Standards-Aligned CaveSim Programs for Texas 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 learn bat biology (and skeletal morphology) during a 2018 2-day program

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 <u>is</u> biology class!" The students in this class were having so much fun learning that they forgot they were in class.

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Summary

Thank you for your interest in CaveSim programs! The centerpiece of our programs is our mobile CaveSim system, but we have an entire ecosystem of TEKS-aligned hands-on lessons and activities that goes with the mobile cave. Our high school programs are tailored specifically to high school standards, and cover a wide range of subjects including biology, chemistry, physics, engineering, geology, and even PE and art.

Programs are led by MIT-trained CaveSim inventor Dave Jackson. Dave and his wife Tracy (both real cavers) have taught CaveSim programs around the US since 2010. Tracy has a Masters in Teaching from Colorado College. Dave and other CaveSim staff teach the programs.

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, and we're excited about working with you.

Texas schools that have done and loved our programs (alphabetically, by district)

Austin: Austin HS, McCallum HS, Andrews ES, Baranoff ES, Barrington ES, Barton Hills ES, Blanton ES, Boone ES, Brentwood ES, Cowan ES, Hill ES, Houston ES, NYOS, Pecan Springs ES, Sanchez ES, T.A. Brown ES, Wooldridge ES; Georgetown: Frost ES; Hays: Dahlstrom MS; Granbury: Brawner Intermediate; Baccus ES; Lake Travis: Lakeway ES; Hutto MS; New Braunfels: Memorial ES; Dripping Springs: Sycamore Springs ES; Conroe: Creighton ES; Del Valle Elementary.

Standard Program Components (with TEKS 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 TEKS	Photos of past 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: ● 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. ● Look for cave biota (critters, all artificial), and discuss the cave ecosystem after they exit the cave. ● Study the structure of the cave, and discuss how the passage was formed. CaveSim staff talk about the role microorganisms (extremophile bacteria) play in metabolizing limestone using enzymes. We can also discuss the formation of sinkholes (common in Texas), and the benefits / dangers that they afford humans. ● CaveSim staff explain how aqueous cave formations (helictites, soda straws, gypsum) are formed. Fluid dynamics is discussed. ● Look for indigenous cave artifacts and rock art, and discuss the importance of such artifacts to native people and to archaeologists and anthropologists. ● Look for modern, man-made equipment in the cave, including rescue cache and vertical caving rope ladder (etrier). Students learn that the etrier (rope ladder) is named after the French word for stirrup. Space required: the 24’ trailer is typically kept outside. See www.cavesim.com/site-logistics for more details. In inclement weather, we may close the trailer and do indoor activities.	§112.35. **Chemistry**. c) 10) A) describe the unique role of water in solutions in terms of polarity §112.37. **Environmental Systems**. b) 1) Students study a variety of topics that include: biotic and abiotic factors in habitats, ecosystems and biomes, interrelationships among resources and an environmental system, sources and flow of energy through an environmental system §112.36. **Earth and Space Science**. b) 5) B) These dynamic processes are responsible for the origin and distribution of resources as well as geologic hazards that impact society. §112.32. **Aquatic Science**. c) 8) A) demonstrate basic principles of fluid dynamics, including hydrostatic pressure, density, salinity, and buoyancy.	 *A student at Austin High School explores CaveSim in 2018. Photo by AHS teacher Elise Gonzalez.*

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<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.
- 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.

<u>Space required</u>: typically outdoors on flat ground. May also be placed indoors where ceiling height is >12’6”. Footprint is 8’ x 9’.

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§112.39. **Physics**. b) 1) Students study ...: laws of motion; … conservation of energy and momentum; forces; thermodynamics.... Students... practice experimental design and interpretation, work collaboratively with colleagues, and develop critical-thinking skills.
c) 1) A) demonstrate safe practices during laboratory and field investigations
c) 3) D) research and describe the connections between physics and future careers
c) 4) D) calculate the effect of forces on objects, including the law of inertia, the relationship between force and acceleration, and the nature of force pairs between objects using methods, including free-body force diagrams.
c) 6) A) investigate and calculate quantities using the work-energy theorem in various situations

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Above, a student uses mechanical advantage to lift herself up the A-frame. Below, students and CaveSim staff destroy a rope in 20 seconds using another rope.

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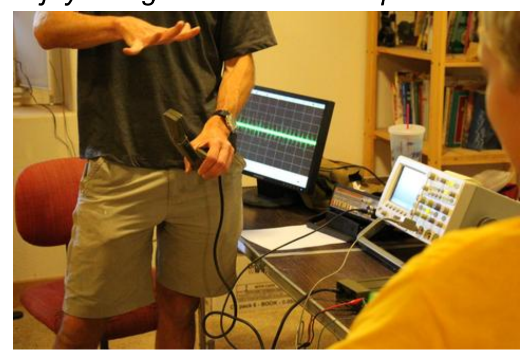
<u>Carbide demonstrations</u>: to illustrate chemistry and physics concepts, CaveSim staff bring working carbide lamps and carbide to programs. Demonstrations can include: ● CaveSim staff light a working carbide lamp by placing carbide and water in the lamp to produce a small (and safe) quantity of flammable gas. The resultant gas (acetylene) burns to produce light and heat, but the lamp body also becomes hot because of the exothermic reaction between the carbide and water. ● CaveSim staff place carbide and ice in an open pan. As the ice melts, the water reacts with the carbide, producing the aforementioned acetylene gas. CaveSim staff discuss the positive feedback associated with the reaction, as well as the concepts of limiting reactants. <u>Space required</u>: typically conducted outdoors, but cannot be done in the rain. May be done indoors in a lab setting where smoke may be safely produced without setting off alarms.	§112.35. **Chemistry**. c) 8) H) describe the concept of limiting reactants in a balanced chemical equation. c) 11) C) classify reactions as exothermic or endothermic….	 *Above, carbide lamp demonstration by CaveSim staff at a high school program in Oklahoma. Below, stock photo of the lamps we use.* 

<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. ● 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. <u>Space required</u>: typically outdoors for convenience, but can also be done in any classroom or indoor setting. Must be done indoors if raining. The oscilloscope has a VGA output, which can be projected to a smartboard, projector, or computer monitor for better viewing by students.	§112.39. **Physics**. c) 2) (D) design and implement investigative procedures... selecting appropriate equipment and technology…. c) 2) (E) demonstrate the use of ... equipment, techniques, and procedures, including multimeters (current, voltage, resistance)... and/or other equipment and materials that will produce the same results. c) 3) D) research and describe the connections between physics and future careers. c) 4) A) generate and interpret graphs and charts describing different types of motion, including investigations using real-time technology… c) 5) D) identify and describe examples of electric and magnetic forces and fields in everyday life…. c) 5) E) characterize materials as conductors or insulators based on their electric properties. c) 5) F) investigate and calculate current through, potential difference across, resistance of, and power used by electric circuit elements connected in both series and parallel combinations c) 7) B) investigate and analyze characteristics of waves, including velocity, frequency, amplitude, and wavelength, and calculate using the relationship between wavespeed, frequency, and wavelength;	 *High school students in Oklahoma 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).*

<u>Bat skeleton and guano</u> demonstrations and lessons: ● Discussion of similarities and differences between bat wing morphology and human hand morphology. Discussion of evolutionary pressures that may have created the similarities and 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. ● 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. ● Discussions about **Texas history** and the role that Texas caves played in the civil war (as sources of saltpeter for the production of gunpowder). <u>Space required</u>: typically done by the trailer to engage students as they wait to explore. Can also be done anywhere inside.	§112.34. **Biology**. b) 1) Students in Biology study a variety of topics that include: … biological evolution, …, metabolism and energy transfers in living organisms, …; and ecosystems and the environment. §113.43. **World Geography Studies**. c) 12) A) analyze how the creation, distribution, and management of key natural resources affects the location and patterns of movement of products, money, and people	 *CaveSim program lead Dave Jackson teaches high school students about bat biology in Oklahoma.*
<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. <u>Space required</u>: outdoors is strongly recommended, as the activity will make a big mess of indoor flooring. If the activity must be done indoors, a hard surface (like linoleum) is a must.	§112.34. **Biology**. c) 12) A) interpret relationships, including predation, parasitism, commensalism, mutualism, and competition, among organisms. §111.41. **Geometry**. c) 13) The student uses the process skills to understand probability in real-world situations and how to apply independence and dependence of events. The student is expected to: (C) identify whether two events are independent and compute the probability of the two events occurring together with or without replacement; (D) apply conditional probability in contextual problems	 *HS students in Oklahoma roleplay bats spreading WNS fungus.*

<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.	§116.53. **Adventure/Outdoor Education**. c) 2) A) use internal and external information to modify movement during performance.	 *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.	§130.43. **Principles of Construction**. c) 5) A) use a standard ruler, a metric ruler, a measuring tape, and an architectural/engineering scale to measure. §116.53. **Adventure/Outdoor Education**. b) 2) Students enrolled in adventure outdoor education are expected to develop competency in outdoor education activities that provide opportunities for enjoyment and challenge. Emphasis is placed upon student selection of activities that also promote a respect for the environment and that can be enjoyed for a lifetime.	 *Students at a 2018 Austin PARD 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 covered: Electromagnetics, product design, material science, and mechanical engineering.

Cost: $6/student if students work in groups of 2, or $10/student if students work alone (pays for electronic components that students keep)

Recommended lab time: 55 to 120 minutes.

Recommended class size: Up to 25 students.

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

Advanced Light Lab: Same as Light Lab, but students also include programmable computer chips in their project. The students learn about duty cycle and Pulse Width Modulation, which can be used to control LED brightness.

Prerequisites: Prior computer programming experience

Subjects covered: Computer programming concepts (including machine language concepts), mathematical functions, and time/frequency domain relationships (Fourier transform concepts)

Cost: $10/student if students working in groups of 2, or $15/student if students work individually.

Recommended lab time: 120 minutes.

Recommended class size: Up to 15 students.

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 covered: Experiment design, scientific method, and biology concepts.
Cost: $6/student (students working in groups of 2). This pays for live cultures, Petri dishes, agar, foil, and other materials.
Recommended lab time: 45 to 60 minutes, with a follow-up on a second day (with or without CaveSim staff present).
Recommended class size: Up to 30 students.

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
Cost: $2/student
Recommended lab time: 30-40 minutes.
Recommended class size: Up to 30 students.

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? Please visit www.cavesim.com/schools/pricing and 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.