Standards-Aligned CaveSim Programs for Oklahoma Middle Schools

Brought to you by MIT-trained electrical engineer Dave Jackson, CaveSim creator and program lead. Contact Dave: dave@cavesim.com

Students in Grove, OK learn bat biology (and skeletal morphology) during a 2018 2-day program

OK student quote, while working on a Petri dish during the CaveSim Biota Lab: "Mrs. Chaney [the biology teacher], why don't we get to do this kind of stuff in biology class?" CaveSim staff person, "This is biology class!" The students in this class were having so much fun learning that they forgot they were in class.

Table of Contents:

Summary

The centerpiece of CaveSim programs is our mobile cave, which we bring to your school from Colorado in a 24' trailer. The cave contains formations, cave life, and artifacts. Students get a computerized score based on how carefully they avoid these objects as they explore.

CaveSim is about much more than exploring a mobile cave. Our high school programs are tailored specifically to Oklahoma high school standards[1], and cover a wide range of subjects including biology, chemistry, physics, engineering, geology, and even PE and art.

Programs are led by CaveSim inventor, educator, and MIT-trained electrical engineer Dave Jackson. Dave and his wife Tracy are both real cavers, and have been doing CaveSim programs at schools around the country for the last 11 years. Our lessons are designed by Tracy, who has a Masters of Art in Teaching, and are brought to you by Dave and our highly skilled CaveSim staff.

In addition to learning a wide range of classroom subjects, students also learn that they can do what Dave and Tracy have done: take what they've learned in school and use it to follow their passions to make the world just a little bit better. We look forward to bringing CaveSim to your school to engage your students in a whole new way.

Oklahoma organizations that have done and loved our programs

Grove: HS: May '17 (1 day); Sept '18 (2 days); Lower ES: May 2017 (2 days), Oct '18 (2 days); Upper ES: May '17 (1 day), Sept '18 (2 days);
Edmond Public Schools: Centennial Elementary (two years); John Ross Elementary (two years); Frontier Elementary (one year)
Science Museum Oklahoma: Six days of programs over four years.

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[1] https://sde.ok.gov/oklahoma-academic-standards

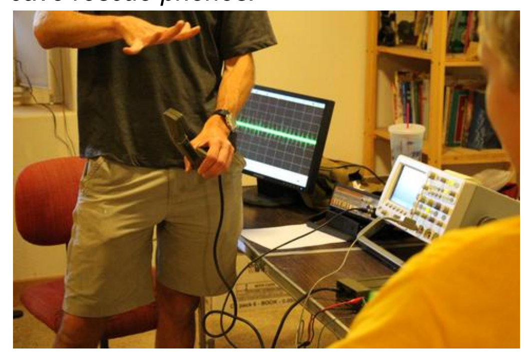
Standard Program Components (with Oklahoma standards alignment)

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 OK SDE Standards	Photos of past CaveSim programs
<u>Horizontal caving</u> in CaveSim mobile cave (contains 60' of passage with multiple levels in a 24' 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 in Austin explores CaveSim in 2018.*
● Look for indigenous artifacts & rock art, and discuss the importance of artifacts to native people, archaeologists, and anthropologists.	Social Studies OKH.1.4 Compare cultural perspectives of American Indians and European Americans regarding land ownership, structure of self-government, religion, and trading practices.	
● Try to avoid bumping into artificial cave formations. Students learn from CaveSim staff about the impact of skin oil on stalactites, stalagmites, and other speleothems. The polar nature of the water molecule and the non-polar nature of skin oil are discussed as a way to explain why touching destroys cave formations.	Social Studies 6.4.6 (and 7.4.6): Describe the role of citizens as responsible stewards of natural resources and the environment	
● Study the structure of the cave, and discuss how cave tunnels form. CaveSim staff talk about the role microorganisms (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.	
● 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 and interpret data for patterns in the fossil record that document the existence, diversity, extinction, and 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 geologic history.	

CaveSim program element	Corresponding OK SDE Standards	Photos of past CaveSim programs
Vertical caving 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-PS3-2: 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. MS-PS2-2: Plan an investigation to provide evidence that the change in an object’s motion depends on the sum of the forces on the object and the mass of the object.	
● 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.	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-PS3-6: Construct, use, and present arguments to support the claim that when the kinetic energy of an object changes, energy is transferred to or from the object. MS-PS2-1: Apply Newton’s Third Law to design a solution to a problem involving the motion of two colliding 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.*
● 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.	Physical Education S1.M23 Demonstrates correct technique for basic skills in one self-selected individual-performance activity.	

CaveSim program element	Corresponding OK SDE 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 and ice in an open pan. As the ice melts, the water reacts with the carbide, producing the acetylene gas. CaveSim 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-PS1-4: 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.	 *Above, carbide lamp demonstration by CaveSim staff in Grove, OK. 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 because of the exothermic reaction b/w carbide & water. The reaction rate is controlled by the rate of dripping in the lamp. We discuss the concepts of limiting reactants.	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.	
● Students design and test a system to hold carbide using basic recyclable materials.	MS-PS3-3: Apply scientific principles to design, construct, and test a device that either minimizes or maximizes thermal energy transfer. MS-PS1-6: Undertake a design project to construct, test, and modify a device that either releases or absorbs thermal energy by chemical processes.	
● 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 and 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-PS1-1: 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-PS1-5: 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.	

CaveSim program element	Corresponding OK SDE Standards	Photos of past CaveSim programs
<u>Cave rescue phones</u> hands-on lessons: ● 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 and reconnect wires for hands-on learning. 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 conductor are discussed. The differences between analog and digital information transmission are also discussed.	MS-PS4-3: Integrate qualitative scientific and technical information to support the claim that digitized signals (sent as wave pulses) are a more reliable way to encode and transmit information.	 *Students in Grove, OK enjoy using the cave rescue phones.*
● Demonstrations with oscilloscopes (see https://whatis.techtarget.com/definition/oscilloscope) by CaveSim owner Dave Jackson, who has also designed high speed computer chips for oscilloscopes. The oscilloscope 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 and frequency based graphs. Resonances/oscillation of electrical and sound signals and the Fourier transform are also discussed. Students use tuning forks and water to demonstrate the relationships among frequency, wavelength, and speed.	MS-PS4-1: Use mathematical representations to describe a simple model for waves that includes how the amplitude of a wave is related to the energy in a wave. MS-PS4-2: Develop and use a model to describe that waves are reflected, absorbed, or transmitted through various materials.	 *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 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.	

CaveSim program element	Corresponding OK SDE Standards	Photos of CaveSim programs
<u>Bat skeleton and guano</u> 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-LS1-3: Use argument supported by evidence for how the body is a system of interacting subsystems composed of groups of cells. MS-LS1-4: Use arguments 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-LS1-5: Construct a scientific explanation based on evidence for how environmental and genetic factors influence the growth of organisms. MS-LS4-6: Use mathematical representations to support explanations of how natural selection may lead to increases and decreases of specific traits in populations over time.	 *CaveSim program lead Dave Jackson teaches students about bat biology in Grove, Oklahoma.*  *Students in Oklahoma roleplay bats spreading WNS fungus.*
● 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-LS2-2: Construct an explanation that predicts patterns of interactions among organisms across multiple ecosystems.	
<u>Bat epidemiology activity</u>: 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-LS2-4: Construct an argument supported by empirical evidence that changes to physical or biological components of an ecosystem affect populations. MS-LS2-5: Evaluate competing design solutions for maintaining biodiversity and ecosystem services.	

CaveSim program element	Corresponding OK SDE 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 S2.M13 Makes appropriate decisions, based on the weather, level of difficulty due to conditions or ability to ensure safety of self and others. S4.M1 Exhibits personal responsibility by using appropriate etiquette, demonstrating respect for facilities, and exhibiting safe behaviors. S4.M5 Cooperates with a small group of classmates during adventure activities, game play, or team-building activities.	 *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.	Physical Education S1.M22 Demonstrates correct technique for basic skills in one self-selected outdoor pursuit.	 *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 may occur over a two-day period.
- Extra funding for lab materials and staff time.

<u>Engineering Lab:</u> 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.

<u>Subjects/standards covered:</u> Electromagnetics, product design, material science, and mechanical engineering. **Technology Education Standard 8**: The student will apply the technology design process to create useful products and systems; **Standard 10**: The student will apply problem-solving and critical thinking techniques for troubleshooting, research and development, invention and innovation and experimentation and implement these strategies as a multidisciplinary approach; **Standard 11**: The student will apply creativity in developing technology products and systems. 1. Create a model to explain a solution to a problem. 2. Test and evaluate a design for improvement. 3. Identify quality controls necessary in a technology product or system process; **Standard 12**: The student will apply safe and proper use of tools, machines, materials, processes and technical concepts.


Students from The Colorado Springs School work on Engineering Lab (left) and Advanced Light Lab (right)

<u>Biota Lab:</u> 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 at a two-day program in Grove, Oklahoma get ready to inoculate their Petri dishes.

Subjects/standards covered: Experiment design, scientific method, and biology concepts. **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 and use a model to describe the function of a cell as a whole and ways parts of cells contribute to the function. **MS-LS3-2**: Students who demonstrate understanding can: 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.

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. **MS-ESS2-2**: Construct an explanation based on evidence for how geoscience processes have changed Earth's surface at varying time and spatial scales. **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.

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.

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 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.