Houses in the Desert

Project Summary

Project Description:
"Houses in the Desert" is a design project in which students design an energy-efficient house to remain comfortable in the desert's temperature extremes, using their knowledge of thermodynamics, insulation, conduction, and the conversion of light energy into heat energy.

Type of Project:
Design

Conceptual Learning Goals:
Students should develop an improved understanding of the following concepts:

- heat flow
- insulation
- thermal equilibrium
- conversion of light to heat by light absorbtion

Students will be exposed to the following concepts:

- heat capacity and specific heat
- radiant energy
- desert climate and surrounding issues

Scientific Thinking Goals:
Students will learn to:

- conduct background research on the Internet
- use principles learned in class to develop criteria for their designs
- apply their knowledge of heat and temperature to a real-world setting
- justify decisions with evidence

Prerequisites:
Students should be familiar with the concepts of:

- heat and temperature
- heat flow
- conversion of light energy into heat energy through absorption

Timeframe (assuming one 50-minute period per day):
10 days

Target Grade Range:
7th-9th grade

Handouts:

survey evidence notesheet
search notesheet
synthesize evidence worksheet
heat flow drawings and heat flow analysis worksheets

General Comments:
This project is intended as a *capstone* activity; it asks students to apply their knowledge to a new situation, rather than teaching specific new concepts. Students often have a hard time applying principles such as "Heat always flows from higher temperatures to lower temperatures" in real settings. They may confuse temperature with heat energy. In addition, students may have many ideas about substances being naturally cold or naturally hot. This project helps students work through these issues by applying their knowledge to a *changing* situation–the sometimes hot, sometimes cold environment of the desert. The project also provides an opportunity to talk about the role of sunlight in heating the earth. Students may also still be learning that insulation prevents heat flow both in and out. A design which reflects an understanding of this concept is the primary goal.

Light reflection and absorbtion are also central concepts. This project has been used with students who have measured light reflection and the rise in temperature due to light absorbtion in several labs. This can be used to advantage in the house design.

Several concepts are touched on which are not central to the project, but which may help students reconcile their experiences with a heat flow model. Specific heat can explain many phenomena, such as why marble benches are often cooler than room temperature or how bodies of water make climates more temperate. Some students may even begin to ask questions about evaporative cooling, which may also help with their house designs. Expert architects use many strategies in building desert houses, but the primary strategy is the use of materials with a high heat capacity to even out temperature differences (e.g., adobe construction in the American Southwest).

Evidence and Material Usage:
There are two collections of evidence associated with this project; one group of evidence provides background science information on the desert, heat flow, insulation, energy conversion and heat capacity. Since most of these concepts are familiar to students, we provide these pieces of evidence primarily as a reminder and as a concrete pieces of evidence students can use to support their designs.

The second collection of evidence provides three example house designs, each of which has some features students can learn from. The House of Wood has good ventilation but poor insulation and inopportune windows for energy conversion. The House of Straw has extraordinary insulation properties, but little heat capacity. The House of Mud has a high heat capacity and some insulation. Either the House of Straw or the House of Mud might be an appropriate model for a desert house, but

for different reasons. It is interesting to note that the adobe houses of the American Southwest use adobe bricks made from both straw and mud.

The heat flow worksheets are designed to help refocus students on the physics in their house designs. This project runs the risk of turning into an art project. We encourage students to include good science by repeatedly insisting students must justify their designs using science evidence, and by asking them to complete the heat flow analysis of their designs.

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Suggested Lesson Plan

DAY 1:
Goals:
Introduce the design problem and raise some of the science issues.

Activities:	**Uses Computer?**	**Uses Internet?**
1. Discussion of desert climate (hot days, cold nights)	no	no
2. Discussion of design task (explain need for evidence, importance of justification)	no	no
3. Create projects and begin surveying evidence	yes	yes

Tips for Teachers:
If this is the first time the class has used KIE, you will want to add at least half a period to introduce them to the software and to KIE's use of "evidence". It is important that students understand before they begin that the Internet information they will be looking at is not a textbook; they will be looking, for example, at sample designs and evaluating them critically rather than taking them at face value.

Rules for the design: we usually forbid electric heating and air conditioning, and say the house should cost no more than the house the students' live in. It's often helpful to talk a little about how much energy an airconditioner really uses: stereo, about 50watts, a lightbulb about 75-100watts, hair dryer, 1200-1500 watts (note that this is a very small heater), and central air, thousands of watts.

You may wish to have the students first survey the house example evidence, then ask what happens to heat in each example before moving on to the science evidence. Don't give away the answer to this question until they've had a chance to answer it themselves!

You may wish to talk about what decisions students will need to make, such as materials for their house, color, windows and their orientation, etc.

Depending on the students' backgrounds, you may wish to link the discussion of desert climate to earth science concepts, such as how the sun heats the earth (with light!) or life science concepts, such as what organisms do to adapt to this environment.

You can send the kids home with an assignment to come up with an initial design sketch which they can revise as they go. This is also a good emergency filler if you have computer or Internet trouble at any point in the activity.

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Suggested Lesson Plan

DAY 2
Goals:
Familiarize themselves with the rest of the evidence.

Activities:	**Uses Computer?**	**Uses Internet?**
1. Finish surveying evidence and taking notes	Yes	Yes

Tips for Teachers:
You can expect some students to finish the surveying early. Usually asking if they know which evidence they will use to support their own design is enough to send them back to the evidence for a closer look. Emphasize that they don't need to use all the ideas in each piece of evidence. You can also ask which pieces of evidence the students believe; they typically will not have been turning a critical eye to the evidence.

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Suggested Lesson Plan

DAY 3
Goals:
Learn to do Internet searches and gather some useful ideas for houses.

Activities:	**Uses Computer?**	**Uses Internet?**
1. Introduce searching and brainstorm keywords to search on. "Windows" is a good example of a word that is too broad and has other meanings.	No	No
2. Have students search the Internet. They should try to save at least two sites that will support their designs.	Yes	Yes

Tips for Teachers:
In 1996, students found a site called "How to build a house for the desert" that was put up by a person who had built and designed his own energy-efficient house (the teachers had not uncovered this in searching for evidence for the project). This led to a discussion of "why can't we just do what they did?" The answer was, you can, as long as you can explain and support it, and you give credit to your source. Several students improved on this design that initially appeared to be "the answer". Students also started informally sharing their finds with friends and hiding them from others. Encourage sharing by stopping class 10 minutes or so into the searching and asking what people found and what keywords they used to search.

If you haven't before, you should probably explain to the students that their innocuous searches may come up with lewd or inappropriate sites. Generally you can tell before entering such a site what it is–they should know what the consequences are for going into one in your classroom.

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Suggested Lesson Plan

DAY 4
Goals:
Wrap up evidence and begin applying to the design problem in SpeakEasy.

Activities:	Uses Computer?	Uses Internet?
1. Do the Synthesize Evidence Worksheet	N	N
2. Begin the SpeakEasy discussion	Y	Y

Tips for Teachers:
The Synthesize evidence worksheet is a good time to take stock. You may wish to focus them on which pieces of evidence might support their own designs.

Encourage students to use evidence as they make their SpeakEasy comments. Also, ask them to link in good things they found. This gives kids an incentive to read each others' comments.

Since students work individually in SpeakEasy, you can have students who aren't online working on their design ideas.

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Suggested Lesson Plan

DAY 5:
Goals:
Continue SpeakEasy.

Activities:	Uses Computer?	Uses Internet?
1. Continue with SpeakEasy and individual designs	Yes	Yes

Tips for Teachers:
We typically assign students 3 comments by the end of the day--one opinion and two discussion comments.

Tell students they can continue to make comments until the end of the project.

An in-class discussion at the end of the day may help tie together loose ends.

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Suggested Lesson Plan

DAY 6
Goals:
Complete initial designs and begin sharing

Activities:	Uses Computer?	Uses Internet?
1. Share ideas with the class	No	No
2. Create an initial joint design	No	No

Tips for Teachers:
By now, students probably have some design ideas. Open class with a brief discussion of their ideas for design strategies, i.e., what do various houses try to do? Do they keep heat out? Do they store heat?

Each lab group of students should come up with a joint design. This negotiation may take a while; this is good because the students don't fall into *design fixation*: in other words, they don't immediately fall into a rut.

Remind students of the main choices to make: material, color, and type of windows.

Remind students they will need to support every decision with evidence, be it from the web, from survey evidence, from other parts of class, or from their own lives.

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Suggested Lesson Plan

DAY 7:
Goals:
Analyze the designs

Activities:	Uses Computer?	Uses Internet?
1. Complete the heat flow worksheets	No	No

Tips for Teachers:
You can open class with a brief discussion of what a heat flow diagram looks like. Bigger arrows mean more heat energy flowing, smaller arrows mean less. Impress on them that they are not drawing light–arrows bouncing off a mirrored roof are a common mistake. Mostly students will need prodding to remember which way heat flows–always high temperature to low temperature, even if they don't want it to go in that direction!

Encourage students to revise their design ideas based on their analysis.

Students might analyze a different group's design if there is time.

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Suggested Lesson Plan

DAY 8:
Goals:
Draft the design report.

Activities:	Uses Computer?	Uses Internet?
1. Draft the on-line design report	Yes	Maybe

Tips for Teachers:
Students should now be working on the parts of the on-line design report.

Remind them to include links to things they saved–going back to 'Survey.html' will allow them to copy and paste the links into their ClarisWorks document.

Walking around class and asking to see what evidence students have to support their designs is very helpful.

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Suggested Lesson Plan

DAY 9:
Goals:
Finish on-line design report and print.

Activities:	Uses Computer?	Uses Internet?
1. Finish the on-line design report	Y	N
2. Print the design report	Y	N

Tips for Teachers:
Continue encouraging students to use evidence in their reports.

Have the students save their documents as html. They can open and print them from Netscape or from ClarisWorks.

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Suggested Lesson Plan

DAY 10:
Goals:
Share designs with the class

Activities:	Uses Computer?	Uses Internet?
1. Share designs	No	No

Tips for Teachers:
Have students present their designs out loud. An opaque projector can be helpful. If you have previously done debate projects, you might wish to have the students critique each other's evidence.

Another way to share designs is to have a design fair. An outsider (such as a local architect or contractor) can visit each design and judge them, selecting one or two best designs per class. These can then be published on the web. Or, students can be judges and select best designs: most creative, most likely to stay comfortable, best evidence, etc.