Standards-Aligned CaveSim Programs for Oklahoma High Schools

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

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

OK HS student quote, while working on a Petri dish during the CaveSim Biota Lab: "Mrs. Chaney [the HS 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 2

Oklahoma organizations that have done and loved our programs 2

Standard Program Components (with Oklahoma standards alignment) 3

Special Program Components (aka labs) 8

Pricing and FAQ 11

Safety and special needs 12

Challenge by choice 12

Classroom management 12

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 (April 2019, 1 day); John Ross Elementary (April 2019, 1 day)
Science Museum Oklahoma: May 2017 (1 day); October 2017 (1 day); April 2019 (2 days)

---

[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 CaveSim programs
Horizontal caving 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 (artificial) and discuss cave ecosystems.	HS-LS2-4: Use a mathematical representation to support claims for the cycling of matter and flow of energy among organisms in an ecosystem. PE S5.H2 Level 1: Chooses an appropriate level of challenge in a self-selected activity. Level 2: Chooses an appropriate level of challenge to experience success & desire to participate in a self-selected physical activity.	 *A student at Austin High School explores CaveSim in 2018.*
● Look for indigenous artifacts & rock art, and discuss the importance of artifacts to native people, archaeologists, and anthropologists.	History 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 about the impact of skin oil on stalactites and other speleothems. The polar nature of water and the non-polar nature of skin oil are discussed to explain why touching destroys cave formations. Students learn about the relationship between the molecular-level characteristics and the macroscopic interactions of oil and water.	HS-PS3-5: Develop and use a model of two objects interacting through electric or magnetic fields to illustrate the forces between objects and the changes in energy of the objects due to the interaction.	
● 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.	HS-LS1-7: Use a model to illustrate that cellular respiration is a chemical process whereby the bonds of food molecules and oxygen molecules are broken and the bonds in new compounds are formed resulting in a net transfer of energy.	
● Study the impact of diluted acid on various rock types. Discuss why and how carbonate rocks react with acid. Discuss the relative strength of chemical bonds in various rock types, and why the different rock types have different bond strength (based on how the rocks were formed).	HS-PS1-3: Plan and conduct an investigation to gather evidence to compare the structure of substances at the bulk scale to infer the strength of electrical forces between particles. HS-PS1-1: Use the periodic table... to predict the relative properties of elements based on the patterns of electrons in the outermost energy level of atoms.	

CaveSim program element	Corresponding OK SDE 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. ● Students use water buckets on the tower to demonstrate Newton’s second law by making observations of balanced and unbalanced systems (with zero and non-zero net forces), recording rate of ascent/descent data, and drawing conclusions.	HS-PS2-1: Analyze data and use it to support the claim that Newton’s second law of motion describes the mathematical relationship among the net force on a macroscopic object, its mass, and its acceleration. Examples of data could include tables or graphs of position or velocity as a function of time for objects subject to a net unbalanced force, such as a falling object, an object rolling down a ramp, or a moving object being pulled by a constant force. HS-PS2-2: Use mathematical representations to support the claim that the total momentum of a system of objects is conserved when there is no net force on the system.	
● Students design a system to protect a wooden board from being destroyed when a water bucket is rapidly lowered from the top of the tower onto the board.	HS-PS2-3: Apply scientific and engineering ideas to design, evaluate, and refine a device that minimizes the force on a macroscopic object during a collision.	
● While wearing helmets, students use harnesses, mechanical ascenders, and footloops 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.H1 Demonstrates competency and/or refines activity-specific movement skills in two or more lifetime activities. S2.H2 Uses movement concepts and principles (e.g., force, motion, rotation) to analyze and improve performance of self and/or others in a selected skill.	*Above, a Grove HS 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.* 

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. Students compare carbide (CaC_2) with road salt ($CaCl_2$) to develop a hypothesis about how carbide will react with water.	HS-PS1-1: Use the periodic table... to predict the relative properties of elements based on the patterns of electrons in the outermost energy level of atoms. HS-PS1-2: Construct and revise an explanation for the outcome of a simple chemical reaction based on the outermost electron states of atoms, trends in the periodic table, knowledge of the patterns of chemical properties, and formation of compounds. HS-PS3-4: Plan and conduct an investigation to provide evidence that the transfer of thermal energy when two components of different temperature are combined within a closed system results in a more uniform energy distribution among the components in the system (second law of thermodynamics).	 *Above, carbide lamp demonstration by CaveSim staff at Grove high school in Oklahoma. Below, stock photo of the lamps we use.* 
● CaveSim staff light a working carbide lamp by placing carbide and water in the lamp to produce a small (and safe) quantity of flammable gas (acetylene). The acetylene burns to produce light and heat, but the lamp body also becomes hot because of the exothermic reaction between the carbide and water. The rate of reaction is controlled by the rate of dripping in the lamp (which controls the concentration of water in the reaction chamber). We discuss the concepts of limiting reactants.	HS-PS1-5: Apply scientific principles and evidence to provide an explanation about the effects of changing the temperature or concentration of the reacting particles on the rate at which a reaction occurs. HS-PS1-6: Refine the design of a chemical system by specifying a change in conditions that would produce increased amounts of products at equilibrium.	
● 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.	HS-PS1-7: Use mathematical representations to support the claim that atoms, and therefore mass, are conserved during a chemical reaction.	

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.	HS-PS4-2: Evaluate questions about the advantages and disadvantages of using a digital transmission and storage of information.	 *High school students in Oklahoma 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.	HS-PS4-1: Use mathematical representations to describe relationships among the frequency, wavelength, and speed of waves.	
● Students use the aforementioned cave rescue phones to conduct electromagnetism experiments with analog meters, simple generators, and the aforementioned oscilloscope.	HS-PS2-5: Plan and conduct an investigation to provide evidence that an electric current can produce a magnetic field and that a changing magnetic field can produce an electric current. HS-PS3-3: Design, build, and refine a device that works within given constraints to convert one form of energy into another form of energy.	*A CaveSim staff person teaches students about electricity and magnetism using cave rescue telephones and electronic test equipment (oscilloscopes).*

CaveSim program element	Corresponding OK SDE Standards	Photos of past 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).	HS-LS4-4: Construct an explanation based on evidence for how natural selection leads to adaptation of populations.	 *CaveSim program lead Dave Jackson teaches high school students about bat biology in Oklahoma.*
● Photographic and/or video demonstration of the ongoing White Nose Syndrome (WNS) epidemic that has killed nearly 6 million bats in the last ~10 years. Lesson about the WNS fungus (Pseudogymnoascus destrucans) and how it metabolizes the bat alive. ● Discussion of bats' colonial behaviors, and the advantages and disadvantages of such behaviors.	HS-LS2-8: Evaluate evidence for the role of group behavior on individual and species' chances to survive and reproduce. HS-LS4-3: Apply concepts of statistics and probability to support explanations that organisms with an advantageous heritable trait tend to increase in proportion to organisms lacking this trait. HS-LS2-7: Design, evaluate, and refine a solution for reducing the impacts of human activities on the environment biodiversity.	
<u>Bat epidemiology activity</u>: As mentioned above, millions of bats are dying in the US from WNS. Students learn about the spread of this disease, and about the overarching epidemiological concepts, through a truly hands-on game. In this game, students apply powdered laundry detergent to their hands, and CaveSim staff use a blacklight to monitor the spread of the "disease" (i.e., fluorescent detergent) among the "bat" (i.e., student) population. Students play the game in multiple 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.	HS-LS2-2: Use mathematical representations to support and revise explanations based on evidence about factors affecting biodiversity and populations in ecosystems of different scales. HS-LS2-6: Evaluate the claims... that the complex interactions in ecosystems maintain relatively consistent numbers and types of organisms in stable conditions, but changing conditions may result in a new ecosystem. HS-LS4-5: Synthesize, communicate, and evaluate the information that describes how changes in environmental conditions can affect the distribution of traits in a population causing: 1) increases in the number of individuals of some species, 2) the emergence of new species over time, and 3) the extinction of other species.	 *HS students in Oklahoma roleplay bats spreading WNS fungus.*

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 S4.H3 Level 1: Uses communication skills and strategies that promote team or group dynamics. Level 2: Assumes a leadership role (e.g., task or group leader...) in a physical activity setting.	 *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. <u>Space required</u>: typically set up near the stretcher (see above). Any indoor or outdoor setting is fine.	Physical Education S5.H2 Level 1: Chooses an appropriate level of challenge in a self-selected activity. Level 2: Chooses an appropriate level of challenge to experience success and desire to participate in a self-selected physical activity.	 *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.

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. **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)

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 at a two-day high school program in Oklahoma get ready to inoculate their Petri dishes.

Subjects/standards covered: Experiment design, scientific method, and biology concepts. **HS-LS1-1**: Construct an explanation based on evidence for how the structure of DNA determines the structure of proteins, which carry out the essential functions of life through systems of specialized cells. **HS-LS1-2**: Develop and use a model to illustrate the hierarchical organization of interacting systems that provide specific functions within multicellular organisms. **HS-LS1-3**: Plan and conduct an investigation to provide evidence of the importance of maintaining homeostasis in living organisms. **HS-LS1-4**: Use a model to illustrate the role of cellular division (mitosis) and differentiation in producing and maintaining complex organisms

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 covered: Geology, hydrology, karst topography

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. Our average price is $1508/day. 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.