Use of "October Sky" in Teaching Science

Handout to accompany presentation of Stephen Cook, Ark. School Math &Science

501-622-5138 or cooks@asms1x.dsc.k12.ar.us

October Sky PowerPoint Presentation

Description: (from Teach with Movies website) Rated PG; 1999; 108 minutes; Color.

Inspired by the launching of Sputnik (October, 1957), a high school student in a coal town in West Virginia decides to launch his own rockets. Despite ridicule led by the football team, of which his older brother was the star, and the opposition of his father, Homer and his outsider friends persist and succeed. They have the support of their science teacher and of Homer's mother, who is determined that her sons will not end up in the mines. Against all odds, the boys win the national science fair with an entry describing their rockets. All of the boys go to college, something unusual in coal country at that time. Homer goes on to become a scientist with NASA.

October Sky is a charming tale and the boys' success is inspiring. The movie is taken from an autobiography (with certain modifications for purposes of clarification) originally entitled "The Rocket Boys" by Homer H. Hickam. The book has been republished under the same name as the film. This film can be used to spark or enhance an interest in math and physics and to inspire children to work hard to fulfill their dreams. It demonstrates the rewards of working toward a goal against daunting odds. October Sky shows the positive influence teachers can have on their students, a mother's support of her child's dreams, the love of a son for his father and his need for his father's approval, as well as the value of people who may be different from the generally accepted prototype of the popular high school athlete. The film is based on a true story.

Bibliography / Resources

Space Mathematics, by B. Kastner, 1985 Educational Programs Division, NASA EP-175
The Amateur Scientist 20th Century Collection, CD ROM (available Sky Publ.1-800-253-0245)
"The VASIMR Rocket", by F. Diaz, *Scientific American*, November 2000 issue
UALR Engineering Tech. Dept hybrid rocket technology research & demos (501-569-8002)
Movie Reviews appeared in: *New Yorker* Feb 22 – Mar 1,1999 p. 184; *Rolling Stone* Mar 4 1999 p. 186; *The American Spectator* Apr 1999 p. 68; *Christian Century* Mar 24-31 1999 p. 331; *People* 3/1/99 p. 31; *Harper's Bazaar*, Mar 1999, p. 308
Websites: www.homerhickam.com & www.teachwithmovies.org
www.state.ar.us.agc/coal.htm (Ark. State Geological Commission)
http://165.29.91.7/armem/ross (history of coal mining in Johnson County, AR**)**

Use in Teaching – Physics (Additional Notes / Resources)

Physics teachers covering free fall and projectile motion can include problems based on October Sky, such as the following free fall problem:
The rocket designated Auk XXIII, launched by Big Creek Missile Agency from Cape Coalwood, WVA, flew for 42 seconds. What altitude did it reach? (answer:7056 feet see Rocket Boys p300)

Projectile problems typically require an initial velocity. The equation below enables finding the velocity V gained by a launch vehicle when its propellant is burned to depletion: $V = v_{ex} \ln R$ where v_{ex} = exhaust velocity of the engine, ln is the natural logarithm, and R is the mass ratio of the rocket, defined by R = takeoff weight / burnout weight . From the exhaust velocity (in m/sec), and propellant flow $\Delta m / \Delta t$ (in kg/sec), the rocket thrust R_T (in Newtons) can be calculated from $R_T = (\Delta m / \Delta t) v_{ex}$. The PASCO 2002 Physics & Data Collection catalog (p 35) describes what it takes to experimentally obtain rocket impulse. From that, rocket thrust can be

found from average thrust = impulse divided by duration. (A related quantity of interest is specific impulse $I_{sp,}$ found from $I_{sp} = v_{ex} / g$, where $g = 9.80$ m/sec^2)
For problems based on the above, see the NASA publication listed in the bibliography. The Scientific American article will be of interest both in that regard and for latest developments.

Use in Teaching – Chemistry (Additional Notes / Resources)

Extreme caution and appropriate safety devices (goggles, availability of fire extinguisher, fire blanket, etc) must accompany performing the demo described below, and any work with reactions involving potential rocket fuels. Teachers should supervise all student activities.

Demonstration. Potassium chlorate ($KClO_3$) is one of the fuels the rocket boys experimented with. Starting with a piece of fine mesh steel or iron wool roughly 4 inches wide by 6 inches long, pour enough solid granular potassium chlorate over it, and spread it out to completely cover it. Work it into the iron wool until it becomes thoroughly enmeshed in it. (Excess $KClO_3$ should be dissolved in water and poured down the sink.) Roll up the treated iron wool into a cylindrical shape. Using a metal (burette or other) clamp and ring stand, mount it hanging approximately a foot above a big metal container full of sand. Use a match it light it – and get your hand out of there immediately! When any part of the oxidizer gets above 400^o C, it will decompose, liberating oxygen: $2KClO_3 \rightarrow 2KCl + 3O_2$. The oxygen will immediately combine with the iron in a very rapid combustion reaction: $3Fe + 2O_2 \rightarrow Fe_3O_4$. Be sure and note the molten iron present immediately afterwards (iron melts at 1500 ^{o}C !)
(I often begin this demonstration by casually asking the question, "Will iron burn??" After some discussion, we eventually decide that iron will burn if it's in the right form (iron wool). I light a piece of untreated iron wool and demonstrate that it burns very slowly. After discussion of what factors affect the rate of combustion, I do the above)

The rocket boys launched rockets using various rocket fuels -- black powder; potassium nitrate & sugar; a zinc – sulfur powder mix; --and various binders. See Rocket Boys for details.

Use in Teaching – Earth Science / Env. Studies (Additional Notes / Resources)

Energy from Coal, Coal Mining, Environmental Impacts (from Teach with Movies website)

- There are two principal methods of mining coal. Strip mining coal close to the surface is the most economical, but also the most environmentally destructive. Power equipment of various kinds (power shovels or draglines) remove the earth and rock to expose the coal. The coal is then broken up and loaded onto trucks or railroad cars. When the coal is not located close to the surface, the second method, underground or deep mining is used. A shaft is dug to the location of the coal seam, either vertically, on a slant or, if the coal is located in a mountain, horizontally. The coal is cut, using machines or controlled explosions. The key to deep mining is controlling cave-ins, dispersing methane gas and carbon dioxide, and suppressing coal dust. Pillars of coal are left to help support the roof. Steel beams are laced across the roof to prevent the rock from coming down onto the heads of the miners. In some mines the roof behind the coal face is allowed to collapse as the face moves forward along the seam. Huge fans and complicated ventilation systems are used to draw out the gases and bring in clean air. Coal dust is highly combustible and must be strictly controlled. Limestone dust is sprayed in the mine to keep the coal dust in check. The work in the deep mines is automated as much as possible. Continuous mining machines combine the separate steps of cutting, drilling, blasting and loading the coal at rates as high as 10.8 metric tons of coal per minute. The coal is then transferred by electric trolley to the surface where it is taken to preparation plants to be screened, washed, sorted by size and crushed before shipment.

- In a mine, coal dust pollutes the air and literally covers everything. A common ailment among miners is black lung disease (pneumoconiosis) caused by inhaling coal dust. Homer's father was suffering from this disease. The mine owners failed to compensate miners for this occupational hazard. The Federal Government has stepped in and set up a health and worker's compensation plan for the miners.

Youth Media International has produced a study guide for educational use of October Sky. Their Activity One, part C involves students in learning about the once vital coal industry and the effects it had on both the environment and the miners. (see the Hickam website)

Ready to Use Activity Available: STS Lessons in the Movie October Sky

by Stephen Cook, Ark. School Math & Science

Activity: STS Lessons in the Movie October Sky

Objectives
Upon completion of this activity, the student should
1) better understand what doing science and the scientific method are all about
2) realize that scientific understanding typically precedes technological advance
3) realize that individuals and society as a whole decide which technologies they will embrace, and the terms of the relationship, and that the process may involve conflict
4) be able to discuss the impact of coal mining & burning coal on individuals, society, and the environment

Background
Students should have done some reading about the scientific method, and the relationship between science and technology in their text. They should realize that STS stands for both "Science, Technology, and Society" and a particular approach to science education.

Procedure
A. Watching October Sky
Students should watch the movie October Sky. (If class time is used for this, the movie will just fit into two 55 minute long class periods.)

B. Discussion of the Movie's Themes
The teacher will break the class up into three groups. Each group will be given a question related to the theme of the movie. After discussion amongst themselves, they will prepare a response to the question, which they will later present to the class as a whole. For the three questions, see the Questions – part B section.

C. Discussion of the Scientific Understanding Behind Technical Advances
The teacher will break the class up into three groups. Each group will be given a question related to the belief that understanding of scientific principles allows technological advances. After discussion amongst themselves, they will prepare a response to the question, which they will later present to the class as a whole. For the three questions, see the Questions – part C section.

D. Coal Technology → Impacts on Individuals, Society, Environment
Listed below are several impacts that aspects of coal technology (including extraction, utilization, associated waste, etc) have on individuals, society, and the environment. Place a check in the space provided by those which are depicted or alluded to in "October Sky".
___ mine subsidence leads to collapse of buildings
___ fires in abandoned mines
___ water pollution from mine acid drainage
___ affects on aquatic ecosystems & wildlife from mining
___ black lung disease in coal miners
___ mining accidents, cave-ins, explosions (resulting in injuries and deaths)
___ local air pollution from burning coal (resulting in decreased visibility, increased respiratory ailments, etc)
___ labor disputes between mine workers & management
___ difficulty of reclaiming exhausted mines to original natural state
___ disorganization of water strata due to mining disturbs water table
___ large mounds of waste earth rimming mines / unsightly slag / soil erosion

___ scenic / aesthetic degradation associated with mine operation / scars
___ regional acid rain from burning coal
(resulting in “dead lakes”, decreased forest productivity, etc)
___ burning coal aggravates global warming problem
(produces more CO_2 per weight burned than oil or gas)

E. Technology Assessment: Tradeoffs

At the top of a blank sheet, students should write “COAL ?” They should divide the remaining area into two columns. The left hand column should be headed “Who benefits?”; the right hand one should be headed “Who suffers adverse impacts?”. Based on what they saw depicted in the movie “October Sky”, students should place the various stakeholders involved with or affected by coal technology in one column or the other. Beneath each entry they should write a brief justification (from one word to one sentence). After doing this exercise based on the movie alone, they should then complete it based on what they know and what they can discover about coal in general.

Questions – part B

Based on the discussion and presentations you heard, briefly answer each of these questions:

1) A science teacher has argued that the turning point / key scene in the movie ties in with a critical step in the scientific method. Seen this way, one can argue that the movie is really about faith in the order and predictability of the physical world, and about the ongoing effort to refine our understanding of how it works. Explain.

2) It has been argued that October Sky is most fundamentally a coming of age story – one that has two levels. The first level (called “The Rocket Boys” level) involves the growing up of Homer and his friends. The second level (called “The October Sky” level) involves a whole nation struggling with a new technology. Explain.

3) October Sky is a story of age old conflict. At the surface the conflict is the familiar one between father and son, old and new. But prober deeper, the conflict is also between management and worker, between two technologies, and between different orientations (going back to Plato and Aristotle). Explain.

Questions – part C

Based on the discussion and presentations you heard, briefly answer each of these questions:

1) Based both on the movie and your own knowledge, what scientific understanding can be used to guide the development of rocket technology and achieving the ultimate goal of putting a satellite into orbit?

2) What scientific understanding can be used to locate mineral or energy resources (like coal, oil or natural gas)?

3) An important problem facing 16th and 17th century coal miners in England

involved water flooding the mines and making mining impossible for part of the year. Horses were initially used to lift water out of the mines, but eventually they were replaced by steam engines (powered themselves by coal). What advances in scientific understanding led to more efficient steam engines?

Teacher Supplement to Activity: STS Lessons in the Movie October Sky

The STS Approach to Science Teaching

"An STS Approach" refers not just to building "Science", "Technology", and "Society" aspects into more traditionally narrow courses, but also to the educational movement that these three initials represent. Perhaps the most important goal of this movement is promoting scientific literacy. One of the books written in response to what some have viewed as a crisis in science education – Science for all Americans, published by the American Association for the Advancement of Science – describes scientific literacy as follows:

> Scientific literacy – which encompasses mathematics and technology as well as the natural and social sciences—has many facets. These include being familiar with the natural world and respecting its unity; being aware of some of the important ways in which mathematics, technology, and the sciences depend upon one another; understanding some of the key concepts and principles of science; having a capacity for scientific ways of thinking; knowing that science, mathematics, and technology are human enterprises, and knowing what that implies about their strengths and limitations; and being able to use scientific knowledge and ways of thinking for personal and social purposes.

Teaching that embodies the STS approach should

1) make clear the relationship of scientific or technological developments to society and socially-relevant issues

2) make clear the mutual influences of "science", "technology" and "society" on each other

3) develop learners' understanding of themselves as interdependent members of society and society as impacting the function of natural cycles & systems

4) recognize that weighing the risks and benefits of a technology will involve tradeoffs, conflict, and differences of opinion, and that presenting a balance of differing viewpoints about issues and options is important

5) help learners venture beyond the specific subject matter to broader considerations of science, technology, and society, which include a treatment of personal and societal values / ethics

6) provide material that engages students in developing problem solving and decision-making skills

7) encourage learners to become involved in a societal or personal course of action after weighing the tradeoffs among values and effects drawn from

various scenarios or alternatives

Note: the above list is based on recommendations that came out of a July 19, 1988 meeting at Penn State University of the STS Task Force

Teacher Supplement to Activity: STS Lessons in the Movie October Sky
Sample Solutions to the Activity

Part B

1) October Sky is about children coming of age and about doing science. Science can begin with curiosity, child-like wonder, and a questioning, seeking orientation. Either from this, or from some other need, come problems – indeed the first step in the scientific method involves identifying the problem. In the movie, the key problem is how to build a high-flying rocket. The boys put their faith in the idea that the physical world has an order and predictability to it based on scientific principles. They apply their understanding of those principles to guide their rocket design. As their knowledge grows, they make refinements. They hypothesize that making certain changes will improve performance – then test the hypothesis by launching. A key part of the scientific method is this testing and refining of hypotheses based on the results of the testing. After much success, the boys suffer a setback when one of their rockets supposedly starts a fire. The new problem becomes showing that this didn't happen by finding the missing rocket. The key turning point in the movie comes when Homer quits the mine – and puts his faith in his ability to find the rocket. Using trigonometry and equations of projectile motion, he and Quentin predict where it should have landed and go there. They can't find it, and wonder "What did we do wrong?" Then Homer wonders, "Was there wind that day?" Refining their analysis to include the wind leads them to the rocket, taking part in the science fair, and the movie's climax.

2) The coming of age story at the first level involves Homer and the other rocket boys trying to find their path – in this case, a way out of small town West Virginia, to college, and finding satisfying life work. Before this can happen they must learn the value of hard work, take responsibility, and overcome youthful ignorance, restlessness, recklessness, and innocence. Sexual innocence is part of the latter, of course, but it's more a matter of making the transition from high school and adolescence, to "The School of Hard Knocks" and adulthood. Homer's coming to grips with working in the mine, and being ripped off in the big city at the National Science Fair provide a couple of examples of this -- as does all the work required to make his rockets fly the way he wants them to. At the second level, in October, 1957, our country experiences a coming of age crisis of its own with the launch of Sputnik. This new technology and its implications both challenges and threatens our nation. Sputnik jolts America. It leads to much questioning (especially in the area of science education). The nation -- like Homer and the rocket boys -- goes through a gradual process of getting comfortable with rockets and becoming competent with the new technology. Eventually, it overcomes its youthful, technological innocence – and takes its first steps into space and to the Moon. The two coming of age levels are touchingly brought together at the end of the movie. As their last rocket is gaining altitude, Quentin says, "Look at it go, Homer. This one's gonna

go for miles!" Symbolically he could be talking about the rocket boys heading to college and into adulthood – or he could be talking about the country as a whole and its space adventures to come. Indeed, our view of the rocket boys' soaring rocket soon gives way to a huge NASA rocket lifting off many years later.

3) The father / son conflict in October Sky is obvious. Its origin is partly rooted in different world views and appreciation of different technologies. Part of it is an old vs. new thing. Indeed, the movie begins with Sputnik's beeps being characterized as "the sound that separates the old from the new". Homer's father represents an old technology: coal & coal mining. As Homer laments in an early letter to Dr. von Braun, "Everyone's more interested in what's down in the ground than what's up above!". The "what's up above" is space and rockets and the new technology. The contrast between these two orientations is captured in a classic Renaissance painting, "The School of Athens". There, Plato, is shown pointing upwards to the celestial realm, while Aristotle is more concerned with the terrestrial domain tied to the ground.

   Homer's father's life and dreams involve the mine. His wife worries that he loves the mine more than he does her. What he knows and loves is underground. He initially may feel threatened by the new technology. In dumping one of Homer's rockets into the trash, he refers to it as "this idiot thing"! He characterizes his son's efforts with rockets as "wasting your time". In his defense, he is suffering some technology-induced stress. As profits decline, there is concern that the mine is dying. His own health is threatened by negative impacts of the coal mining technology that he derives his livelihood from. The bullets that are shot into his house can be partly traced to a mining management vs. labor dispute. If a mine accident doesn't claim his life first, black lung disease may eventually. Homer, in contrast, is youthful and has his whole life ahead of him – assuming a problematic rocket launch doesn't cut it short! His dreams are quite different from his father's. Indeed, near the end of the movie, he tells his father – who has tried to recruit him to the side of coal mining technology – "I'm never going down there again. I want to go into space!"

Part C

1) fundamental to how a rocket works: Newton's 3rd Law (Law of Action / Reaction)
   important to rocket nozzle design: fluid dynamics principles,
   including Bernoulli's principle
   important to materials integrity of rocket: knowledge of melting points
   rocket fuel: knowledge of oxidation / reduction chemical reactions
   knowledge of how rate of chemical reaction depends on particle size
   need for fuel binder to eliminate hot spots
   fundamental to attaining Earth orbit: Newton's Law of Universal Gravitation,
   celestial mechanics theory

2) physical conditions under which mineral or fossil fuel forms and is trans-formed; appreciation of geologic time, paleoclimatic conditions;
   geologic principles including law of superposition, principle of faunal succession, correlation of rock strata, cross-cutting relations;
   forces that deform rocks; plate tectonics / continental drift;
   properties of rocks: hardness, permeability, porosity, etc.
   geophysical remote sensing theory & methodology

3) understanding of what heat is: a form of energy
concept of mechanical equivalent of heat
heat engine theory / maximizing useful work / Carnot efficiency
Laws of Thermodynamics

Part D

Depicted or alluded to in October Sky (and thus deserving checkmarks) are the following:

___ black lung disease in coal miners
___ mining accidents, cave-ins, explosions (resulting in injuries and deaths)
___ labor disputes between mine workers & management
___ difficulty of reclaiming exhausted mines to original natural state
___ large mounds of waste earth rimming mines / unsightly slag / soil erosion
___ scenic / aesthetic degradation associated with mine operation / scars

Part E

From the October Sky movie we put in the following:

COAL ?

Who Benefits?	**Who Suffers Adverse Impacts?**
Mine workers (jobs)	mine workers (health)
	families of mine workers (loss due to mining accidents, poverty)
	coal mining area population (disruption due to labor disputes)
Mine owners (profits)	coal mining area population (scenic degradation)
Consumers of steel & products that use steel	

From what we can learn about coal technology in general, we can add to this chart as follows:

Who Benefits?	**Who Suffers Adverse Impacts?**
Consumers of electricity generated using coal	those who breathe air polluted by burning air
	those who drink or use water polluted by coal mining operations
	people in NE USA, Canada (suffer from effects of acid rain largely due to coal fired Midwest power plants)

aquatic ecosystems / wildlife / forests
(from coal mining, coal burning)