to dry.* *Also demonstrate different techniques for making fins, nose cones, and payload* *Directions for making several types of paper rockets are found in the Resources section.* *A Google search on "Rocket fin shapes" provides drawings of possible fins, and a Google search on "rocket nose cones" provides drawings of possible nose cones.*
Prior to the beginning of construction, have students work in pairs or small groups to choose a mission, plan a rocket design and decide what their rocket will look like, how it will function and what materials are needed for construction.	*Tell students, "You will need to decide what you want your rocket to do and how you can best design it to for your mission. Think about what we have learned about the types of rockets, and how they are used, and about how the features of a rocket change its performance. "* *Possible missions include achieving high altitude records, landing on a "planetary" target, carrying payloads, testing a rocket recovery system.* *Have students brainstorm possible missions, and record. You can add any that are not listed.* *Students should submit a written plan. It may be helpful to provide students with a list of possible construction materials before they begin planning.* *Student sheets for their Mission Proposal and for the Post Flight Report is found in the Resources section below.*
Have students build their rockets. This will require at least two days allowing for glue on rockets to dry.	*Provide instructions sheets to students. These are found in the Resources below. The Parachute Recovery system is optional.* *Circulate to answer questions and provide assistance.*
Have students launch their rockets using the Pop Rocket Launcher.	*Directions are in the Resources section below.* *On launch day, post a launch schedule. Organize the schedule so that similar missions are flown consecutively. For example, if the objective is to achieve the greatest altitude, other students will be needed to track the rockets.*

Activity	Process Notes
	Have students record flight results for discussion and future lessons.
Whole group activity: Discuss flight results with students.	*Ask these questions:* - *Why are rockets designed with specific missions in mind?* - *What design feature of the rocket has the greatest effect on flight performance?* *Information for discussion is in the activity sheets found in the Resource section.* *Optional: Discuss Newton's Laws of Motion and how they apply to rockets. Information can be found at http://exploration.grc.nasa.gov/education/rocket/newton1r.html*
Have students write a Post Flight Report	*Post Flight Report sheet is provided in the Resources below.* *Students will use it to describe their rocket's flight, and whether their mission was successful, to draw conclusions about why or why not, and to predict how they might improve their rocket. Students should incorporate information from key concepts and data from test flight.*
Optional Follow Up – Refining Rocket Design	*Have students re-design their rockets based on what they learned in discussing their rocket's performance.* *Re-launch to see if the rockets perform better.* *Have students compare data from both launches and amend their report to reflect how changes in design affected changes in rocket performance. Students should incorporate information from key concepts and data from test flights.*
Fun Follow Up – October Sky	*Hold an October Sky viewing party with follow-up discussion.*

Activities are adapted from NASA's "Pop! Rockets" and "Advanced High-Powered Paper Rocket" lessons. Retrieved from: http://www.nasa.gov/pdf/295791main_Rockets_Pop_Rockets.pdf *and http://www.nasa.gov/audience/foreducators/topnav/materials/listbytype/Advanced_High_Power_Paper_Rockets.html#.VbeU2_lVikp.*

Tier 2 Intervention and Support Examples

While typical classroom activities such as the one detailed in this guide will be effective for many students, some may need additional support. Computer Assisted Instruction and Peer Tutoring are two strategies that can help struggling students.

Example 1: Computer Assisted Instruction (CAI)
Computer Assisted Instruction uses technology to either supplement or replace traditional classroom instruction. Research shows that it is a useful tool, as well as a cost efficient means to provide students who are struggling with support to help them make academic gains, particularly in math. Some research suggests that the individualized instruction and pacing offered by CAI may account for this. In addition, CAI can reduce the effects of frequent absences and larger classes that reduce the instructional time students receive.

Barrow, L. & Rouse, C. (2007). *Technology's edge: The educational benefits of computer-aided instruction.* Chicago, IL: Federal Reserve Bank of Chicago. Retrieved from: http://eric.ed.gov/?id=ED505645

Example 2: Peer Tutoring
Peer tutoring pairs low performing students with high performing students on a one to one basis to practice or complete academic tasks. The research on peer tutoring supports the practice. Students in a peer tutoring relationship make academic gains including improvements in math and reading performance. Peer tutoring also promotes higher order thinking and accommodates the diverse student needs in a classroom. In addition, peer tutoring has a positive impact on motivation and students' social skills.

Nguyen, M. (2013). *Peer tutoring as a strategy to promote academic success.* Durham, NC: Duke School Research Partnership Office, Center for Child and Family Policy. Retrieved from https://childandfamilypolicy.duke.edu/pdfs/schoolresearch/2012_PolicyBriefs/Nguyen_Policy_Brief.pdf

Resources

The following resources are identified as part of the activity. Read through these resources carefully to become familiar with any concepts and instructions as they pertain to the content and activity.

NASA – http://www.nasa.gov/

Rockets Educator's Guide
http://www.nasa.gov/audience/foreducators/topnav/materials/listbytype/Rockets.html#.VbeVKvlViko
Rocket Index – links to key concepts
http://exploration.grc.nasa.gov/education/rocket/shortr.html
Pop Rocket Instructions
http://www.nasa.gov/pdf/295791main_Rockets_Pop_Rockets.pdf
Pop Rocket Launcher
https://www.nasa.gov/pdf/295790main_Rockets_Pop_Rocket_Launcher.pdf
Directions for making a high power paper rocket for Activity 2
http://www.nasa.gov/audience/foreducators/topnav/materials/listbytype/Advanced_High_Power_Paper_Rockets.html#.VX43s_lViko
Behind the scenes with a rocket scientist
http://www.nasa.gov/multimedia/podcasting/GOES_OWithRocketScientist.html
The Rocket Modeler shows how variations in design change the motion of a rocket.
http://exploration.grc.nasa.gov/education/rocket/rktsim.html

You Tube – http://www.youtube.com /

Newton's Laws
https://www.youtube.com/watch?v=cP0Bb3WXJ
Model rocket aerodynamics
https://www.youtube.com/watch?v=aeump8X7tVU

Newton's Laws of Motion from the Smithsonian

https://howthingsfly.si.edu/flight-dynamics/newton%E2%80%99s-laws-motion

PowerPoint about Newton's Laws

http://education.jlab.org/index.html (Search for "Newton's Laws")

Additional information on Newton's Laws

http://exploration.grc.nasa.gov/education/rocket/TRCRocket/rocket_principles.html

MIT – http://web.mit.edu/

Rocket flight and Newton's Laws from
http://web.mit.edu/16.00/www/aec/rocket.html

Rockets Away with Netwon's Laws of Motion unit guide

http://www.purdue.edu/discoverypark/gk12/downloads/Rockets.pdf

Slides on model rocket fin and nose design

https://docs.google.com/presentation/d/1_Wzog8twP8xiCyjE-G8a2CwZ9XzLcnp1sXYkbBTyW80/embed?hl=en&size=s&slide=id.gc4e5028_15_13

The following resources will provide additional information and suggestions for enhancing STEM in the classroom. Read through the resources carefully to become familiar with any concepts and instructions as they may pertain to the content and the extension of activities.

North Carolina Extended Essential Standards: Science – http://www.dpi.state.nc.us/

6-8 Extended Standards http://www.dpi.state.nc.us/docs/acre/standards/extended/science/6-8.pdf

Essential Standards

http://www.dpi.state.nc.us/docs/acre/standards/new-standards/science/6-8.pdf

The Teaching Channel – https://teachingchannel.org

Video of best practices for teaching STEM in middle school classrooms https://www.teachingchannel.org/videos/making-science-engaging

The following optional resources provide additional information and concepts, or may be used in sharing with others or to expand the activity. Read through these resources to become familiar with the information and to determine their level of usefulness within the school setting.

Bertram, V. & McDonald, J. (2013, November). ***Bringing real world science to the classroom. US News and World Report.*** **Retrieved from:**

http://www.usnews.com/opinion/articles/2013/11/11/how-to-get-middle-and-high-school-students-interested-in-stem

Web page from NASA that offers many resources related to rocketry and space flight.

https://www.nasa.gov/audience/foreducators/rocketry/multimedia/index.html#.VXiGIPlVikr

Videos from NASA

http://www.nasa.gov/multimedia/videogallery/index.html

A Pictorial History of Rockets

https://www.nasa.gov/pdf/153410main_Rockets_History.pdf

STEM-works is a website from SMU that offers many STEM related activities that can be accessed by subject.

http://stem-works.com/activities

STEM activities for middle school, focused on girls.

http://www2.ivcc.edu/mimic/nsf/Middle%20School%20Activities/STEM%20Activities%20Handbook.pdf

Website with many lessons for all STEM topics.

https://www.teachengineering.org/index.php

National Academy of Science publication on learning STEM through games and simulations.

http://www.nap.edu/openbook.php?record_id=13078&page=119

Videos of STEM projects.

https://www.teachingchannel.org/videos/teaching-stem-strategies

Language Arts link for both lessons.

Rocket Boys by Homer Hickam. Discussion questions for the book can be found at http://www.homerhickam.com/groups/rbos.shtml, Homer Hickham's website. From Wikipedia: "Homer Hadley Hickam, Jr. (born February 19, 1943) is an American author, Vietnam veteran, and a former NASA engineer. His autobiographical novel *Rocket Boys: A Memoir*, was a No. 1 New York Times Best Seller, is studied in many American and international school systems, and was the basis for the 1999 film October Sky. Hickam has also written a number of best-selling memoirs and novels including the "Josh Thurlow" historical fiction novels. His books have been translated into several languages."

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Measuring Success

Identifying outcomes and collecting data to measure the success of STEM strategies can help track the quality of implementation as well as the effectiveness of these strategies. In addition to state/district benchmark assessments, following are some additional suggestions that may be useful to measure success.

- Evaluate the mission proposals and post-flight reports for completeness.
- Have students write a paper on the role drag (friction with the air) plays in the performance of a rocket and how drag can be reduced.
- Have students compare the space shuttle with the new rockets that will be used to travel into the solar system.

Appendices

A. Glossary

B. References

C. Research Alignment

Appendix A: Glossary

21st Century Skills – The term 21st century skills refers to a broad set of knowledge, skills, work habits, and character traits that are believed—by educators, school reformers, college professors, employers, and others—to be critically important to success in today's world, particularly in collegiate programs and contemporary careers and workplaces (Great Schools Partnership, 2014).

Achievement Gap – Closely related to learning gap and opportunity gap, the term achievement gap refers to any significant and persistent disparity in academic performance or educational attainment between different groups of students, such as white students and minorities, for example, or students from higher-income and lower-income households (Great Schools Partnership, 2014).

Authentic Instruction – In education, the term authentic instruction refers to a wide variety of educational and instructional techniques focused on connecting what students are taught in school to real-world issues, problems, and applications**.**

Computer assisted Learning – Computer assisted instruction uses technology to either supplement or replace traditional classroom instruction. Research shows that it is a useful tool, as well as a cost efficient means to provide students who are struggling with support to help them make academic gains, particularly in math.

Cooperative Learning – Cooperative learning is a successful teaching strategy in which small teams, each with students of different levels of ability, use a variety of learning activities to improve their understanding of a subject.

Engineering method – The engineering approach to identifying and solving problems, is (1) highly iterative, (2) open-ended, in that a problem may have many possible solutions, (3) a meaningful context for learning scientific, mathematical, and technological concepts, and (4) a stimulus to systems thinking, modeling, and analysis. In all of these ways, engineering design is a potentially useful pedagogical strategy K-12. Engineering habits of mind2 are aligned with what many believe are essential skills for citizens in the 21st century.3 These include (1) systems thinking, (2) creativity, (3) optimism, (4) collaboration, (5) communication, and (6) ethical considerations (Katehi, Pearson, & Feder, 2009).

Embedded Assessment – Embedded assessment is also called formative assessment. It takes place throughout a lesson or unit to assess student progress, and is used to determine skills students have mastered and where they may need support.

Hypothesis – In science, a hypothesis is an idea or explanation that you then test through study and experimentation. Outside science, a theory or guess can also be called a hypothesis. A hypothesis is something more than a wild guess but less than a well-established theory ("Hypothesis," n.d.).

Integrated Learning – Refers to an instructional design that incorporates a range of teaching, learning and technological strategies (e.g., Students may work individually, in small groups, in large groups or whole class. Teachers may use direct instruction, distance learning, hands-on activities and a range of other strategies).

Opportunity Gap – Closely related to achievement gap and learning gap, the term opportunity gap refers to the ways in which race, ethnicity, socioeconomic status, English proficiency, community wealth, familial situations, or other factors contribute to or perpetuate lower educational aspirations, achievement, and attainment for certain groups of students (Great Schools Partnership, 2014).

Peer Tutoring – Peer tutoring pairs low performing students with high performing students on a one to one basis to practice or complete academic tasks.

Process skills – Process skills support learning and are essential to scientific investigations. They are observing, communicating, measuring, comparing, contrasting, organizing, classifying, analyzing, inferring, hypothesizing and predicting.

Project Based Learning – Project-based learning refers to any programmatic or instructional approach that utilizes multifaceted projects as a central organizing strategy for educating students. When engaged in project-based learning, students will typically be assigned a project or series of projects that require them to use diverse skills—such as researching, writing, interviewing, collaborating, or public speaking—to produce various work products, such as research papers, scientific studies, public-policy proposals (Great Schools Partnership, 2014).

Relevant – In education, the term relevant typically refers to learning experiences that are either directly applicable to the personal aspirations, interests, or cultural experiences of students (personal relevance) or that are connected in some way to real-world issues, problems, and contexts (life relevance) (Great Schools Partnership, 2014).

Scientific inquiry – "The diverse ways in which scientists study the natural world and propose explanations based on the evidence derived from their work. Scientific inquiry also refers to the activities through which students develop knowledge and understanding of scientific ideas, as well as an understanding of how scientists study the natural world." (National Academies Press, 2015, p. 23)

STEM (Science, Technology, Engineering, Math) Education – Is an infusion of Science, Technology, Engineering, and Mathematics through project-based learning to understand complex problems and to prepare our next generation of innovators (North Carolina Department of Public Instruction, n.d.)

Student Centered Learning – The term student-centered learning refers to a wide variety of educational programs, learning experiences, instructional approaches, and academic-support strategies that are intended to address the distinct learning needs, interests, aspirations, or cultural backgrounds of individual students and groups of students. To accomplish this goal, schools, teachers, guidance counselors, and other educational specialists may employ a wide variety of educational methods, from modifying assignments and instructional strategies in the classroom to entirely redesigning the ways in which students are grouped and taught in a school (Great Schools Partnership, 2014).

School climate/culture – The term school culture generally refers to the beliefs, perceptions, relationships, attitudes, and written and unwritten rules that shape and influence every aspect of how a school functions, but the term also encompasses more concrete issues such as the physical and emotional safety of students, the orderliness of classrooms and public spaces, or the degree to which a school embraces and celebrates racial, ethnic, linguistic, or cultural diversity (Great Schools Partnership, 2014).

Student Engagement – In education, student engagement refers to the degree of attention, curiosity, interest, optimism, and passion that students show when they are learning or being taught, which extends to the level of motivation they have to learn and progress in their education (Great Schools Partnership, 2014).

Appendix B: References

Barrow, L. & Rouse, C. (2007). *Technology's Edge: The educational benefits of computer-aided instruction.* Chicago, IL: Federal Reserve Bank of Chicago. Retrieved from http://eric.ed.gov/?id=ED505645

Bertram, V. & McDonald, J. (2013, November). *Bringing real world science to the classroom.* US News and World Report. Retrieved from http://www.usnews.com/opinion/articles/2013/11/11/how-to-get-middle-and-high-school-students-interested-in-stem

Great Schools Partnership. (2014). *Glossary of education reform*. Portland, ME: Author. Licensed through Creative Commons. Retrieved from http://edglossary.org/contact/

Hypothesis. (n.d.). Retrieved from http://www.vocabulary.com/dictionary/hypothesis

Katehi, L., Pearson, G. & Feder, M. (2009). The status and nature of K-12 engineering education in the United States. *The Bridge, 39*(3), 5-10. Retrieved from https://www.nae.edu/File.aspx?id=16147

Langdon, D., McKittrick, G., Beede, D., Kahn, B. & Doms, M. (2011). *Good jobs now and for the future.* Washington, D.C.: United States Department of Commerce.

Maday, T. (2008). *Stuck in the middle: Strategies to engage middle-level learners*. Washington, DC: WEGA, AdLit.org.

National Academies Press. (2015). *National science education standards.* Washington, D.C.: Author. Retrieved from http://www.nap.edu/openbook.php?isbn=0309053269

National Academy of Sciences. (1997). *Preparing for the 21st century: The education imperative*. Retrieved from http://www.nas.edu/21st/education/

National Aeronautics and Space Administration. (2011). *Rocket activity: Pop! Rockets* [PDF document]. Retrieved from http://www.nasa.gov/pdf/295791main_Rockets_Pop_Rockets.pdf

National Aeronautics and Space Administration. (2011). *Rocket activity: Advanced high-power paper rockets* [PDF document]. Retrieved from http://www.nasa.gov/pdf/295786main_Rockets_Adv_High_Power_Paper.pdf

National Math and Science Initiative. (2014). Retrieved from https://www.nms.org/AboutNMSI/TheSTEMCrisis/STEMEducationStatistics.aspx

National Research Council. (2011). *Successful STEM education: Identifying effective approaches in science, technology, engineering and mathematics.* Washington, D.C.: Author.

North Carolina Department of Public Instruction (n.d.) STEM Education and Leadership [website]. Retrieved from http://www.ncpublicschools.org/stem/

Nguyen, M. (2013). *Peer tutoring as a strategy to promote academic success.* Durham, NC: Duke School Research Partnership office in the Center for Child and Family Policy. Retrieved from https://childandfamilypolicy.duke.edu/pdfs/schoolresearch/2012_PolicyBriefs/Nguyen_Policy_Brief.pdf

Rothwell, J. (2013). *The hidden STEM economy.* Washington, DC: Brookings Institute.

Whitehurst, G. J. (2004, April). *Making education evidence-based: Premises, principles, pragmatics, and politics.* Evanston, IL: Northwestern University Institute for Policy Research, Distinguished Public Policy Lecture Series. Retrieved from http://www.northwestern.edu/ipr/events/lectures/DPPL-Whitehurst.pdf

Appendix C: Research Alignment

Citation	Brief Summary of Strategy	Sample Size	Impact/Evidence of Effectiveness	Implementation
Dunleavy, M. & Heineke, W. (2007). The impact of 1:1 laptop use on middle school math and science standardized test scores . *Computers in Schools*. 24(3/4), 7-16.	This study investigates the effect of 1:1 laptop to student ratios on math and science achievement in at-risk middle school students. The study used a pre- and post-test control group design. Study results are based on analysis of longitudinal data comparing students randomly assigned to 1:1 classes and those assigned to more traditional classes. The district library provided extensive resources via the Internet, and the computers were loaded with a number of software programs.	Middle school in an urban district in a mid-Atlantic state. The study involved the 1:1 school population as of 2005: 300 students and 12 teachers across grades six through 8.	Results show that under the right conditions, 1:1 laptop use can increase science achievement. In addition, the results indicate a gender relevant impact; boys showed a greater positive impact than did girls; boys outperformed girls in the same 1:1 science classrooms. Additional non-significant gender specific impacts on English and writing achievement were also noted. Further, there was no significant impact on math achievement.	Students were exposed to the treatment situation for two years for purposes of the study and were given 24 hour access to notebook computers during the school week. Control students had access to the same technology based resources by way of the school's computer lab, except for the 1:1 computer access. Teachers were provided with on-going technology training and support both at the school and the district level.

Citation	Brief Summary of Strategy	Sample Size	Impact/Evidence of Effectiveness	Implementation
	Teachers could schedule time in the lab, which contained 20 iMacs.[From article]			
Krawec, J., Huang, J., Montague, M., Kressler, B. & Melia de Alba, A. (2012). The effects of cognitive strategy instruction on knowledge of math problem-solving processes of middle school students with learning disabilities. *Learning Disability Quarterly*, 32(6), 80-92.	The purpose of this study was to examine the effectiveness of the Solve It! (Montague, 2003) cognitive strategy routine to improve the strategic knowledge and, consequently, the math problem solving of middle school students with LD. The study also examined specific differences in strategy use for AA students and students with LD and whether Solve It! differentially	Participants included seventh- and eighth-grade students with LD (n = 77) and average-achieving students (n=77).	Findings of students' reported strategy use during math problem solving as measured by the MPSA showed that treatment students outperformed comparison students on the strategies reported from pretest to posttest. Students who received Solve It! instruction reported using more strategies to solve mathematical word problems than students in the comparison group after the intervention. Results also showed that Solve It! was equally effective for students regardless of ability level (AA students and students with LD).	Treatment teachers participating in the intervention attended a 3-day professional development workshop in August prior to the start of school, which provided comprehensive training on the program. Three days of intensive instruction were implemented and then once-weekly 30-min problem solving practice sessions

Citation	Brief Summary of Strategy	Sample Size	Impact/Evidence of Effectiveness	Implementation
	improved students' strategy knowledge by ability. Solve It! is a researcher-developed intervention to improve the problem-solving performance of students with LD by explicitly teaching the cognitive processes and metacognitive strategies that proficient problem solvers use to solve math word problems (Montague et al., 2000). The four phases of Mayer's (1985) problem solving model (i.e., translation, integration, planning, and execution) provide the framework for the			followed, with word problems aligned to the week's math content standard. Instruction during all other times of the week was delivered as usual. Therefore, students in the intervention group received Solve It! instruction over the course of the year by embedding instruction in the district curriculum once weekly for 30 min, following the 3-day initial instruction. Comparison teachers were instructed to proceed with "business as usual" and were asked to focus on word problem solving

Citation	Brief Summary of Strategy	Sample Size	Impact/Evidence of Effectiveness	Implementation
	seven cognitive processes emphasized in the routine. Student strategies are reading and paraphrasing, visualizing, hypothesizing and estimating, and computing and checking. The Solve It! instructional manual (Montague, 2003) includes scripted lessons and an instructional guide for the teacher as well as class materials such as class charts and student cue cards. Practice problems and outlined solution paths are also included.			during at least one class period per week for the duration of the year.
Le, V., Stecher, B., Lockwood, J.R.,	This research study looks at the	Five cohorts of elementary and	Students exposed over several years to reform oriented teaching practices	Mosaic II is an observational study,

Citation	Brief Summary of Strategy	Sample Size	Impact/Evidence of Effectiveness	Implementation
Hamilton, L., Robyn, A., Williams, V., Klein, S. (2006). *Does reform-oriented teaching make a difference? The relationship between teaching practices and achievement in mathematics and science.* Santa Monica, CA: RAND Corporation.	relationship between "reform oriented" teaching practices, those that emphasize hands-on learning and actively involving students in their own learning and student achievement in math and science. These instructional practices center on inquiry based activities and "intellectual conversation skills, such as questioning. For this study, cohorts of students were followed for three years, and achievement was measured using both multiple choice and open ended questions on end of year achievement	middle school students in three school districts; three in math and two in science. A cohort consisted of all the students in a grade in one of the two selected subjects.	performed better on math and science assessments than those who had less exposure. In both math and science, the strength of the relationship between teaching practices and performance was related to how performance was assessed; the relationship was strongest when open ended measures were used.	relying on naturally occurring variation in teaching practices as the basis for uncovering relationships between reform-oriented practice and student outcomes. Each year, all participating teachers completed a survey, filled out classroom logs, and responded to a set of vignette-based questions about instructional practices.

Citation	Brief Summary of Strategy	Sample Size	Impact/Evidence of Effectiveness	Implementation
	tests. Items requiring problem solving skills were differentiated from those requiring only procedural skills. Multiple measures were used to assess instructional practices. These were: • Teacher surveys • Classroom vignettes • Teacher logs • Classroom observations			

Citation	Brief Summary of Strategy	Sample Size	Impact/Evidence of Effectiveness	Implementation
Newman, D., Finney, P., Bell. S.,Turner, H., Jaciw, A., Zacamy, J. & Gould, L. (2012). *Evaluation of the effectiveness of the Alabama Math, Science, and Technology Initiative (AMSTI).* Greensboro, NC: SERVE Center at UNCG.	This randomized control study examines the Alabama Math, Science, and Technology Initiative (AMSTI) primarily to determine whether the intervention had an impact on student achievement in math and/or science after one year and after two years. It also looks at the impact of the program on active learning instructional practices in math and in science. In addition, it explores the impact of AMSTI on various demographic groups after one year. AMSTI is a school wide intervention. Alabama	82 schools, 780 teachers, 30,000 students	The effect of AMSTI on student achievement in mathematics after one year, as measured by end-of-the-year scores on the Stanford Achievement Test Tenth Edition (SAT 10) mathematics problem solving assessment of students in grades 4–8, was 2.06 scale score units. The effect of AMSTI on student achievement in science, as measured by end-of-the-year scores on the SAT 10 science assessment, required only in grades 5 and 7, was not statistically significant after one year. AMSTI also had a significant positive effect on classroom active learning strategies after one year. The effect on math achievement after two years translates to a gain equivalent to 50 additional days of instruction. AMSTI also had a positive effect on science achievement after two years. There was also a positive effect on student engagement. There was no significant impact on either math or science based on demographic subgroup. However, some groups did have an increase in reading achievement.	Teachers and principals participate in 2 week summer institutes to train in the AMSTI curriculum. Teachers are provided all materials to deliver hands-on, inquiry-based instruction.

Citation	Brief Summary of Strategy	Sample Size	Impact/Evidence of Effectiveness	Implementation
	implemented the program over two years. The AMSTI intervention is based on the theory that teacher quality and effectiveness are vital to improving student achievement in mathematics and science. It centers around five principles: (1)Classroom practice should incorporate hands-on, inquiry-based instruction. (2) Mathematics and science curricula should focus on a reduced number of topics, emphasizing depth versus breadth of knowledge. (3)Performance-based assessments should complement			

Citation	Brief Summary of Strategy	Sample Size	Impact/Evidence of Effectiveness	Implementation
	standardized testing strategies. (4)Content-specific and ongoing professional development must be provided to teachers. (5)Adequate and accessible technological resources and classroom materials, from handheld calculators to computers, are required for effective classroom instruction.			

Citation	Brief Summary of Strategy	Sample Size	Impact/Evidence of Effectiveness	Implementation
Pane, J., Griffin, B., McCaffrey, D. & Karam, R. (2014). Effectiveness of Cognitive Tutor Algebra I at scale. *Educational Evaluation and Policy Analysis, 36*(2), 127-144.	CTAI is a technology-based mathematics curriculum designed to promote student understanding of algebraic concepts and principles, to develop students' problem-solving skills, and to enable them to master higher order mathematical concepts (Ritter, Anderson, Koedinger, & Corbett, 2007). It is part of a broader set of curricula covering a number of secondary mathematics courses. In addition to textbook materials, each course includes an automated computer-based Cognitive Tutor (Anderson, Corbett,	The study was conducted in 73 high schools and 74 middle schools in 51 school districts in seven states. Nearly 18,700 students in Grades 9 through 12 participated in the high school study, with 89% of the participants in 9th grade. Nearly 6,800 students in Grades 6 through 8 participated in the middle school study, with more than 99% of them in 8th grade.	The project conducted two parallel experiments, one in middle schools and one in high schools. The study used a pair-matched cluster randomized design to assign schools to study condition. Schools within each state were matched into pairs on a number of criteria, including school-level variables and the achievement profile of students targeted for participation, as specified by the schema that schools prepared as part of enrollment in the study. Analysis of posttest outcomes on an algebra proficiency exam finds no effects in the first year of implementation, but finds evidence in support of positive effects in the second year. Positive effects hold across all groups that participated in the study. The estimated effect is statistically significant for high schools but not for middle schools; in both cases, the magnitude is sufficient to improve the median student's performance by approximately eight percentile points. It is necessary to be cautious in interpreting these results	The company recommends that students spend 2 days per week of their class time using the computer-based, individualized one-on-one tutorial provided by the software while the teacher works with individual students as needed, and 3 days on classroom activities that are student-centered and involve group work and problem solving, guided by the teacher and the textbook but not using the software.[From article]

Citation	Brief Summary of Strategy	Sample Size	Impact/Evidence of Effectiveness	Implementation
	Koedinger, & Pelletier, 1995) that provides individualized instruction to address students' specific needs. The individualization is built into the software and is facilitated by detailed computational models of student thinking in a domain. Through the tutor, students work on challenging problems that reflect real-world situations and provide opportunities for students to progress from concrete to abstract thinking.		because mean student pretest scores were lower in the treatment group than the control group.	

Best/Promising Practices

Promising Practices	Citation(s)	Comments/Limitations
Instructional strategies	Braun, H., Coley, R., Jia, Y. & Trapani, C. (2009). *Exploring what works in science instruction: A look at the eighth-grade science classroom.* Princeton, NJ: Educational Testing Service.	This study identified teacher and student characteristics associated with student science achievement: • Students with many books in the home scored considerably higher than students with fewer books; and students who were absent frequently scored much lower than other students. • Students whose teachers held a standard teaching certificate scored slightly higher than other students. The study also identified pedagogical strategies associated with higher average scores: • Reading a science textbook. • Doing hands-on activities in science. • Writing long answers to science tests and assignments. • Students talking about measurements and results from hands-on activities. • Students working with others on a science activity or project. • Students taking a science test. • Teachers doing a science demonstration. • Students discussing science in the news. • Students reading a book or magazine about science. • Students preparing a written science report.
Evocation, Realization of Meaning, and Reflection (ERR) Instructional	Nixon, S., Saunders, G., & Fishback, J. (2015). Implementing an instructional framework and content literacy strategies into middle and high school science	The purpose of this research was to determine if teachers were using the Evocation, Realization of Meaning, and Reflection (ERR) instructional framework and how they were using the four instructional strategy groups from the ERR Framework to provide content literacy instruction in science classes.

Promising Practices	Citation(s)	Comments/Limitations
Strategy	classes. *Literacy Research and Instruction, 51*(4), 344-365.	Data were collected using an online survey. Analysis revealed that teachers were using the Framework and found it beneficial. Over half reported using the Framework most of the time; the majority reported using the Evocation Stage and finding it beneficial. The Reflection Stage was most often omitted.
Technology Immersion	Shapley, K., Sheehan, D., Maloney, C. & Caranikas-Walker, F. (2010). Evaluating the implementation fidelity of technology immersion and its relationship with student achievement. *The Journal of Technology, Learning, and Assessment*, 9(4), 1-69.	At the 4th year of the project, teachers at 4 of 21 schools had achieved substantial immersion, 16 had partial immersion and 1 had minimal immersion. No schools had substantial to full levels of student access and use. Strength of implementation of student access and use was a consistent predictor of student reading and math scores. Although laptop use for home learning was minimal, use of laptops for home learning was the strongest predictor of student reading and math scores. School level and teacher level were inconsistent predictors of student scores.