Standards-Aligned CaveSim Programs for New York Middle Schools

Thank you for your interest in CaveSim! The centerpiece of our program is our mobile cave. Housed in a 31’ trailer, the cave contains 150’ of passage filled with formations, cave biota, and ancient artifacts (all artificial), and students get a computerized score based on how carefully they avoid these objects as they explore. There are no VR goggles, and the experience is a real exploration.

Our programs are about much more than just fun. Students learn valuable content in biology, chemistry, physics, geology, engineering, SEL, and other subjects. To accomplish all this, students do much more than just explore a mobile cave. They do physical science experiments on a 12' vertical caving tower. They learn about life science via labs with live cultures. Lessons with cave rescue phones and visualization equipment teach students about electromagnetics and STEM. Carbide lamp demos illustrate exothermic reactions, conservation of mass, and other chemistry concepts. Rescue practice provides ample opportunity to work on SEL skills. In short, we provide an experience that is so interesting that students readily absorb valuable educational content without realizing that they’re learning.

With engineering skills learned at MIT, I created the entire cave, including the electronics and software that give students feedback about their careful-caving skills. As a result, students learn that real people can create amazing things by excelling in school and following their passions. My staff and I are excited to help your students see the value of education in a whole new way.

— Dave Jackson, owner and inventor, CaveSim LLC.

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A 6th grader learns physics experentially on the CaveSim tower

Middle school student quote, after exploring the mobile cave at a program in Nevada: “This is the coolest thing I’ve ever done!”

A CaveSim team member helps a participant put on a helmet at a CaveSim event in California. Note the mobile cave in the background.

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Prior middle school programs, by state

CA: College Connections Academy (San Jose)
CO: Aurora Hills MS, Aspen Creek K-8, Falcon MS, Carson MS, Atlas Prep, Manitou Springs MS, Good Shepherd School, Ben Franklin Academy, The Colorado Springs School, The University School of Colorado Springs, University Schools MS, Ouray School, Pinnacle Charter School, Roosevelt Charter Academy
GA: Hillside Montessori
KY: Barren County Intermediate Center, Allen County MS
MS: Jackson Academy
OK: Grove MS, Stillwater Virtual Academy
TN: Winchester Christian Academy (preK-8), Jackson County MS
TX: Bedichek MS, Dahlstrom MS, Bishop Garriga MS, Incarnate Word Academy

A teacher explores the mobile cave in Maybell, CO

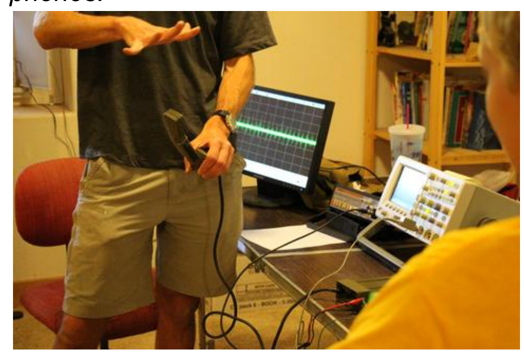
Standard Program Components (with New York State standards alignment)

Standard components are included in the cost of the program. Programs are typically conducted by having students work with us at a series of different stations/lessons, as follows:

CaveSim program element	Corresponding NYSED Standards	Photos of past CaveSim programs
<u>Horizontal caving</u> in CaveSim mobile cave (contains 150’ of passage with 3 levels in a 31’ trailer). While wearing helmets, students explore the cave and: ● Look for cave life & discuss the cave ecosystems. Compare cave- and surface-dwelling organisms and the impact that in-cave and surface resources have on the size & characteristics of organisms.	MS-LS2-1. Analyze and interpret data to provide evidence for the effects of resource availability on organisms and populations of organisms in an ecosystem.	 *A student emerges from CaveSim.*
● Look for indigenous artifacts & rock art, and discuss the importance of artifacts to native people, archaeologists, and anthropologists.	Social Studies Grade 6; A. 2. Identify, effectively select, & analyze different forms of evidence used to make meaning in social studies (including primary & secondary sources such as art…, artifacts….)	
● Try to avoid bumping artificial cave formations. Students learn about the impact of skin oil on stalactites and other speleothems and on cave microbial life. The polar nature of water and the non-polar nature of skin oil are discussed to explain why touching destroys cave formations.	Humans impact biodiversity both positively and negatively. (secondary to MS-LS2)	
● Study the structure of the cave, and discuss how cave tunnels form. CaveSim staff discuss the role microbes (extremophile bacteria) play in metabolizing limestone using enzymes. ● CaveSim staff explain how aqueous cave formations (helictites, soda straws, gypsum) are formed. Fluid dynamics and the role of extremophiles are discussed.	MS-LS2-3. Develop a model to describe the cycling of matter and flow of energy among living and nonliving parts of an ecosystem. Science assumes that objects and events in natural systems occur in consistent patterns that are understandable through measurement and observation. (MS-LS2-3)	 *A student moves carefully through CaveSim to avoid stalactites*
● Study the impact of diluted acid on various rock types to learn about which rock types are conducive to cave development. Discuss how carbonate rocks form (i.e., fossilization of remnants of lime-based and carbonate life forms). Students learn about how cave-based rock strata tell us about the geologic history of North America.	MS-LS4-1. Analyze & interpret data for patterns in the fossil record that document the existence, diversity, extinction, & change of life forms throughout the history of life on Earth under the assumption that natural laws operate today as in the past. MS-ESS2-1. Develop a model to describe the cycling of Earth’s materials and the flow of energy that drives this process.	

CaveSim program element	Corresponding NYSED Standards	Photos of past CaveSim programs
<u>Vertical caving</u> on CaveSim portable 12’ A-frame w/ crash pads: ● While wearing helmets, students use a Bosun’s chair, ropes, and pulleys to learn about mechanical advantage afforded by 1:1 and 5:1 pulley systems, and learn that work is unchanged when a mechanical advantage is introduced. Students work together to lift a fellow student up the tower using the different systems.	MS-PS3-5. Construct, use, and present an argument to support the claim that when work is done on or by a system, the energy of the system changes as energy is transferred to or from the system. MS-PS2-2. Plan and conduct an investigation to provide evidence that the change in an object’s motion depends on the sum of the forces on the object and the mass of the object. MS-PS3-2. Develop a model to describe that when the arrangement of objects interacting at a distance changes, different amounts of potential energy are stored in the system.	 *Above, a student gets lifted by classmates and staff via mechanical advantage up the A-frame. Below, students & CaveSim staff destroy a rope in 20 seconds using another rope.* 
● Students use the tower to rapidly lower water buckets onto a wooden board. Students record data about the mass of the bucket, the speed of the bucket, and the amount of energy transferred to the board.	Apply scientific ideas or principles to design, construct, and test a design of an object, tool, process or system. (MSPS3-3)	
● While wearing helmets, students use harnesses, mechanical ascenders, and foot loops to ascend the 12’ A-frame. CaveSim staff discuss the ascender mechanics, as well as equipment safety and the important differences between caving and rock climbing equipment. ● Students engage in a discussion about vertical caving safety, and forces and vectors are discussed in the context of the 12’ A-frame. ● With the help of students, CaveSim staff demonstrate the power of friction to rapidly destroy Nylon rope. ● With the help of students, CaveSim staff demonstrate the power of friction to allow a person to ascend a rope using the Prusik knot. Students learn to tie the Prusik, the Alpine Butterfly, the Lark’s Head, and other knots. ● Students learn about sinkholes, karst windows, vertical caves, and other geologic features that can sometimes form suddenly, creating natural hazards.	MS-ESS3-2. Analyze and interpret data on natural hazards to forecast future catastrophic events and inform the development of technologies to mitigate their effects. Physical Education 1.1.6. Demonstrates emerging forms of specialized skills in a variety of games and sports.	

CaveSim program element	Corresponding NYSED Standards	Photos of past CaveSim programs
<u>Carbide demonstrations</u>: to illustrate chemistry and physics concepts, CaveSim staff bring working carbide lamps and carbide to programs. Demonstrations include: ● CaveSim staff place carbide & ice in a pan. The ice melts, water reacts w/ the carbide, acetylene gas is made. Staff discuss the positive feedback associated with the reaction. Students investigate the interaction of the ice and the water heated by the carbide/water reaction.	MS-PS1-2. Analyze and interpret data on the properties of substances before and after the substances interact to determine if a chemical reaction has occurred. MS-PS1-7. Use evidence to illustrate that density is a property that can be used to identify samples of matter.	 *Above, carbide lamp demonstration by CaveSim staff. Below, stock photo of the lamps we use.* 
● CaveSim staff light a carbide lamp by placing carbide & water in the lamp to produce acetylene gas. The acetylene burns to produce light and heat, but the lamp body also becomes hot b/c of the exothermic reaction b/w carbide & water. Reaction rate is controlled by the rate of dripping in the lamp. We discuss limiting reactants.	MS-PS1-4. Develop a model that predicts and describes changes in particle motion, temperature, and phase (state) of a substance when thermal energy is added or removed.	
● Students design and test a system to hold carbide using basic recyclable materials.	MS-PS1-6. Undertake a design project to construct, test, and modify a device that either releases or absorbs thermal energy during a chemical and/or physical process. MS-PS3-3. Apply scientific principles to design, construct, and test a device that either minimizes or maximizes thermal energy transfer.	
● CaveSim staff mix carbide & water in a sealed container to demonstrate conservation of mass & energy. The container is placed on a balance and the mass is recorded before & after the reaction. Students observe that the mass changes only after the resultant acetylene gas is released from the container. Students draw models of the reactants and products of the reaction. Students learn about the components of carbide, which is a man-made fuel created with naturally occurring ingredients.	MS-PS1-5. Develop and use a model to describe how the total number of atoms does not change in a chemical reaction and thus mass is conserved. MS-PS1-1. Develop models to describe the atomic composition of simple molecules and extended structures. MS-PS1-3. Gather and make sense of information to describe that synthetic materials come from natural resources and impact society. MS-PS1-8. Plan and conduct an investigation to demonstrate that mixtures are combinations of substances	

CaveSim program element	Corresponding NYSED Standards	Photos of past CaveSim programs
Cave rescue phones hands-on lessons: ● We bring 2 cave rescue phones to the program. The phones are connected by wire, allowing us to discuss basic circuits and demonstrate that a circuit requires at least one complete loop to function. Students can disconnect and reconnect wires for hands-on learning, and talk with each other over the phones. CaveSim staff discuss the relationship between wire length, electrical resistance, electrical energy dissipation in the wire, and phone volume. Electrical circuits involving the earth as one of the conductors are discussed. The differences between analog and digital information transmission are also discussed.	MS-PS2-3. Ask questions about data to determine the factors that affect the strength of electric and magnetic forces. MS-PS3-6. Make observations to provide evidence that energy can be transferred by electric currents. An electric circuit is a closed path in which an electric current can exist. (MS-PS3-6) Energy may take different forms (e.g. energy in fields, thermal energy, energy of motion). (MS-PS3 5) MS-PS4-3. Integrate qualitative scientific and technical information to support the claim that digitized signals are a more reliable way to encode and transmit information than analog signals.	 *Students enjoy using the cave rescue phones.*
● Demonstrations with oscilloscopes (see https://whatis.techtarget.com/definition/oscilloscope) by CaveSim owner Dave Jackson who designed high speed chips for scopes. The scope graphs voltage on the phone wire vs. time; students see vocal energy on screen. We discuss graph axes and the relationship b/w time- and frequency-domain. Resonances/oscillation of electrical and sound signals and the Fourier transform are discussed. Students see relationships among frequency, wavelength, and speed.	MS-PS4-1. Develop a model and use mathematical representations to describe waves that includes frequency, wavelength, and how the amplitude of a wave is related to the energy in a wave. Develop a model to describe unobservable mechanisms. (MSPS3-2) Construct and interpret graphical displays of data to identify linear and nonlinear relationships. (MS-PS3-1)	 *A CaveSim staff person teaches students about electricity and magnetism using cave rescue telephones and electronic test equipment (oscilloscopes).*
● Students use the aforementioned cave rescue phones to conduct electromagnetism experiments with waterproof speakers, meters, function generators, and the aforementioned oscilloscope.	MS-PS4-2. Develop and use a model to describe that waves are reflected, absorbed, or transmitted through various materials. MS-PS2-5. Conduct an investigation and evaluate the experimental design to provide evidence that fields exist between objects exerting forces on each other even though the objects are not in contact. The transfer of energy can be tracked as energy flows through a designed or natural system. (MSPS3-3), (MS-PS3-6)	

CaveSim program element	Corresponding NYSED Standards	Photos of CaveSim programs
Bat skeleton and guano demonstrations and lessons: ● Discuss similarities/differences b/w bat wing morphology and human hand morphology. Discussion of evolutionary pressures that may have created the similarities/differences. ● Discuss bat tail structure and usage of the tail in steering, balance, and in catching insects. ● Discuss different bat types/sizes and how they help humans. Real-life lesson about bat eradication and impact on crops. ● Discuss history & the role caves played in the civil war (sources of saltpeter for the production of gunpowder).	MS-LS1-3. Construct an explanation supported by evidence for how the body is composed of interacting systems consisting of cells, tissues, and organs working together to maintain homeostasis. In multicellular organisms, the body is a system of multiple interacting subsystems. These subsystems are groups of cells that work together to form tissues and organs that are specialized for particular body functions. (MS-LS1-3)	
Bat echolocation games: ● Students play an echolocation tag game to investigate predator/prey relationships, to learn about evasive adaptations that some moths use, and to experience how bats use sound to find insects and navigate their surroundings. ● Students play a bat migration game to learn about the ways in which changes to bat habitat impact bat populations. ● Students use sound to locate a wall with their eyes closed. CaveSim staff explain how echolocation really works, and discuss the relationship between the speed of sound, distance between objects, and time of flight of a sound.	MS-LS1-8. Gather and synthesize information that sensory receptors respond to stimuli, resulting in immediate behavior and/or storage as memories. MS-LS2-4. Construct an argument supported by empirical evidence that changes to physical or biological components of an ecosystem affect populations. Proportional relationships (e.g. speed as the ratio of distance traveled to time taken) among different types of quantities provide information about the magnitude of properties and processes. (MS-PS3-1),(MS-PS3-4) Each sense receptor responds to different inputs (electromagnetic, mechanical, chemical), transmitting them as signals that travel along nerve cells to the brain. (MS-LS1-8)	*CaveSim program lead Dave Jackson teaches students about bat biology*  *Students roleplay bats and insects in an echolocation game*
Bat epidemiology activity: Millions of bats have died in the US from WNS. Students learn about WNS spread and about epidemiological concepts via a hands-on game. Students use UV fluorescent dye in test tubes and transfer the dye among the class. CaveSim staff use a blacklight to monitor the spread of the "disease" (i.e., dye) among the "bat" (i.e., student) population. Students play the game in rounds with the number of bat-bat interactions equaling the round number. Students graph interaction count vs. disease prevalence. Stochastic (i.e., random) processes are discussed. Students discuss various ways in which the disease might be stopped, and the pros/cons of each.	Collect data to produce data to serve as the basis for evidence to answer scientific questions or test design solutions under a range of conditions.(MS-PS3-6) Conduct an investigation to produce data to serve as the basis for evidence that meet the goals of an investigation. (MS-LS1-1) MS-LS2-5. Evaluate competing design solutions for maintaining biodiversity and protecting ecosystem stability.	 *Students study bat facts in a bat migration game*

CaveSim program element	Corresponding NYSED Standards	Photos of past CaveSim programs
<u>Cave rescue stretcher</u>: we bring an adult-sized cave rescue stretcher (Sked) to our programs. Students take turns getting into the stretcher. With the direct supervision of CaveSim staff, the student in the stretcher is carried through and around obstacles by fellow students. Students learn teamwork, communication, and leadership. <u>Space required</u>: any indoor or outdoor setting. May be done in classrooms or even hallways.	Physical Education: Social awareness and relationship skills 4.2.6. Uses communication skills and strategies that promote positive relationships in physical activity settings. Physical Education: Responsible decision making 4.3.6. Identifies problem solving skills and conflict resolution tactics in physical activity settings.	 *Austin High School student and football player gets ready to ride (successfully!) in the Skedco stretcher.*
<u>Squeezebox</u>: we bring an adjustable-height wooden box through which students can crawl to safely test their ability to navigate tight spaces. Students use a tape measure to quantify how tight a space they can move through. Staff discuss the idea that cave exploration can be a lifelong activity.	Physical Education: Self-awareness and management 4.1.6. Responds appropriately to successes and failures in physical activity settings. Physical Education: Lifetime Activities 1.4.6. Demonstrates emerging forms of specialized skills in lifetime activities.	 *Students use a tape measure to quantify their squeezebox skills.*

Special Program Components (aka labs)

Our standard programs (described above) can be enhanced with the addition of our labs. Our labs provide a very in-depth educational experience in a specific subject, such as biology or engineering. We never use kits because our goal is to teach students that engineering and science projects are accessible to them without the use of pre-prepared materials. We emphasize environmental conservation by including post-consumer recyclable materials in our engineering labs. Labs require:

- Classroom space
- Limited group size and sufficient time. Typically one class will spend 60 to 120 minutes on a lab (without doing other activities in that time), which may occur over a two-day period.
- Extra funding for lab materials and staff time.

Engineering Lab: Students create circuits using LEDs, switches, batteries, and other components to create an LED light system. They get hands-on experience with soldering (with supervision from CaveSim staff), and then design and make their own caving flashlight enclosure from recyclable materials. After creating their lights, students test their work in water to see if their lights are waterproof. Students have the chance to revise their designs if needed.

Subjects/standards covered: Electromagnetics, product design, material science, and mechanical engineering. NYSED standards: MS-ETS1-2. Evaluate competing design solutions using a systematic process to determine how well they meet the criteria and constraints of the problem.

Middle school students work on Engineering Lab

Biota Lab: Students culture cave biota in Petri dishes, and learn that single-celled organisms can demonstrate intelligence. Students choose from multiple experiments, and discuss the factors that impact the outcome of their experiments.

Students get ready to inoculate their Petri dishes.

Subjects/standards covered: Experiment design, scientific method, and biology concepts. NYSED standards: MS-LS1-1. Plan and conduct an investigation to provide evidence that living things are made of cells; either one cell or many different numbers and types of cells; MS-LS1-2. Develop and use a model to describe the function of a cell as a whole and ways parts of cells contribute to the function.

Karst Lab: Students get to make their own cave formations and karst topography using safe household materials. Students learn hydrology, geology, basic chemistry, landforms, states of matter.

Subjects/standards covered: Geology, hydrology, karst topography. NYSED standards: Plan an investigation individually and collaboratively, and in the design: identify independent and dependent variables and controls, what tools are needed to do the gathering, how measurements will be recorded, and how many data are needed to support a claim. (MS-PS3-4); MS-ESS2-2. Construct an explanation based on evidence for how geoscience processes have changed Earth's surface at varying temporal and spatial scales.

Helmet Lab: Students conduct an egg-drop experiment in a novel manner. Working in groups of two or three, students design a helmet for their egg, first on paper and then with recyclable materials. Students must demonstrate that the egg can be removed from the helmet. Students begin by prototyping with plastic eggs, and then switch to real eggs for the final test in which the egg helmets are dropped from the top of the CaveSim vertical caving tower. Students make observations about which design elements worked well and which could use improvement. Students reflect on the engineering design process and the value of trial and error.

Subjects/standards covered: MS-PS3-1. Construct and interpret graphical displays of data to describe the relationships of kinetic energy to the mass of an object and to the speed of an object. MS-ETS1-3. Analyze data from tests to determine similarities and differences among several design solutions to identify the best characteristics of each that can be combined into a new solution to better meet the criteria for success. MS-ETS1-4. Develop a model to generate data for iterative testing and modification of a proposed object, tool, or process such that an optimal design can be achieved.

The value of education: As an inventor and educator, Dave encourages students to study hard, find their passion, and understand that education is very important in life. During each program, Dave uses his personal story (including getting multiple degrees from MIT) to teach students that education leads to great success and adventure.

Keynote presentation in Lake George, CO.

Pricing and FAQ

How much do programs cost? This depends on factors like travel distance, number of days, and number of students. Current pricing is shown at https://www.cavesim.com/schools/pricing/. Please contact us for a quote.

Are deposits or contracts required? No. We will reserve your program date(s) once we agree on a price and you send us an email stating that you want us to visit your school at the agreed-upon price.

How are payments made? By check, made out to CaveSim LLC, as specified on the invoice that we'll email you. W9 available upon request.

Does CaveSim carry insurance? Yes. Once you commit to working with us, please let us know if you need a Certificate of Additionally Insured.

How much space is needed? Is power required? See www.cavesim.com/pages/site-logistics

Is this an outdoor activity? Typically yes. The cave stays inside the trailer (we don't move it into your school). Some activities can be moved inside in inclement weather (the tower can be moved indoors if you have 13+ foot ceilings in some part of your school). In light to moderate rain/snow, we put up tents to protect students and the cave.

Is the cave heated and air conditioned? Yes. Please provide access to 1 working 20A outlet in summer, and 2 outlets (15A and 20A) in winter.

How much setup and takedown time are needed? Typically 1.5 hours for setup, and 1 hour for takedown.

How many students can participate in a day? For elementary, 150-200. For MS/HS, 100-150. Educational value and number of students are inversely related. We're excited about working with you to size your groups for the best possible educational experience.

Does CaveSim do multi-day programs? Yes. We have done as many as six consecutive days in one school district.

Contact us: Email jacksondmit@cavesim.com or call 914-330-7824.

Safety and special needs

Teachers/staff can explore the cave, and students with special needs (physical or otherwise) may be assisted by school staff, students, and/or CaveSim staff. While each student is different, numerous wheelchair-bound students have explored CaveSim. Some students may have more difficulty avoiding cave formations, and our only requirement is that each student understands their goal of not touching the formations (for the safety of the system and students). Students who are unable to understand the careful-caving goal may participate in our other activities. CaveSim has night-vision cameras which allow us to check on students as they explore. We also have five access points to allow us to let participants out of the trailer if needed.

We follow the BSA's Youth Protection policy, which includes no 1:1 student/adult interaction.

Challenge by choice

Most students love exploring CaveSim. Occasionally we have a student who is unsure, uncomfortable, or afraid. We encourage him/her to set a goal for themselves and see if they can attain that goal. We teach challenge by choice, and have plenty of activities for students to try.

Classroom management

We’ve been doing our programs since 2010, and our staff includes former classroom teachers, so we have a good handle on classroom management. Because we spent over two years creating CaveSim, we set expectations at the start of the program: we expect students to respect the equipment and everyone involved in the program. We rarely experience discipline problems, but when we do we ask students to either change their behavior or take a break from the activity until they are ready to participate properly. Our goal is to work as a team with you, so please feel free to communicate with us about any issues that you foresee.