Standards-Aligned CaveSim Programs for Colorado Middle Schools

Thank you for your interest in CaveSim! The centerpiece of our program is our mobile cave. Housed in a 24’ trailer, the cave contains 60’ 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.

Our programs are about much more than just fun. Students learn valuable content in life science, physical science, earth science, PE and even art. To accomplish all this, students rotate through stations. Students learn physical science first-hand on a 12' vertical caving tower. They learn about microorganisms and other life science lessons via hands-on bat-related activities. Lessons with cave rescue phones and visualization equipment teach students about properties of waves. Carbide lamp demos illustrate exothermic reactions, conservation of mass, and other chemistry concepts. In short, we provide an experience that is so thrilling and 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.

Teacher quotes:

“We loved having you guys, and I am so excited to keep this program going. I've heard fantastic things from each site and I know they will want to continue it in the future.” **— Deitra Biely, 7th-8th grade science teacher, Grove Middle School, Grove, OK**

“Your staff was terrific.” **— Annette Humphrey, Middle School Science, Good Shepherd School, Denver**

“The kids learned a lot and had a good time. It was definitely worthwhile.” **— Amos White, MS Division Lead, The Colorado Springs School**

“The day went very well and the outcomes were beneficial to our seminar.” **— Blisse Beardsley, Middle School Math Teacher, CSS**

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Table of Contents:

Middle schools whose students have benefitted from our programs

Colorado:

Boulder Valley School District: Aspen Creek K-8
Falcon D49: Falcon Middle School
Fountain Fort Carson D8: Carson Middle School
Harrison D2: Atlas Preparatory School
Manitou Springs School D14: Manitou Springs MS
parochial schools: Good Shepherd School, Denver
private schools: Ben Franklin Academy; The Colorado Springs School; The University School of Colorado Springs
Weld County School District 6: University Schools

Kentucky:

Allen County: Allen County Intermediate Center
Barren County: Barren County Middle School

Oklahoma:

Grove: Grove Middle School

Texas:

Hays CISD: Dahlstrom Middle School

Learning physical science on the 12' CaveSim vertical caving tower

Standard Program Components (with Colorado Academic Standards[1] alignment)

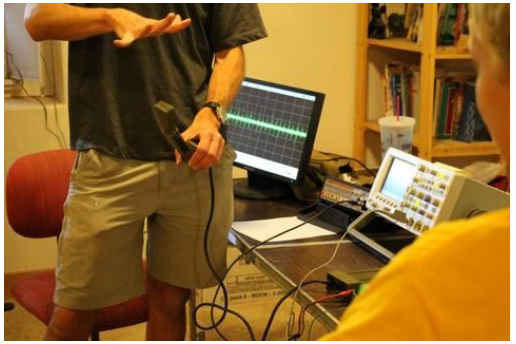
Standard components are included in the cost of the program. Students rotate through a series of different stations/lessons. Color key: Science Standards; Visual Arts Standards; Physical Education Standards;

Exploration of CaveSim & Associated Lessons	Corresponding CDE Standards	Photos of programs
Students look for cave life (artificial) inside the mobile cave. We discuss the cave ecosystems. Students compare cave- and surface-dwelling organisms and the impact that in-cave and surface resources have on the size & characteristics of organisms.	MS-LS1-6: Construct a scientific explanation based on evidence for the role of photosynthesis in the cycling of matter and flow of energy into and out of organisms. MS-LS2-3: Develop a model to describe the cycling of matter & flow of energy among living & nonliving parts of an ecosystem. LS2:B Cycle of Matter & Energy Transfer in Ecosystems: Food webs are models that demonstrate how matter & energy are transferred b/w producers, consumers, & decomposers as the three groups interact….	 *A student explores CaveSim in 2018.*
Students look for artifacts & rock art, and discuss the importance of artifacts to native people, archaeologists, and anthropologists.	Visual Arts Grade 6, 1-1-b: Develop from oneself & various cultures a mental storehouse of images & the uses, symbolism & meaning of those images.	
Students learn from CaveSim staff about the impact of skin oil on stalactites, stalagmites, and other speleothems. The polar nature of the water molecule & the non-polar nature of skin oil are discussed as a way to explain why touching destroys cave formations.		
Students discuss how cave tunnels form. Students learn about the role microorganisms (extremophile bacteria) play in metabolizing limestone w/ enzymes. Staff explain how aqueous cave formations form. Fluid dynamics & the role of extremophiles are discussed.	MS-LS3 Cross Cutting Concept 1: Energy and Matter: Within a natural system, the transfer of energy drives the motion and/or cycling of matter.	
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 geologic history.	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-ESS1-4: Construct a scientific explanation based on evidence from rock strata for how the geologic time scale is used to organize Earth's 4.6-billion-year-old history.	

[1] For Colorado Academic Standards information, please visit https://www.cde.state.co.us/standardsandinstruction/standards

Vertical Caving on the 12' Vertical Caving Tower	Corresponding CDE Standards	Photos of CaveSim programs
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.	PS2:A Forces & Motion: For any pair of interacting objects, the force exerted by the 1st object on the second object is equal in strength to the force that the 2nd object exerts on the first, but in the opposite direction (Newton's third law). The motion of an object is determined by the sum of the forces acting on it; if the total force on the object is not zero, its motion will change. The greater the mass of the object, the greater the force needed to achieve the same change in motion. For any given object, a larger force causes a larger change in motion.	 *Above, a Grove, OK student uses mechanical advantage to lift herself up the A-frame. Below, Grove students & CaveSim staff destroy a rope in 20 seconds using another rope.* 
Students use buckets of water interconnected by ropes run through pulleys to investigate Newton's first, second, and third laws.	PS-2-2: Plan an investigation to provide evidence that the change in an object's motion depends on the sum of the forces on the object & the mass of the object. Clarification: Emphasis is on balanced [Newton's 1st Law] & unbalanced forces in a system, qualitative comparisons of forces, mass & changes in motion [Newton's 2nd Law]....	
Students use the tower to drop water buckets onto a wooden board. Students observe that the board gets destroyed, and then they work in groups to design and test a system to protect the board from getting broken.	PS-2-1: Apply Newton's 3rd Law to design a solution to a problem involving the motion of two colliding objects. MS-PS-3-2: 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.	
Students use harnesses & mechanical ascenders to climb rope. Staff discuss ascender mechanics, equipment safety, & important differences between caving and rock climbing equipment.	PE Grade 6 2-1-h: Accurately identify activities that are aerobic and anaerobic. PE Grade 7 2-2-b: Engage in a variety of strength and endurance fitness activities	
Students engage in a discussion about vertical caving safety, and forces and vectors are discussed in the context of the 12' A-frame.	PE Grade 7 4-1-d: Identify safety rules for the activity and area being used	
W/ help of students, staff demonstrate the power of friction to rapidly destroy Nylon rope, as well as the power of friction to allow a person to ascend a rope using the Prusik knot.		

Carbide Demonstrations	Corresponding CDE Standards	Photos of CaveSim programs
Staff put carbide & ice in a pan; ice melts; water reacts w/ carbide to form acetylene. Students study state/ temperature changes associated w/ the exothermic carbide/water reaction. Positive feedback is discussed.	MS-PS1-4: Develop a model that predicts and describes changes in particle motion, temperature, and state of a pure substance when thermal energy is added or removed.	 *Carbide lamp demonstration by CaveSim staff in Grove, OK.*
Staff put carbide & water in a lamp to form acetylene. The acetylene burns to make light & heat, but the lamp body also becomes hot b/c carbide/water reaction is exothermic. Reaction rate is controlled by the rate of dripping in the lamp. Limiting reactants & reflector properties are discussed.	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. PS4:B Electromagnetic Radiation: When light shines on an object, it is reflected, absorbed, or transmitted…. The path that light travels can be traced as straight lines, except at surfaces b/w different transparent materials... where the light path bends.	
Students learn that carbide is synthesized from coal & lime in arc ovens. Societal impact is discussed.	MS-PS1-3: Gather & make sense of information to describe that synthetic materials come from natural resources & impact society.	 *Example of the lamps we use.*
CaveSim staff mix carbide and water in a sealed container to demonstrate conservation of mass and energy. The container is placed on a gram 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.	PS1-5: Develop & use a model to describe how the total number of atoms does not change in a chemical reaction & thus mass is conserved. PS1:A Structure & Properties of Matter: Substances are made from different types of atoms, which combine… in various ways. Atoms form molecules that range in size from two to thousands of atoms. Solids may be formed from molecules, or they may be extended structures w/ repeating sub-units (e.g., crystals). Each pure substance has characteristic physical & chemical properties.... Gases & liquids are made of molecules or inert atoms that are moving about relative to each other. In a liquid, the molecules are constantly in contact w/ others; in a gas, they are widely spaced except when they happen to collide. In a solid, atoms are closely spaced & may vibrate in position but don't change relative locations. The changes of state that occur w/ variations in temperature or pressure can be described & predicted using these models of matter.	
Students work together to design a carbide lamp from recyclable materials. Staff help students test their designs.	PS1-6: Undertake a design project to construct, test, & modify a device that either releases or absorbs thermal energy by chemical processes.	

Cave Rescue Phones / Waterproof Speakers	Corresponding CDE Standards	Photos of CaveSim programs
We bring two cave rescue phones to our programs. The phones are connected by wire, which allows us to discuss basic circuits, and demonstrate that a circuit requires at least one complete loop to function. Students can disconnect/reconnect wires to study circuits. Students 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 & digital information transmission are also discussed.	MS-PS3 Cross-cutting Concept 2: Energy and Matter: Energy may take different forms (e.g., energy in fields, thermal energy, energy of motion). The transfer of energy can be tracked as energy flows through a designed or natural system. 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 in Grove, OK enjoy using the cave rescue phones.*  *A CaveSim staff person teaches students about electricity and magnetism using cave rescue telephones and electronic test equipment (oscilloscopes).*
Demos with waterproof speakers, which we use to show that sound is a wave that can move matter, and that electrical energy can be converted to mechanical (sound) energy (and vice versa). Students learn how we made the speakers to learn that they can make cool things with simple materials.	MS-PS3 Described above. PS4:A Wave Properties, described above.	
Demonstrations w/ oscilloscopes (see https://whatis.techtarget.com/definition/oscilloscope) by CaveSim owner Dave Jackson, who has designed high speed computer chips for o'scopes. The o'scope produces a graphical representation of voltage on the cave rescue phone wire vs. time, which allows students to visualize their vocal energy on a screen. We discuss graph axes, and the relationship between time-based & frequency based graphs. Resonances/oscillation of electrical and sound signals & the Fourier transform are discussed. Students use their voices and the phones to demonstrate relationship b/w frequency & wavelength.	PS4:A Wave Properties: A simple wave has a repeating pattern with a specific wavelength, frequency, and amplitude. A sound wave needs a medium through which it is transmitted. Geologists use seismic waves and their reflection at interfaces b/w layers to probe structures deep in the planet. MS-PS2 Cross-cutting Concept 2: Systems and Systems Models: Models can be used to represent systems and their interactions – such as inputs, processes and outputs – and energy and matter flows w/in systems.	
Students use the aforementioned cave rescue phones to conduct electromagnetism experiments with analog meters, simple generators, and the aforementioned oscilloscope.	MS-PS2-3: Ask questions about data to determine the factors that affect the strength of electric and magnetic forces. 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.	

Bat Biology & Epidemiology Lessons/Activities	Corresponding CDE Standards	Photos of CaveSim programs
Bat skeleton and guano demonstrations and lessons: ● Discussion of similarities/differences b/w bat wing morphology and human hand morphology. Discussion of evolutionary pressures that may have created the similarities/differences. ● Discussion of bat tail structure and usage of the tail in steering, balance, and in catching insects. ● Discussion of different types/sizes of bats, and the role that they play in helping humans. Real-life lesson about bat eradication by farmers and the impact on their crops. ● Discussions about history & the role caves played in the civil war (sources of saltpeter for the production of gunpowder).	MS-LS1-4: Use argument based on empirical evidence and scientific reasoning to support an explanation for how characteristic animal behaviors and specialized plant structures affect the probability of successful reproduction of animals and plants respectively. MS-LS1-3: Use argument supported by evidence for how the body is a system of interacting subsystems composed of groups of cells. LS2:C Ecosystem Dynamics, Functioning, and Resilience: Ecosystems are dynamic in nature; their characteristics can vary over time. Disruptions to any physical or biological component of an ecosystem can lead to shifts in all its populations.	 *CaveSim program lead Dave Jackson teaches bat biology in Oklahoma.*
● Photo/video demos of the ongoing White Nose Syndrome (WNS) epidemic that has killed >6 million bats in the last ~10 years. Lesson about WNS fungus (Pseudogymnoascus destrucans) which metabolizes live bats. ● Discussion of bats' colonial behaviors, and the advantages and disadvantages of such behaviors.	MS-LS2-4: Construct an argument supported by empirical evidence that changes to physical or biological components of an ecosystem affect populations. MS-LS1-5: Construct a scientific explanation based on evidence for how environmental and genetic factors influence the growth of organisms.	 *Students in Oklahoma roleplay bats spreading WNS fungus by using a UV fluorescent dye.*
Bat epidemiology activity: As mentioned above, millions of bats are dying in the US from WNS. Students learn about the spread of WNS, and about overarching epidemiological concepts, through 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 being equal to the round number. Students make a graph of 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.	MS-PS3: Academic Context and Connections: Colorado Essential Skills and Science and Engineering Practices: 1. Construct and interpret graphical displays of data to identify linear and nonlinear relationships. MS-LS2-5: Evaluate competing design solutions for maintaining biodiversity and ecosystem services.	

CaveSim program element	Corresponding CDE Standards	Photos of CaveSim programs
Cave rescue stretcher: 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. Space required: any indoor or outdoor setting. May be done in classrooms or even hallways.	PE Grade 6, 1-2-b: Cooperate with a small group of classmates during activities, game play or team-building activities. PE Grade 7, 3-1-b: Participate in group cooperation games and adventure activities to encourage team-building and fun. PE Grade 8, 4-1-c: Make appropriate decisions to ensure the safety of self and others during outdoor activities.	 *Austin High School student and football player gets ready to ride (successfully!) in the Skedco stretcher.*
Squeezebox: 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.	PE Grade 6, 3-1-b: Accept differences among classmates in physical development, maturation and varying skill levels.	 *Students at a 2018 Austin program 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 can be scheduled over a two-day period.
- Extra funding for lab materials and staff time.

CaveSim program element: Biology Lab	Corresponding CDE Standards	Photos of past CaveSim programs
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, including the impact of external stimuli. Subjects covered: Experiment design, scientific method, and biology concepts, including prokaryotic/eukaryotic, kingdoms of life, nuclei, and membranes.	MS-LS1-7: Develop a model to describe how food is rearranged through chemical reactions forming new molecules that support growth and/or release energy as this matter moves through an organism. MS-LS1-1: 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 & use a model to describe the function of a cell as a whole & ways the parts of cells contribute to the function. MS-LS3-2: Develop and use a model to describe why asexual reproduction results in offspring with identical genetic information and sexual reproduction results in offspring with genetic variation.	 *Students at a two-day high school program in Oklahoma get ready to inoculate their Petri dishes.*

CaveSim program element: Engineering Lab	Corresponding CDE Standards	Photos of CaveSim programs
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 covered: Electromagnetics, product design, material science, and mechanical engineering.	CDE Essential Skills in the area of Entrepreneurial Skills (see https://www.cde.state.co.us/standardsandinstruction/essentialskills-pdf)	 *Middle school students in Colorado work on their circuit designs..*

CaveSim program element: Karst Lab	Corresponding CDE Standards	Photos of past CaveSim programs
Students make their own karst topography using basic household materials. Students add water to their models and watch as sinkholes form in real time. We discuss hydrology, geology, basic chemistry, landforms, states of matter, and the limitations of the small-scale model.	MS-ESS2-4: Develop a model to describe the cycling of water through Earth's systems driven by energy from the sun and the force of gravity. MS-ESS3-1: Construct a scientific explanation based on evidence for how the uneven distributions of Earth's mineral, energy, and groundwater resources are the result of past and current geoscience processes. 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.	 *Colorado students work on topography models*

Pricing and FAQ

How much do programs cost? This depends on factors like travel distance, number of days, and number of students. Our typical price is between $1408 and $1508/day. Need-based discounts are sometimes available. 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.

Are permission slips required? Yes. Paperless and printable versions in both English and Spanish are available: www.cavesim.com/waiver.

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 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 understand 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.