Standards-Aligned CaveSim Programs for Mississippi Middle Schools

Thank you for your interest in CaveSim! The centerpiece of our program is our mobile cave. Housed in a 26' 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, social studies, 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, inventor and lead educator, 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**

Document revision December 1, 2020

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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 Mississippi Academic Standards[1] alignment)

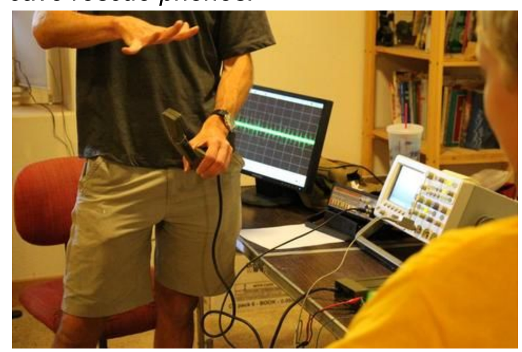
Standard components are included in the cost of the program. Students rotate through a series of different stations/lessons. Color key: Science Standards; Visual Arts Standards; Physical Education Standards; Social Studies

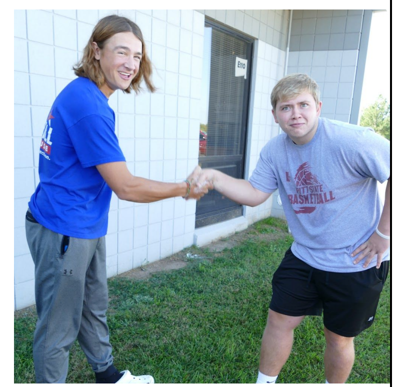
Exploration of CaveSim & Associated Lessons	Corresponding Mississippi Standards	Photos of programs
Students look for cave life (artificial) inside the mobile cave. We discuss the cave ecosystems. Students compare cave- and surface-dwelling organisms and the impact that in-cave and surface resources have on the size & characteristics of organisms.	L.6.3 Students will demonstrate an understanding of the relationships among survival, environmental changes, and diversity as they relate to the interactions of organisms, populations, and the environment. L.7.3.4 Explain how disruptions in cycles (e.g., water, oxygen, carbon, and nitrogen) affect biodiversity and ecosystem services (e.g., water, food, and medications) which are needed to sustain human life on Earth. L.6.3.5 Develop and use food chains, webs, and pyramids to analyze how energy is transferred through an ecosystem from producers (autotrophs) to consumers (heterotrophs, including humans) to decomposers.	 *A student explores CaveSim in 2018.*
Students look for artifacts & rock art, and discuss the importance of artifacts to native people, archaeologists, and anthropologists.	Social Studies H.6.1 Explain the characteristics and development of culture	
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.	P.7.5A.3 Compare and contrast chemical and physical properties (e.g., combustion, oxidation, pH, solubility, reaction with water)	
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.	L.6.1.1 Use argument supported by evidence in order to distinguish between living and non-living things, including viruses and bacteria L.7.3.1 Analyze diagrams to provide evidence of the importance of the cycling of water, oxygen, carbon, and nitrogen through ecosystems to organisms.	
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.	E.8.7.1 Use scientific evidence to create a timeline of Earth's history that depicts relative dates from index fossil records and layers of rock (strata).	

[1] For Mississippi College- and Career-Readiness standards information, please visit https://www.mdek12.org/OAE/college-and-career-readiness-standards

Vertical Caving on the 12’ Vertical Caving Tower	Corresponding Mississippi 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.	P.6.6 Students will demonstrate an understanding of Newton’s laws of motion using real world models and examples. P.6.6.2 Use mathematical computation and diagrams to calculate the sum of forces acting on various objects.	 *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.	P.6.6 Students will demonstrate an understanding of Newton’s laws of motion using real world models and examples.	
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.	P.6.6.1 Use an engineering design process to create or improve safety devices (e.g., seat belts, car seats, helmets) by applying Newton’s Laws of motion. Use an engineering design process to define the problem, design, construct, evaluate, and improve the safety device.	
Students use harnesses & mechanical ascenders to climb rope. Staff discuss ascender mechanics, equipment safety, & important differences between caving and rock climbing equipment.	P.6.6.3 Investigate and communicate ways to manipulate applied/frictional forces to improve movement of objects on various surfaces	
Students engage in a discussion about vertical caving safety, and forces and vectors are discussed in the context of the 12’ A-frame.	P.6.6.6 Investigate forces (gravity, friction, drag, lift, thrust) acting on objects (e.g., airplane, bicycle helmets).	
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.	P.6.6.7 Determine the relationships between the concepts of potential, kinetic, and thermal energy.	

Carbide Demonstrations	Corresponding Mississippi 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.	P.7.5A.2 Analyze and interpret qualitative data to describe substances using chemical properties (the ability to burn or rust). P.7.5C.5 Describe concepts used to construct chemical formulas (e.g. CH4, H20) to determine the number of atoms in a chemical formula	 *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.	P.7.5A.3 Compare and contrast chemical and physical properties (e.g., combustion, oxidation, pH, solubility, reaction with water). P.7.5D.1 Analyze evidence from scientific investigations to predict likely outcomes of chemical reactions.	
Students learn that carbide is synthesized from coal & lime in arc ovens. Societal impact is discussed.	P.7.5C.6 Using the periodic table, make predictions to explain how bonds (ionic and covalent) form between groups of elements (e.g., oxygen gas, ozone, water, table salt, and methane).	
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.	P.7.5E Students will demonstrate an understanding of the law of conservation of mass. P.7.5A.1 Collect and evaluate qualitative data to describe substances using physical properties (state, boiling/melting point, density, heat/electrical conductivity, color, and magnetic properties). P.7.5B.1 Make predictions about the effect of temperature and pressure on the relative motion of atoms and molecules (speed, expansion, and condensation) relative to recent breakthroughs in polymer and materials science. P.7.5B.2 Use evidence from multiple scientific investigations to communicate the relationships between pressure, volume, density, and temperature of a gas.	 *Example of the lamps we use.*

Cave Rescue Phones / Waterproof Speakers	Corresponding Mississippi 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.	P.8.6.7 Research the historical significance of wave technology to explain how digitized tools have evolved to encode and transmit information (e.g., telegraph, cell phones, and wireless computer networks).	 *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.	P.6.6.4 Compare and contrast magnetic, electric, frictional, and gravitational forces P.8.6.5 Conduct scientific investigations that describe the behavior of sound when resonance changes (e.g., waves in a stretched string and design of musical instruments). P.8.6.1 Collect, organize, and interpret data about the characteristics of sound and light waves to construct explanations about the relationship between matter and energy.	
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.	P.8.6.8 Compare and contrast the behavior of sound and light waves to determine which types of waves need a medium for transmission P.8.6.4 Use scientific processes to plan and conduct controlled investigations to conclude sound is a wave phenomenon that is characterized by amplitude and frequency.	
Students use the aforementioned cave rescue phones to conduct electromagnetism experiments with analog meters, simple generators, and the aforementioned oscilloscope.	P.8.6.2 Investigate research-based mechanisms for capturing and converting wave energy (frequency, amplitude, wavelength, and speed) into electrical energy	

Bat Biology & Epidemiology Lessons/Activities	Corresponding Mississippi Standards	CaveSim program photos
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).	L.8.2A Students will demonstrate an understanding of how sexual reproduction results in offspring with genetic variation while asexual reproduction results in offspring with identical genetic information. L.8.4B Students will demonstrate an understanding of how similarities and differences among living and extinct species provide evidence that changes have occurred in organisms over time and that similarity of characteristics provides evidence of common ancestry. Social Studies E.6.1 Explain the concept of natural resources and how people use and value them. Social Studies G.6.7 Compare and contrast ways that humans and physical environment are impacted by the extraction of resources. 7C.14 Identify and evaluate the key events and people involved in the American Civil War. P.7.5D.4 Build a model to explain that chemical reactions can store (formation of bonds) or release energy (breaking of bonds).	 *CaveSim program lead Dave Jackson teaches bat biology*
● 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.	L.8.4A Students will demonstrate an understanding of the process of natural selection, in which variations in a population increase some individuals' likelihood of surviving and reproducing in a changing environment.	 *Students roleplay bats spreading WNS fungus by using a UV fluorescent dye.*
Bat epidemiology activity: Millions of bats are dying in the US from WNS. Students learn about WNS spread and overarching epidemiological concepts via a hands-on game. Students use fluorescent dye in test tubes and transfer the dye among the class. Staff use a blacklight to track the spread of the "disease" among the "bat" (i.e. student) population. The is played in rounds w/ 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.	L.6.3.4 Investigate organism interactions in a competitive or mutually beneficial relationship (predation, competition, cooperation, or symbiotic relationships).	

CaveSim program element	Corresponding Mississippi 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 standards: 5. Exhibit responsible personal and social behavior that respects self and others in physical activity settings.(S, P, L)	 *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 standards: 6. Value physical activity for health, enjoyment, challenge, self-expression, and/or social interaction. (P, L, F, C)	 *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 Mississippi 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.	L.6.1.2 Obtain and communicate evidence to support the cell theory. L.6.1.3 Develop and use models to explain how specific cellular components (cell wall, cell membrane, nucleus, chloroplast, vacuole, and mitochondria) function together to support the life of prokaryotic and eukaryotic organisms to include plants, animals, fungi, protists, and bacteria (not to include biochemical function of cells or cell part). L.6.1.4 Compare and contrast different cells in order to classify them as a protist, fungus, plant, or animal. L.6.1.5 Provide evidence that organisms are unicellular or multicellular. L.6.4 Students will demonstrate an understanding of classification tools and models such as dichotomous keys to classify representative organisms based on the characteristics of the kingdoms: Archaebacteria, Eubacteria, Protists, Fungi, Plants, and Animals.	 *Students at a two-day high school program in Oklahoma get ready to inoculate their Petri dishes.*

CaveSim program element: Engineering Lab	Corresponding MS 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.		 *Middle school students work on their circuit designs.*

CaveSim program element: Karst Lab	Corresponding Mississippi 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.	L.7.3.5 Design solutions for sustaining the health of ecosystems to maintain biodiversity and the resources needed by humans for survival (e.g., water purification, nutrient recycling, prevention of soil erosion, and prevention or management of invasive species). E.8.9A.7 Explain the interconnected relationship between surface water and groundwater. E.8.9B.3 Using an engineering design process, create mechanisms to improve community resilience, which safeguard against natural hazards	 *Students work on topography models*

<table>
<tr><th>CaveSim program element: Geology Lab</th><th>Corresponding Mississippi Standards</th><th>Photos of past CaveSim programs</th></tr>
<tr><td>Students make a small rock collection and use various geology tests to assess each of their rocks. Tests include Mohs scale of hardness, density (sink/float), magnetism, and reaction with acid (vinegar)</td><td>P.7.5D.2 Design and conduct scientific investigations to support evidence that chemical reactions (e.g., cooking, combustion, rusting, decomposition, photosynthesis, and cellular respiration) have occurred.</td><td rowspan="3">
Students work on geology investigation</td></tr>
<tr><td>Students use various safe household powders and vinegar to study acid-base reactions. Some reactions are exothermic (reaction with powdered laundry detergent), while others produce CO_2 (reaction with baking soda)</td><td>P.7.5D.3 Collect, organize, and interpret data using various tools (e.g., litmus paper, pH paper, cabbage juice) regarding neutralization of acids and bases using common substances.</td></tr>
<tr><td>Geology demonstrations with fossils, the three major rock types, crystal structure, and other geology concepts.</td><td>E.8.7.3 Construct and analyze scientific arguments to support claims that most fossil evidence is an indication of the diversity of life that was present on Earth and that relationships exist between past and current life forms.</td></tr>
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FAQ

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.