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. And there is more at stake than our young peoples' success. Reports indicate that continued scientific leadership and economic growth for the United States is linked to STEM (National Research Council, 2011). Yet, as STEM has become increasingly important, 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. According to the most recent National Assessment of Education Progress (NAEP), only 26% of 12th graders are proficient in math, and 20% are proficient in science; while Caucasian and Asian students' scores are somewhat higher, minority students score even lower. Nearly 75% of 12th grade students can't write proficiently (National Center for Education Statistics, 2015). While various sources point to a range of possible educational and social reasons for students' lackluster performance, that include the "achievement gap" and the " opportunity gap" research points to engagement as a very real factor. According to a 2013 Gallup poll (Busteed, 2013), while 76% of elementary students report being engaged in their school work, by high school this number falls to 44%. Twenty-eight percent of students are not engaged at school, and 17% are actively disengaged; by high school, two out of three students report being bored every day at school (Afterschool Alliance, 2015). Clearly, students need to be proficient in the STEM disciplines to succeed. Just as clearly educators must look at motivating and engaging students. "If students aren't motivated, it is difficult, if not impossible, to improve their academic achievement, no matter how good the teacher, curriculum or school is" (Usher & Kober, 2012). STEM can play a pivotal role in motivating and engaging students.

While no one approach will motivate every student, experts at the Center on Education Policy, in a series of papers on student motivation, examine a range of influences on motivation, including rewards, goals and family and social factors. They point to several strategies that can help to motivate and engage students; among these are inquiry based learning and integration of technology in classrooms (Usher & Kober, 2012). Other research indicates that when schools take into account students' interest in classroom activities and make learning relevant by linking schoolwork to the real world, providing hands-on learning and helping students understand how schoolwork connects to their lives so that students see the long-term impact of their efforts, students are more likely to be engaged (Gallup, 2014)(Afterschool Alliance, 2015). The Eberly Center at Carnegie Mellon offers a list of strategies for motivating and engaging students:

- Clearly articulate learning goals.
- Show relevance to students' academic lives.
- Demonstrate relevance to students' professional lives.
- Highlight real-world applications of knowledge and skills.
- Connect to students' personal interests.

- Allow students some degree of choice.
- Show your own passion and enthusiasm.

Research also 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,
- Provides students with engaging experiences that involve them in the practices of science and sustain their interest (National Research Council, 2011),
- 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).

All these practices are integral to high quality STEM programs.

In addition to these broad concepts, research points to a set of key overarching ideas and practices that support STEM learning. These are:
- 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.

More specifically, research 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 that will support students as they move through post-secondary education and into career choices.

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 into good STEM coursework support positive student attitudes. Students who learn to solve problems, work with others and communicate effectively have an advantage not only in school, but also as they move into in post-secondary education and a career. 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 use the Lego MINDSTORMS system to construct a robot and investigate gears, speed and torque.

Skills: Students will learn to:

- Calculate the circumference of a circle.
- Demonstrate the relationship between the linear distance traveled by a circular object and the circumference of a circle.
- Demonstrate the application of the appropriate gear ratios to maximize speed.

Implementation Plan

Effective STEM-focused high schools tend to share similar characteristics, with common features including the following (Hanover Research, 2015):

- An academic mission focused on preparing students for STEM majors and career tracks, reflected in a rigorous set of courses in the STEM subjects
- The use of small learning communities, allowing for peer collaboration and personalized learning experiences for students
- An integrated curriculum breaking down traditional academic silos and instead using an interdisciplinary lens to explore STEM concepts
- An instructional model embracing inquiry-based approaches to learning, such as project-based and problem-based learning
- The use of technology to improve instruction, facilitate lab-based learning, expand research opportunities, communicate with students and parents, and streamline assessment and feedback
- Efforts to build relationships with community, industry, and university partners to enhance learning opportunities for students
- Highly-qualified and well-prepared teachers with academic and professional experience in the STEM subjects

Uses

Using the Lego Mindstorms kit, students will construct a simple robot and explore the relationship between gears, speed and torque. The activity incorporates both physics and engineering concepts. Students will have opportunities to analyze problems and collaborate with others to solve them. They will have the opportunity to apply what is learned to extend the activity.

Audiences

The primary audience for the lesson is high school students, grades 9-12.

Activities

The activity highlighted is designed to provide students with a hands-on activity that incorporates a range of skills. Teachers can use it to teach both content skills in science and math, and also to teach process skills such as problem solving, team work, time management and communication.

Materials/Equipment/Space

Each group needs:

- Lego Mindstorms Education NXT Base set (www.legoeducation.com, $279.95)
- Computer (PC or MAC)
- Masking Tape
- Tape measure

Time

- Preparation Time: Students will need time to build and program their Taskbots. Once this is complete, the Taskbots can be used for multiple activities.
- Lesson Time: 30-45 minutes ("Gear Down for Speed" lesson)

Lesson Plan of Activity

In this sample physics students will build a robot to learn about gears, speed and torque. Additional suggestions for starting a Robotics Club can extend student interest in STEM learning.

Sample Lesson – STEM Strategy in High School

Activity 1: MINDSTORMS Robot Lesson: Gear Down for Speed

Activity	Process Notes
For the teacher: Prior to the lesson, go to the Texas Tech TSTEM Center and review the information on Construction Guides and Programming Information for MINDSTORMS.	*Link to the TSTEM Center: http://www.depts.ttu.edu/tstem/curriculum/robotics/construction_and_programming.php This is information that explains how the MINDSTORMS Robot system works. You and your students will need to understand this information in order to program and use a robot. Teachers may want to build a Taskbot before involving students.*
Before beginning the Gear Down for Speed lesson, each student group will need to build a Taskbot.	*Divide students into groups of 2-4. Review MINDSTORMS construction information with students. Diagrams detailing how to build a Taskbot can be found at http://www.education.rec.ri.cmu.edu/content/lego/building/build_shows/taskbot.pdf*
Tell students, "We will work in teams to build a Taskbot."	*Provide each group with a MINDSTORMS kit. Walk them through the steps to construct their robots.*
Tell students, "You will need to load the MINDSTORMS program Moving Forward for this activity."	*Secure the Moving Forward program and provide it to students.*
Begin Gear Down activity.	*Tell students, "During this activity we will learn about gears, gear ratios, and how they impact movement." Provide students with the information about gears found in the Resources section below. Distribute the Gear Down worksheet, provided in the Resources section below. Students should record all their work on this sheet.*
Mark a starting point for the Taskbots.	*Tell students, "We will begin by marking a starting point for the Taskbots with masking tape."*
Measure circumference.	*Ask students to measure the diameter of the Taskbot's wheel and compute its circumference. Provide the formula, Circumference = pi x Diameter.*

Activity	Process Notes
Configure	*Tell students, "Configure your Taskbot with a 1:1 ratio."*
Measure speed	*Tell students, "Use the Moving Forward program to measure the distance your Taskbot travels in 3 seconds."*
Calculate	*Tell students, "Calculate the speed of the robot for this gear ratio configuration using the formula: Speed = Distance / Time"* *These values will be used as speed 1 and gear ratio 1 in equation (2)*
Extend	*Tell students, "Using equation (2) and the values from step 4, calculate the speed for two more gear ratios: 1/3 and 3/5 7."*
Verify	*Tell students, "Configure the Taskbot with a gear ratio of 1/3 and calculate its speed (as in steps 1- 4). Repeat this with a gear ratio of 3/5."*
Compare	*Tell students, "Compare the value for the calculated speed with the recorded speed."*
Extend	*Tell students, "Try using your own configurations. Several variables can be changed. Consider wheel size, number of gears, power supplied, and others you may think of."*

Optional Activity 2: Starting a Lego Robotics Program/Club

Activity	Process Notes
Decide what you want to teach and how robotics will support this.	*Is your goal to teach content in math, science, programming, and skills such as teamwork or problem solving, or do you want to prepare your students to participate in competitions?*
Select your hardware and programming language.	*According to the Carnegie Mellon Robotics Academy, LEGO MINDSTORMS NXT is a good choice for high school students. They can be used to teach embedded systems, advanced programming, and engineering competencies, and useful add-ons are available.*
Research available curricula and resources.	*A Lego curriculum link can be found at http://education.rec.ri.cmu.edu/*
Decide on the size of your student group.	*1. All work should be done in student teams of 2-4 to support teamwork and collaborative solutions to problems.* *2. Some competitions limit participants to 10 students.* *3. First time coaches usually do well with about 8 students.* *4. Each student on the team should have an assigned role.* *5. Unisex teams are recommended.*

Activity	Process Notes
	See the information at http://www.education.rec.ri.cmu.edu/content/lego/start/ for additional details on forming teams.
Identify technical and logistical requirements.	*One robot for every team of 2 students is recommended. In addition, one computer for each robot is recommended. See the information at http://www.education.rec.ri.cmu.edu/content/lego/start/ for more information on the practice area and other requirements.*
Prepare a budget and find funding.	*Your budget will need to cover expenses such as robots, programming language, curriculum, and materials. If you plan to compete, it will need to incorporate competition fees. Approximate costs for many of these can be found at http://www.education.rec.ri.cmu.edu/content/lego/start/ Sources of funding may include your school district, local businesses and local non-profits. There may also be grant money available.*
Connect with the robotics community both locally and virtually.	*Chief Delphi is an online community for those interested in robotics. It is at http://www.usfirst.org/roboticsprograms/ftc The NCFIRST website at http://www.ncfirstrobotics.org/ offers a means to contact FIRST programs in North Carolina. You can also contact your district office to ask about programs at other area schools.*
Participate in some training.	*Here is one online training resource. http://www.education.rec.ri.cmu.edu/content/lego/teacher_training/sub_pages/web_courses/index_tx.htm*

Lessons adapted from:

Activity 1: Polytechnic Institute of NYU
http://engineering.nyu.edu/gk12/amps-cbri/pdf/classroom%20activities/keeshan/Gear%20Down%20For%20Speed.pdf
Activity 2: Carnegie Mellon Robotics Academy
http://www.education.rec.ri.cmu.edu/content/lego/start/

Tier 2 Intervention and Support Examples

Example 1: 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. Each member of a team is responsible not only for learning what is taught but also for helping teammates learn, thus creating an atmosphere of achievement. Research indicates that when group goals and individual accountability are used together, improved academic achievement consistently results. Other positive impacts of cooperative learning include improved behavior and attendance, increased self-confidence and motivation, and increased liking of school and classmates. There are several models of cooperative learning. Among these are Group Investigations, Student Teams-Achievement Divisions (STAD) and Jigsaw II. Cooperative learning is relatively easy to implement and is inexpensive.

Balkom, S. (1992). *Cooperative learning.* Washington, D.C.: US Department of Education, Office of Educational Research and Improvement. Retrieved from: https://www2.ed.gov/pubs/OR/ConsumerGuides/cooplear.html

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.

Information on Finding Funding Opportunities

http://www.stemfinity.com/STEM-Education-Grants
http://www.cesa2.org/programs/stem/STEMgrants.cfm

Texas Tech TSTEM Center – http://www.depts.ttu.edu/tstem/

Website offers an abundance of good information on using Lego MINDSTORMS, including details on constructing and programming a MINDSTORMS robot.
http://www.depts.ttu.edu/tstem/curriculum/robotics/construction_and_programming.php
PowerPoint from Texas Tech on planning a Lego lesson.
http://www.depts.ttu.edu/tstem/curriculum/robotics/docs/planning_lego_lesson.pdf

NYU Polytechnic School of Engineering

http://engineering.nyu.edu/gk12/amps-cbri/index.html

Carnegie Mellon University Robotics Academy

http://education.rec.ri.cmu.edu/lego/

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/

High School
http://www.dpi.state.nc.us/docs/acre/standards/new-standards/science/physics.pdf

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.

FIRST Robotics Competition

http://www.usfirst.org/roboticsprograms/frc

NASA Robotics

http://robotics.nasa.gov/links/resources.php

Chief Delphi Forum

Online community teachers may consider for support with their robotics program. However, it is not sponsored by or affiliated with any educations entity.
http://www.chiefdelphi.com/forums/showthread.php?t=104422

FIRST Robotics

According to their web site, "FIRST was founded in 1989 to inspire young people's interest and participation in science and technology. Based in Manchester, NH, the 501 (c) (3) not-for-profit public charity designs accessible, innovative programs that motivate young people to pursue education and career opportunities in science, technology, engineering, and math, while building self-confidence, knowledge, and life skills."
http://www.usfirst.org/roboticsprograms/ftc

Popular Mechanics

How to build a robot that is not from a kit.
http://www.popularmechanics.com/technology/robots/g779/build-your-own-robot/?

Google Online Science Fair

http://education.lego.com/en-us/about-us/google-science-fair

Note: All posters, images, and activity guides identified are copyright cleared for non-commercial use.

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.

To assess understanding and extend learning, have students:

- Compute the circumference for the wheels used for their robot.
- Compare the values of the calculated speeds to the measured speed.
- Develop their own configurations to maximize speed (e.g., consider factors such as : using more than two gears, changing the size of the wheels and using the gears in along three axes, using three motors, etc.).

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, and 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

Afterschool Alliance (2015). Afterschool Programs: Inspiring Students with a Connected Learning Approach. Washington, DC: Afterschool Alliance. Retrieved from http://afterschoolalliance.org//documents/Afterschool_and_Connected_Learning.pdf

Balkom, S. (1992). *Cooperative learning*. Washington, D.C.: US Department of Education, Office of Educational Research and Improvement. Retrieved from https://www2.ed.gov/pubs/OR/ConsumerGuides/cooplear.html

Busteed, B. (2013). *The school cliff: Student engagement drops with each school year*. Retrieved from http://thegallupblog.gallup.com/2013/01/the-school-cliff-student-engagement.html.

Carnegie Mellon Robotics Academy. (n.d.). *Steps to starting a LEGO® robotics program* [webpage]. Retrieved from http://www.education.rec.ri.cmu.edu/content/lego/start/

Carr, J. & Bertrando. S. (2014). *Top 10 instructional strategies for struggling students*. Leadership, 42(1), 24-26.

Gallup, (2014). The state of America's schools: *The path to winning again in education*. Washington, D.C.: Author. Retrieved from http://scee.groupsite.com/uploads/files/x/000/0a5/e37/Gallup%20Report%20--%20State%20Of%20Americas%20Schools.pdf?1397063851

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

Hanover Research: (2015). *Project based learning and best practices for delivering high school STEM education*. Arlington, VA: Author. Retrieved from http://gssaweb.org/webnew/wp-content/uploads/2015/04/Project-Based-Learning-and-Best-Practices-for-Delivering-High-School-STEM-Education.pdf

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.

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

National Center for Education Statistics. (2015). *National assessment of education progress*. Washington, D.C.: US Department of Education.

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

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

Polytechnic Institute of NYU. (2009). *Gear down for speed* [PDF document]. Retrieved from http://engineering.nyu.edu/gk12/amps-cbri/pdf/classroom%20activities/keeshan/Gear%20Down%20For%20Speed.pdf

Usher, A. and Kober, N. (2012*). Student Motivation – An Overlooked Piece of School Reform.* Washington, DC: Center on Education Policy, Graduate School of Education and Human Development, The George Washington University.

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
Kebritchi, M., Hirumi, A. & Bai, H. (2010). The effects of modern mathematics computer games on mathematics achievement and class motivation. *Computers and Education*, 55(2), 427-443.	This study investigated the impact of mathematics games on the mathematics achievement of K-12 students, using 3-Dimentioal modern mathematics games (DimensionM™). The research treatment included using a set of mathematics instructional games called DimensionM™ considered as a modern game, online teaching modules, lesson plans, and resources. The DimensionM™ teaches Pre-Algebra and Algebra I by assigning players mathematics related missions within a 3-D immersive environment designed with advanced graphics and a game story. The games have a learner-	A total of 193 Algebra and Pre-Algebra students and 10 teachers from an urban high school in the southeast.	Data were collected through quantitative instruments of the motivation surveys and the school district-wide benchmark exams. Interviews were also conducted. Data analysis showed a significant positive impact on achievement, but no impact on student motivation. In addition, both teachers and students believed that the games had a positive impact on both math understanding and skills and motivation.	The games supplemented class instruction; students in the treatment group played them for 30 minutes a week over 18 weeks during regular class time. The control group received regular instruction during that time. [From the article]. In addition to the games set, online teaching modules, lesson plans, and resources to use the games consistently were provided across the treatment classes. Algebra classes took place twice a week for both groups.

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	centered nature in which the players learn the mathematical concepts by accomplishing virtual missions. The set of games included a single player Algebra game and two multi-player games incorporating Algebra and Pre-Algebra. Teachers who agreed to take part were randomly assigned to treatment or control groups.			
Sadler, T., Romine,W., Stuart, P. & Merle-Johnson, D. (2013). Game-based curricula in biology classes: Differential effects among varying academic levels. *Journal of Research In Science Teaching, 50*(4), 479-499.	This study stems from a project in which we created a video game enabling students to use biotechnology to solve a societal problem. As students engaged in the game, they necessarily interacted with the underlying biological principles. Mission Biotech (MBt), the game featured in this	A total of 647 students from 31 different biology classes, taught by 10 different teachers, participated in the study.	For the overall project, we designed and implemented assessments at four distinct levels: embedded, close (quizzes), proximal (unit test), and distal (exam based on the concepts taught). Several immediate assessments were embedded within the game environment. Students from classes across all three academic levels demonstrated gains with relatively large effect sizes on the proximal test. Whereas the honors and advanced students demonstrated less substantial	MBt and the supporting curriculum were introduced to teachers as a part of a 2-week summer institute for high school teachers. The teachers implemented a standardized MBt instructional sequence over approximately 12 hours. About half of the instructional time for all teachers was

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	study, was designed to support high school biology education particularly in the areas of genetics and molecular biology. In designing MBt our goal was to expose players to ways in which science concepts are used for important purposes. In MBt, players assume the role of a biotechnologist challenged to diagnose the pathogenic agent causing an emergent epidemic. During game play, the computer provides players with a first-person perspective as they move within a virtual environment modeled after a biotechnology laboratory. Players interact with non-player characters and resources within the environment in order		gains on the distal exam, the general students demonstrated gains of similar effect size on both the proximal and distal assessments. Our results point to the positive potential of high school teachers' use of a game-based curriculum to support science learning. While results confirmed that students in general classes, who were typically younger students, had less prior knowledge than students in other classes, and students in the advanced and honors classes outperformed those in general classes, average increases in post-test scores on the proximal assessment, as compared to pre-test scores, were similar for all three groups. Effect sizes were relatively large for all groups, (d = 0.91, 1.03, and 0.75 for Gen, Hon, and Adv, respectively). In the case of the distal assessment, students from the General classes demonstrated greater gains than their peers. The effect size for the General students was over two and a half times higher than the Honors and Advanced students. A limited number of case studies were also conducted with teachers. Results suggest that a game-based curriculum may have a more positive effect on	devoted to game play; the other half of instructional time was devoted to mini-lectures, a laboratory exercise, a PCR simulation, small group activities, and whole class discussions

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	to better understand their tasks as well as the science behind those tasks. Like many video games, players progress through levels of increasingly complex tasks and rewards. The study focused on the extent to which students learned biology concepts in the context of a game-based curriculum. In particular, we explored learning among high school students, stratified across different academic levels (i.e., general, honors, and advanced).		lower level students than on higher level students.	

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Smith, J. & Suzuki, S. (2015). Embedded blended learning within an Algebra classroom: a multimedia capture experiment. *Journal of Computer Assisted Learning, 31*(2), 133-147.	This two-group, pretest-posttest, quasi-experimental study compared secondary students' learning of Algebra II materials over a 4-week period when identical instruction by the same teacher was delivered through either embedded blended learning or a live-lecture classroom. Instructional materials were developed using the California State Standards and the textbook in use in the school. The media lessons were made available to the screen-capture group through the school's website (Google Drive). Participating students in the screen-capture group accessed	Treatment group=32, control group=24	Data were collected through classroom tests and student surveys. The two groups had equivalent pre-test scores, but differed significantly on the post-test. Analysis indicated a moderate-size main effect of instructional method. In addition, the screen capture students indicated a greater understanding of the material on the student survey than did the live lecture group. 80% of the screen capture expressed a preference for that form of instruction. 93% indicated that they would like their teacher to make more screen capture lessons. Analysis resulted in four themes that indicated why the students preferred the screen capture lessons: (a) ability to control pacing of instruction; (b) new role of the classroom teacher; (c) lack of distraction in the blended learning environment; and (d) accessibility of the embedded multimedia lessons outside the classroom.	For both groups, instruction was delivered in a normal classroom setting. Each day for 4 weeks, teachers provided the same content to both the screen capture and the live lecture groups of students. Both groups received the same instruction. However, students in the screen capture group were able to re-wind, pause, fast forward and playback the material. Students took notes and were given the same assignments and assistance. The software and hardware used were digital whiteboards with screen capture software (SMART technologies), tablet computer (iPad) with

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	multimedia lessons through tablet computers (iPad) and over-ear headphones, which were available to individual students in the classroom. Both groups used the tablet computers in the classroom as enhanced graphing calculators [From article]. Teachers used the equipment to develop lessons prior to instruction.			an internal multimedia capture/movie camera, external microphone and a PC-based movie editing software (Sony VegasPro).

Best/Promising Practices

Promising Practices	Citation(s)	Comments/Limitations
Flipped Model	Clark, K. (2015). The effects of the Flipped Model of Instruction on student engagement and performance in the secondary mathematics classroom. *Journal of Educators Online*, 12(1), 91-115.	This study examined the effectiveness of the flipped model: moving instruction outside the classroom (home) and bring homework inside the classroom. The difference between students in the flipped class and the traditional class was insignificant in terms of academic performance. There was also little difference between groups on the survey responses, although students in the flipped classes often moved their response from agree to strongly

Promising Practices	Citation(s)	Comments/Limitations
		agree, indicating satisfaction with the flipped class. However, qualitative data revealed several recurring themes. These were active engagement and learning; class time and structure; quality of instruction; collaboration; and communication. Students expressed positive perceptions of the flipped model across these domains. 88% of students stated they actively participated in class under the flipped model compared to 76% under the traditional model. The results of the teacher created unit test supported this. The mean for students in the traditional class was 80% while the mean for students in the flipped model was 80.38. However, while students input favored the flipped model, academic performance was largely unaffected. The outcome of this study may indicate that while students were positive about the model, the content to be taught should be considered before implementing it.
Evocation, Realization of Meaning, and Reflection (ERR) Instructional Strategy	Nixon, S., Saunders, G., & Fishback, J. (2015). Implementing an instructional framework and content literacy strategies into middle and high school science classes. *Literacy Research and Instruction, 51*(4), 344-365.	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 to provide content literacy instruction in science classes. 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 often omitted.