THE DAY AFTER TOMORROW: TEACHER GUIDE

Subject: Physical Science & Earth Science
Grade Level: Middle School
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Case Summary

Marc and Margarite watch the movie "*The Day After Tomorrow*" and debate the scientific merit of the events that occur in the movie.

Credits

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Learning Objectives

1. Appropriately use a variety of text and electronic materials to research learning issues.
2. Classify the individual greenhouse gases as elements, compounds, and/or mixtures.
3. Clarify that water and salt are both compounds but that salt water is a mixture.
4. Identify that fossil fuels are based on the element carbon and that the process of burning fossil fuels releases carbon dioxide, a compound.
5. Identify that the melting of ice caps is a physical change.
6. Identify that fresh water mixing with salt water is a physical change.
7. Identify that the burning of fossil fuels is a chemical change.
8. Describe how the molecules of water change as they melt and refreeze in an ice shelf.
9. Distinguish between the effects of ice melting from an ice shelf that is floating in water versus the melting of ice shelves from on land and the effects of each of these on sea levels.
10. Identify that one of the ways global warming will cause sea levels to rise is via expansion of sea water as it warms.
11. Diagram how the earth is warmed by solar radiation in the greenhouse effect and the convection of heat via the North Atlanta Current.
12. Distinguish between radiation and convection.
13. Define thermal pollution
14. Explain how global warming and greenhouse gases may or may not be a thermal pollution issue.
15. Discuss the process of burning fossil fuels and its implications for global warming / greenhouse effect.
16. Distinguish between the greenhouse effect and global warming.
17. Describe why the greenhouse effect is natural and necessary but also how human and non-human factors can exacerbate the greenhouse effect and how that is related to global warming.

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Georgia Performance Standards

S6CS5. Students will use the ideas of system, model, change, and scale in exploring scientific and technological matters. (NSES Content Standard A)

S6CS10. Students will enhance reading in all curriculum. (NSES Content Standard A)

S8P1. Students will examine the scientific view of the nature of matter. (NSES Content Standard B)

b. Describe the differences between pure substances (elements and compounds) and mixtures.

c. Describe the movement of particles in solids, liquids, gases, and plasma states.

e. Distinguish between changes in matter as physical (i.e. physical change) or chemical change (i.e. development of a gas, formation of a precipitate, and change in color).

SPS3. Students will investigate relationships between force, mass, and the motion of objects. (NSES Content Standard B)

b. demonstrate the effect of balance and unbalanced forces on an object in terms of gravity, inertia, and friction.

S6E4. Students will understand how the distribution of land and oceans affects climate and weather. (NSES Content Standard D and E)

a. Demonstrate how the land and water absorb and lose heat at different rates and explain the resulting effects on the weather patterns.

S8P2. Students will be familiar with the forms and transformations of energy. (NSES Content Standard B)

d. Describe how heat can be transferred through matter by collisions of atoms (conduction) or through space (radiation). In a liquid or gas, currents will facilitate the transfer of heat (convection).

S6E4. Students will understand how the distribution of land and oceans affects climate and weather. (NSES Content Standard D and E)

c. Relate how moisture evaporating from the oceans affects the weather patterns and the weather events such as hurricanes.

S6E6. Students will describe various sources of energy and with their use and conservation. (NSES Content Standard B)

b. identify renewable and non renewable resources.

Assessment

1. Learning Issue Research Guides (*see Student Materials document*)
2. Case Activities/Labs (*see Student Materials document*)
    a. When Land Ice Melts
    b. When Floating Ice Melts in the Sea
3. Self and Group Evaluations (*see Student Materials document*)

Implementation Strategy

This is a Problem-Based Learning (PBL) case, designed for use in standard public school classrooms of about 30 students. Subgroups of about 4-5 students were ideal for small group (team) work, such as reading the scenes, breaking down the data, questions, hypotheses, and learning issues, and assuming research responsibilities. Small groups were facilitated by at least one adult (teacher, parent, or graduate/undergraduate student). Students researched learning issues individually and in pairs and reported findings to the small group. Small groups reconvened with the whole class and their teacher frequently to review separate findings and summarize data and new directions.

Day 1: Class and small groups

Class as a whole (10-15 minutes): Students will break into their groups at the beginning of class. They will have both scenes at the beginning of class. Students read scene 1 as one student reads the scene to the entire class. They will have scene 2 which will be a summary of the scenes they will view from the movie. They will then watch selected scenes from the first part of the movie which depicts the Larson B ice shelf cracking and breaking off (*this really happened – see BBC, 2002*) and a global warming conference presentation. Encourage students to record any facts / questions / hypotheses that they see while watching the film.

Small group box charts and learning issue discussion (25-30 minutes):

Students will highlight the facts that were presented in the movie and generate hypotheses about what will happen in the movie and what would happen in real life if a large ice shelf broke; they will generate learning issues related to global warming, polar ice meltings, greenhouse effect, the Larson B ice shelf, and the how ocean currents affect climate. If students get stuck, begin to wander off task or are not getting the gist of the learning issue, allow them to pull a question from the **Stuck Jar** (a jar/box, placed on the table where the group is working, filled with pieces of paper containing guiding questions to help steer students back on track – *see Case Notes below*). Let a student read the question to the group and the group then discusses that question.

Assigning learning issues (5-7 minutes): Students will pick two learning issues and get the appropriate **Learning Issue Research Guides** (*see Case Notes below, and Student Materials document*) – it is helpful for the facilitator to record the names of students assigned to particular learning issues (preferably so that all students know who is researching which issues).

Reflection (5-7 minutes): Students will discuss how they worked in a group and how they hope to work during learning issue research

Day 2 (small groups)

Individuals & pairs research with laptops, & discuss with group	50 min

Day 3 (small groups)

Individuals & pairs research with laptops, & discuss with group	50 min

Day 4 (research and lab can be done simultaneously)

Individuals & pairs research with laptops, & discuss with group	30 min
Student lab activity	20 min

Day 5 (large group→small groups)	
Review initial hypotheses; brief facilitator on research findings	15 min
Discuss learning issue research and attempt to answer the Stuck Jar questions	20 min
Review and discuss case objectives & group's performance (can be tied to students' ability to answer Stuck Jar questions)	10 min
Self and Group Evaluations (*see Student Materials document*)	5 min

Case Notes

This Problem-Based Learning (PBL) case, entitled *"The Day After Tomorrow"*, was designed to be the second in a series of four cases (*see Resources below for a listing of all cases in the series*) addressing physical science concepts in sixth-grade classes at Renfroe Middle School, in the city of Decatur, Georgia. This second case continues with two of the characters introduced in the first case, "Vortex." The two characters watch the movie *The Day After Tomorrow (2004)* (students view the first 10 minutes of the film as the springboard for discussion) and discuss the science presented in the movie and the feasibility of the events that unfold during the film. Students will investigate the science of the greenhouse effect, global warming and fossil fuels. Specifically, physical science concepts related to heat transfer, chemical and physical changes, changes in state and Archimedes' Principle will be explored using guided research and investigative lab activities.

NOTE: While this case was implemented in a 6th grade physical science classroom, it was written with the intent of being usable in both physical science and earth science courses.

Modifications made as a result from student performance in a prior case:

From the first case, "Vortex" we had identified 3 critical areas in need of modification: learning issue generation, learning issue research and identifying physical science concepts from a earth-science related case. We were able to implement two components to this second case that greatly improved our students' abilities in these areas.

Stuck Jar: To improve student generation of learning issues and to aid facilitators in maintaining a focused discussion with optimal involvement by all students, we created a Stuck Jar. In brief, 8-10 questions were created that brought up a learning issue by using a specific example from the case or the movie *The Day After Tomorrow (2004)*. When a facilitator or the group identified themselves as being stuck or going off topic, a student would randomly pick a question from the stuck jar and read it to the group. The group would then discuss the question. Suggested questions are listed below.

Learning Issue Research Guides: We created guided learning issue research activities that helped the students improve their research skills and research performance. Additionally, the research guides helped to focus the case specifically on physical science concepts. To improve student depth of knowledge, the research guides were designed to include overlap between learning issues so that if a student was researching global warming, he/she would also be introduced to the issues of greenhouse effect and fossil fuels, for example. (*see Student Materials document*)

Results

Student performance improved dramatically with this second case as a result of both the modifications we made to the case process and student and facilitator familiarity with the process. In general, student groups were able to arrive at almost all of the intended learning issues and remained on task and involved in a more focused discussion for a more extended period of time (though attention spans waned after 20 minutes of discussion). Facilitators noted improved student involvement and enthusiasm for the case material.

Students were able to complete almost all of their learning issue research and as such, discussions on the follow-up day were more involved and in-depth. Facilitators commented often on how impressed they were with student acquisition of knowledge and the ability to discuss the concepts presented despite the short duration of the case. Gaps were still noted in student research / knowledge, however, and efforts to reduce knowledge gaps will involve more overlap of objectives and learning issues in the research guides for the next case.

This particular hybrid physical/Earth science case was easier to steer towards physical science concepts for two reasons: one, the content had more relevance to physical science than did the Vortex case, and second, we were able to focus the students on the physical science concepts using the stuck jar questions and the learning issue research guides. Students still had difficulty, however, with the concept of Archimedes' Principle.

We continued with our use of parent facilitators and increased from 10 to 16 volunteers (not including several more volunteers who had scheduling conflicts). Facilitators who had participated in the previous case noted significant improvements in students' enthusiasm and ability to discuss the science of the case. Facilitators liked the Stuck Jars for assisting in clarifying and directing discussion. Facilitators did comment though that facilitator authority and behavior problems are still an issue. We are working on the creation and implementation of a facilitator authority plan. We would like to have a system in place that facilitators can use to address behavior problems that may arise in their group that does not take facilitator time away from the group or discussion.

Facilitator Guide:

Scene 1 / Part 1: The case begins with Marc and Margarite discussing the movie "The Day After Tomorrow"

Scene 1 / Part 2: Students watch the first 10 minutes of the movie, "The Day After Tomorrow (from the beginning to the end of the global warming conference in India). Students are provided with a brief summary of the scenes they viewed as scene 1/part 2 and a transcript of the global warming conference

Example of a Potential Box Chart from Day 1

FACTS (from movie)	QUESTIONS
At the movies Movie starts at Larson B ice shelf Larson B ice shelf is in Antarctica Taking core samples Ice shelf cracks and breaks off Ice shelf is size of Rhode Island Greenhouse gases are trapped in the ice Global warming can cause cooling North Atlantic current can alter weather / global warming Burning fossil fuels contributes to global warming Climate change could happen in 100-1000 years if nothing is changed	Is the Larson B ice shelf real? Did it really break off? Is it going to break off? What are greenhouse gases? What is the North Atlantic Current? What are fossil fuels? Is this real? Is the science accurate? What was found in the ice samples? Why do you take ice samples? How big is Rhode Island?
HYPOTHESES	**POTENTIAL LEARNING ISSUES** *(the ones in bold are the key issues that the students need to get, the others are related and may come up)*
The science in the movie is bogus The science is real Major climate change can happen in 10 days Major climate change really takes a long time and the weather things that happen in the movie can't happen Mark and Margarite are going to get married and have kids Global warming is natural and isn't going to do all the things that people say it will The earth is getting warmer and weird things are going to happen to the weather – it will get really hot and everything will die, really crazy tornadoes and hurricanes will happen The earth isn't getting warmer or if it is, it doesn't really matter	**What is the Larson B ice shelf?** Where is it? What happened / is happening to it, if anything? **What is global warming and what causes global warming?** **What is the North Atlantic Current?** How can it be changed by melting ice caps? **How can changing the North Atlantic Current affect climate?** **What are greenhouse gases and what do they have to do with global warming? What is the greenhouse effect?** Diagram how it works. **Why are melting polar ice caps a problem?** How can melting ice shelves or ice shelves breaking off into the ocean change weather? Does it matter which ice shelves break off / melt? **What are fossil fuels and what do they have to do with global warming?** OPTIONAL: How can global warming cause a cooling trend?

Stuck Jar Questions:

- At the beginning of the movie the scientists were working on a large sheet of ice. Where were they? Is this a real place and did something really happen there or is it just a special effect for the movie?

- Dr. Hall says, in his talk at the UN: "the concentration of these natural greenhouse gases in the ice cores, indicate that runaway warming pushed the planet into an ice age that lasted 2 centuries". What are greenhouse gases and what do they do?

- Is global warming real? Is it a natural process or something that humans have caused? Is it a big deal if the earth gets few degrees warmer? Why or why not?

- Dr Hall claims that global warming is going to cause major climate change. What do you think global warming is? What do you think are some of the causes of global warming?

- Dr. Hall, while talking to the UN, says that if we don't stop burning fossil fuels, then global warming will continue and the climate will change dramatically. What are fossil fuels and what do they have to do with global warming?

- The scientists in the movie keep using the phrase "climate change". What is climate change?

- Dr. Hall mentions the North Atlantic Current and that melting ice caps can change this current which can then change the climate. What is the North Atlantic Current and how do you think changing it will change the climate?

Useful Information for the Teacher

- The Arctic and Antarctica are covered with large, heavy sheets of ice. Other islands like New Zealand have ice masses in the form of glaciers on them.
- When land-based ice melts, more water flows into the sea and sea level rises (Archimedes Principle).
- However, the land on which the ice previously rested rises, too when the load is removed.
- Icebergs in the ocean are broken off bits of land ice.

Resources

Global Warming

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