How can we learn from nuclear accidents to make nuclear power plants safer?

OVERVIEW

Subject Focus: Physics, Environmental Science, Science

21st Century Skills Focus: Critical Thinking, Collaboration, Communication

Lesson Context

News of the 2011 Fukushima nuclear power plant disaster dominated the headlines for many months. It once again brought to the forefront in people’s mind how potentially dangerous nuclear reactors can be. Nuclear accidents, such as Chernobyl and Fukushima, have the potential to teach many lessons about reactor safety which can inform the next generation of nuclear reactor design and operation.

Learning Goals

- Identify the causes and effects of the two major nuclear power plant accidents (Chernobyl and Fukushima)
- Identify the types of causes of nuclear accidents (human factors, acts of nature, technological/design)
- Propose recommendations to minimize the change of accidents at Canadian nuclear power plants

Learning Activities

In this lesson, students will read/view about nuclear power accidents, examine the accidents in the guise of Accident Investigators, and watch videos and discuss the state of safety systems at Canada’s nuclear power plants.

Big Idea

Even in a highly regulated industry, such as the nuclear power industry, accidents can still occur. Human factors, faulty designs and acts of nature have all played a role in the nuclear power accidents that have occurred to date, but these can be minimized.

ASSESSMENT & EVALUATION

Prior Knowledge and Skills

- Experience locating information using internet sources
- Some familiarity with nuclear accidents (most likely Fukushima)
- Experience working in cooperative small groups

Success Criteria

- Students participate in meaningful discussion during class discussion
- Accident investigation charts are complete and accurate
- Students identify, in grade-appropriate terms, the causes and effects of two major nuclear accidents

Assessment Strategies

- Observation of large group discussions
- Assessment of student accident investigation charts

RESOURCES & MATERIALS

- BLM – Accident Investigation Chart [.doc] [.pdf] - 1 per student
- Accident Investigation Chart - Chernobyl Exemplar [.pdf] - for teacher reference
- Accident Investigation Chart - Fukushima Exemplar [.pdf] - for teacher reference
- Curriculum alignment [.html]
- Personal electronic device with internet access or classroom computers
**MINDS-ON**

- Begin the discussion by having students recall what they can about nuclear accidents that they have heard of. This could be in the form of a THINK-PAIR-SHARE activity.
- Explain that since the late 1950s, only two **major** (Level 7 - see Did You Know? at right) nuclear power plant accidents have happened worldwide.
- Explain that after each accident, accident investigators went to the sites to determine the cause or causes of the accident.
- Brainstorm with students the types of causes they think accident investigators would have been looking for when they visited the sites and interviewed eyewitnesses after the nuclear accidents. This should include things such as:
  - Structural failures
  - Equipment failures
  - Human error/operation errors
  - Technical failures (e.g., computer errors)
  - Natural disasters

*Implementation Option*

- Have students watch video or film clips of nuclear accidents, such as the ones on CurioCity (see Additional Resources), before or after the initial class discussion.

**Suggested Timing:** 15-20 minutes

**Did You Know?**

Nuclear accidents are rated on a seven-point scale.
1. Anomaly
2. Incident
3. Serious Incident
4. Accident without significant off-site risk
5. Accident with off-site risk
6. Serious accident
7. Major accident


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**ACTION**

- Divide the students into small groups. Each small group will become ‘Accident Investigators’ for one of the two major nuclear accidents (Chernobyl or Fukushima).
- Provide each small group with a copy of **BLM – Accident Investigation Chart**. They will complete the chart using information found in the Accidents section of the TeachNuclear web site, as well as other sources. This could be completed during class time or given as an out-of-class assignment.
- Time permitting, once the charts are complete, have each group share their final recommendations (last line of the chart) with the class.

*Implementation Option*

- **Did You Know?**

According to the International Atomic Energy Agency (IAEA), an **accident** is any unintended event, including operating errors, equipment failures or other mishaps, the consequences or potential consequences of which are not negligible from the point of view of protection or safety.


- You may want to provide the students with a list of web sites to visit, rather than having them find information on their own. The Background/Additional Information section has such links.
- Instead of presenting the recommendations orally, the students could record their results digitally, such as on a Google.doc.
- Students could compare and contrast the two accidents using a graphic organizer, such as a Venn diagram.

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CONSOLIDATION

Suggested Timing: 20-25 minutes

- Have students watch the four Nuclear Power Plant Safety Systems videos from Canadian Nuclear Safety Commission posted on CurioCity or on the CNSC YouTube page. If you wish, you can have small groups watch different videos.
- After the students have watched the videos, have a class discussion using questions such as:
  - What are some of the safety systems used in CANDU reactors?
  - Could the same types of accidents that happened at Chernobyl and Fukushima happen at Canadian nuclear power plants? Why or why not?
  - Based on the videos, and what you learned about the Chernobyl and Fukushima nuclear accidents, how safe do you think Canada’s nuclear power plants are?
  - Is it possible to make a nuclear power plant 100% safe? Why or why not?
  - What are some other ways you can think of that would make a nuclear power plant safer?

EXTENSIONS

- Have students write a short summary about the role of the Canadian Nuclear Safety Commission.
- Students could write a summary of recommendations to minimize the change of accidents at Canadian nuclear power plants.
- Have students research the aftermath of the Chernobyl and Fukushima accidents, for example, Fukushima Three Years After on CurioCity.
- Students could do an accident investigation on a lower-level accident, such as Three Mile Island (see Background Information).

ADDITIONAL RESOURCES — Canadian Nuclear Association

TeachNuclear Web pages
- Accidents
  - Chernobyl
  - Fukushima
  - Three Mile Island

Related TeachNuclear Lesson Plans
- Costs & Benefits of Electricity Generation
- Nuclear and the Environment Jeopardy
- Safe and Secure: Nuclear Waste Storage
- What Is Radiation? Jeopardy

ADDITIONAL RESOURCES — CurioCity by Let’s Talk Science

Videos
- Scientists Keep Radiation in its Place
- What is Radiation? (CNSC)
- Fukushima Three Years After
- Fukushima Nuclear Reactor Problem Explained (CNN)
- Safety systems at Canada’s Pickering nuclear plant
- What has been done since Fukushima to improve the safety of our nuclear power plants? (CNSC)

Career Profiles
- Radiation Physics Specialist / Radiation Safety Officer

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BACKGROUND/ADDITIONAL INFORMATION

Chernobyl
- On this Day - Soviet Announces Nuclear Accident at Electric Plant  (Retrieved Jan. 9, 2015)  
  This New York Times article about the Chernobyl accident, which originally appeared on April 29, 1986, was one of the 
  headline stories of the day. Students can read the original story on this web site.
- Live Science - Chernobyl: Facts About the Nuclear Disaster  (Retrieved Jan. 9, 2015)  
  This page contains information about the accident as well as about the aftermath, including health and environmental impacts.
- Nuclear Energy Institute - Chernobyl Accident and Its Consequences  (Retrieved Jan. 9, 2015)  
  This page has a summary of key facts and information about the Chernobyl accident.
- BBC News - The Chernobyl Disaster  (Retrieved Jan. 9, 2015)  
  This section of the BBC News web site has information as well as images, from both then and now.
  This section of the World Nuclear Association web site has extensive information about the accident and its aftermath.

Fukushima
  This document is a summary of the commission that investigated the Fukushima accident. It includes details about the accident 
  itself, as well as recommendations to prevent future disasters.
  This document, from the Canadian Nuclear Safety Commission, describes specific actions to be implemented to strengthen the 
  defence in depth of Canadian nuclear power plants (NPPs) and major nuclear facilities, enhance emergency preparedness, as 
  well as improve regulatory oversight and crisis communication capabilities.
  This section of the World Nuclear Association web site has extensive information about the accident and its aftermath.

Three Mile Island
- Three Mile Island Lesson Plans  (Retrieved Jan. 9, 2015)  
  This series of lesson plans was developed by the EFMR radiation monitoring organization in the United States. It includes 
  lessons for Junior High (middle school) as well as high school.
- On this Day - Radiation Is Released in Accident at Nuclear Plant in Pennsylvania  (Retrieved Jan. 9, 2015)  
  This New York Times article about the Three Mile Island accident, which originally appeared on March 29, 1979, was one of the 
  headline stories of the day. Students can read the original story on this web site.