lesson plan

# Keeping the Genie in the Bottle: Nuclear Non-Proliferation

How can nuclear technology be exported without allowing the spread of nuclear weapons?

## overview

### LESSON CONTEXT

Although nuclear weapons have only been used in war twice, the threat of nuclear war has dominated global politics since the Second World War. Despite strenuous efforts from the world community, a number of nations have developed their own nuclear arsenals over the past 70 years.

### LEARNING GOALS

- Analyze from a variety of perspectives the risks and benefits to society and the environment of applying scientific knowledge or introducing a technology.
- Participate in a role-playing simulation in order to understand a complex situation.
- Recognize the need for safeguards to ensure the responsible use of technology.

### LEARNING ACTIVITIES

In this lesson, students will learn of the challenges of trying to keep nations with fuel rod reprocessing technology from developing nuclear weapons through participation in a role-playing simulation.

### BIG IDEAS

Strict controls of nuclear technology are required to prevent the spread of nuclear weapons.

**time**
80-95
MINUTES

**subjects**
PHYSICS
SCIENCE
ENVIRONMENTAL SCIENCE
HISTORY
SOCIAL STUDIES
CANADA AND WORLD STUDIES

**skills**
CRITICAL THINKING
COMMUNICATION
COLLABORATION

## assessment & evaluation

### PRIOR KNOWLEDGE AND SKILLS

- Basic understanding of the relationship between nuclear technology and nuclear weapons
- Experience working in cooperative small groups
- Experience participating in role-playing simulations

### SUCCESS CRITERIA

- Students participate actively in role-play exercise
- Students understand that new technologies bring both risks and benefits to society

### ASSESSMENT STRATEGIES

- Keep a checklist of student participation during the simulation. Observe how students demonstrate an understanding of their role, how they focus on their group's tasks, how they engage with the simulation and how they interact with others.
- Student reflection

## resources & materials required

- DOC PDF **BLM – Nuclear Non-Proliferation Background Information** – one per student
- DOC PDF **BLM – Nuclear Non-Proliferation Simulation Overview** – one per group
- DOC PDF **BLM – Nuclear Technology Transfer Treaty (No Inspections)** – four
- DOC PDF **BLM – Nuclear Technology Transfer Treaty (On-Site Inspections)** – four
- DOC PDF **BLM – Nuclear Reactors** – four
- DOC PDF **BLM – Nuclear Weapons** – up to four
- DOC PDF **BLM – Spare Fissionable Material and Spent Fuel Storage** – two
- DOC PDF **BLM – Spent Fuel Reprocessing Facility** – two
- DOC PDF **BLM – Roles and Duties** – one copy of relevant page/group
- PDF Curriculum alignment
- Two-sided plastic chips – at least 300 (150 to each of the nuclear technology-exporting nation groups)
- Stopwatches – one per group
- Electronic device with internet access

## preparation

- Familiarize yourself thoroughly with the parameters of the simulation and the contents of the BLMs.
- The class should be divided into groups prior to the lesson.
- Students should be provided with the **Nuclear Non-Proliferation Simulation Overview BLM** and the **Roles and Duties BLM** page relevant to their group so that they understand what they will be doing in the simulation and can assign roles within their group.
- Have students read background information on nuclear non-proliferation and fuel rod reprocessing, such as the **Nuclear Non-Proliferation Background Information BLM**.

## minds-on

15 MINUTES

- Introduce the students to the concept of nuclear proliferation by asking them what Iran, Iraq and North Korea have or have had in common.
- All three of these nations have been at the centre of international tensions within the past 20 years because of perceived efforts to produce nuclear weapons (in 2002, then-President Bush famously termed these nations the "Axis of Evil"). See the **Nuclear Non-Proliferation Background Information BLM** for more information on these nations' nuclear programs and the international response.
- While all of these nations have been involved in nuclear crises, the results have been dramatically different. In the case of Iraq, the situation was resolved through invasion of the nation, overthrow of the government, and complete dismantling of the nation's nuclear research facilities. North Korea's effort to develop nuclear weapons in the face of international opposition ended with nuclear weapons tests. The situation with Iran is as yet unresolved.
- One other thing that all three of these nations have in common is that all of their nuclear programs involved fuel rod reprocessing. However, fuel rod reprocessing also makes it easier for nations to isolate weapons-grade fissionable materials, such as plutonium, as well as easier to divert those materials for military purposes.

### MISCONCEPTION ALERT

Students may believe that possessing nuclear reactors means that a country automatically has or can produce nuclear weapons. The majority of nations with nuclear reactors do not possess nuclear weapons.

### DID YOU KNOW?

Fuel rod reprocessing involves removal of fissionable materials (uranium-235 and plutonium-239) from spent nuclear fuel chemically. The most common method, known as PUREX (Plutonium-URranium EXtraction), begins with dissolution of spent fuel in nitric acid.

After India developed nuclear weapons using nuclear fuel reprocessing technology in the 1970s, most nations stopped commercial reprocessing of spent nuclear fuel due to concerns about nuclear proliferation (only France, Great Britain and Japan currently reprocess fuel rods commercially). Since fuel rod reprocessing does offer a means of dealing with some aspects of the nuclear waste issue, a number of nations are considering restarting commercial fuel rod reprocessing programs.

- Discuss with the students the question of nuclear proliferation. Particularly address these issues:
  - » *Do all nations have the right to nuclear technology?*
  - » *What can or should the international community do to stop the spread of nuclear weapons?*
- The students will explore, through a role-playing simulation, the key question: How can nuclear technology be exported without allowing the spread of nuclear weapons?

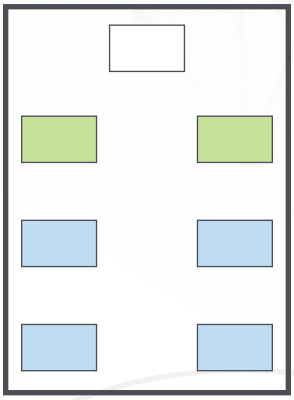
## action

**50–60 MINUTES**

- Organize the students into seven groups.
- Set up the groups representing nuclear technology-exporting nations near the front of the classroom, along with the International Atomic Energy Agency (IAEA) group. See the **Nuclear Non-Proliferation Simulation Overview BLM** for a thumbnail description of how the simulation should run.
- Each group represents an international player in a simulation designed to show the challenges of preventing nuclear proliferation. Two of the groups represent nuclear technology-exporting nations, four of the groups represent nations wishing to acquire nuclear technology (and, possibly, nuclear weapons) and the final group represents the IAEA, which is trying to ensure that all nuclear technology is being used for peaceful purposes only. Place the groups as shown in the diagram at the right.
- Ideally, each group should have three to four people; any extra students should be assigned to the IAEA group. Each of the nation groups should come up with a name for their nation, either real or fictitious.
- If you or the students are unfamiliar with the role-playing simulation instructional strategy, refer to the sidebar below for information. The intent of the simulation is to demonstrate the challenges of preventing covert development of nuclear weapons by nations.
- Each group has a specific role within the simulation:

  The two nuclear technology-exporting nations will negotiate with the four nations that are seeking nuclear technology, sell them nuclear reactors, provide them with nuclear fuel and report back to the IAEA.
  - » These groups begin the simulation with two copies each of the **Nuclear Reactor, Spare Fissionable Material and Spent Fuel Storage BLMs** that they will hand over to the nuclear technology-importing nations they deal with, as well as four copies of the relevant **Nuclear Technology Transfer Treaty BLM** for signature.
  - » Additionally, Nuclear Technology-Exporting Nation #2 will have two copies of the **Spent Fuel Reprocessing Facility BLM** that they will hand over to the nuclear technology-importing nations they deal with.
- The four nations seeking nuclear technology will negotiate with the two nuclear technology-exporting nations, buy nuclear reactors from them and then operate the nuclear reactors.
  - » They will also have to provide reports to the IAEA on their nuclear programs, including accounting for all fissionable materials.
  - » One or more of these nations will try to covertly develop nuclear weapons using the technology and fissionable materials.
- The IAEA will monitor all nuclear-related activity amongst the six nations that make up the international community.
  - » This includes receiving regular reports from both the nuclear technology-exporting nations and the nuclear technology-importing nations on their inventories and movements of fissionable materials, observation of nuclear facilities through remote observation and, where permitted, on-site inspections of a nation's nuclear facilities.

**SAMPLE CLASSROOM LAYOUT**



- Before the simulation begins, secretly select one or more of the nuclear technology-importing groups to be nations that will attempt to develop nuclear weapons.
  - » Give each group a copy of the **Nuclear Weapons BLM** and explain to them that during the simulation they will be attempting to covertly develop nuclear weapons by diverting fissionable material (face-up chips) to their nuclear weapons program without anybody noticing.
  - » Nuclear weapons development is in addition to the group's regular duties as a nuclear technology importing nation.
- Explain that the groups are to follow the instructions on their **Roles and Duties BLMs** and the **Nuclear Reactor**, **Spent Fuel Reprocessing Facility**, **Spare Fissionable Material and Spent Nuclear Fuel Storage** and **Nuclear Weapons BLMs**.
- One additional rule to stress is that no-one is to introduce nuclear fuel (plastic chips) from outside of the simulation – i.e. other than those supplied by the two nuclear technology-exporting nations.

## THE SIMULATION

- The simulation begins with representatives from the two nuclear technology-exporting nations meeting with the four nations interested in acquiring nuclear technology to negotiate technology-transfer treaties.
- Upon the successful completion of these negotiations and signing of the treaties, the nuclear technology-exporting nations will hand over a **Nuclear Reactor BLM**, **Spare Fissionable Material and Spent Fuel Storage BLM** and, if applicable, a **Spent Fuel Rod Reprocessing Facility BLM**, along with 25 units of fissionable material (face-up chips).
- Once the reactors are delivered, then the nations begin operation, following the instructions on the **Nuclear Reactor BLM**.
- All four reactors must be kept in continuous operation throughout the simulation.
- Fissionable material can be acquired from the nations that supplied the reactors or from reprocessing facilities, if the nation is operating one.
- Records must be kept showing nuclear fuel inventories and usage, and then provided to the IAEA and the nation that supplied the reactors. Nuclear technology-exporting nations must also supply reports to the IAEA on fissionable material.
- During the simulation, members of the IAEA group will:
  - » collect regular reports on fissionable materials inventory levels from each nation operating nuclear reactors;
  - » collect reports on fissionable materials exports from each nation supplying nuclear technology (including how much fissionable material was supplied to each nation);
  - » conduct on-site inspections of each nation's nuclear facilities (if allowed); and
  - » observe nations remotely for any suspicious activities.
- The simulation ends after 45 minutes or when one of the nations declares itself a nuclear-armed power, whichever occurs first.

## IMPLEMENTATION OPTION

- IAEA observers could be provided with digital cameras to let them document suspected nuclear weapons development activities.

### RUNNING SIMULATIONS

Simulations are a form of virtual reality – students are placed in a situation that would otherwise be impossible for them to be in. Simulations combine elements of games and role-taking, creating open-ended situations that allow students to explore the complexities of an issue through interaction with others in a controlled environment. Simulations have rules and parameters, but unlike games are non-linear. By allowing students to learn by doing as opposed to reading, listening or watching, simulations are powerful tools for engaging students in active exploration and learning.

Simulations do require a significant amount of commitment and preparation, however, on the parts of both the teacher and the students, and assessment can be complex. Additionally, students and the teacher must have clear understandings of their roles and the rules and parameters of the simulation for the simulation to be effective.

## consolidation

20 MINUTES

- Allow each group five minutes to reflect upon their experiences in the simulation. They should think about how their group performed in the simulation, how effective the simulation was at representing international nuclear non-proliferation situations and how effective the mechanisms designed to monitor nuclear technology use were.
- Debrief the simulation with the students. In particular, focus on the following questions:
  - » *How effective were the efforts to monitor nuclear technology use?*
  - » *What would be the best method for ensuring that no secret nuclear weapons development takes place?*
  - » *Did having a reprocessing facility make it more difficult to keep track of fissionable material?*
  - » *How did participation in this simulation give you a greater understanding of the challenges involved in preventing nuclear proliferation?*
  - » *Is there anything which you would do differently if you participated in this simulation again?*
- Return to the issues discussed before the simulation:
  - » *Do all nations have the right to nuclear technology?*
  - » *What can or should the international community do to stop the spread of nuclear weapons?*
- Have the students' attitudes regarding international controls on nuclear technology controls changed as a result of participating in the simulation? Why or why not?
- After the discussion, have students write a summary of the importance of controls on nuclear technology, based on their experiences in the simulation.

## extensions

- Have students research an incident where the world community has reacted to a nation's attempt to acquire nuclear weapons. What were the mechanisms for the international community's actions (United Nations, International Atomic Energy Agency, other international organizations, nations acting unilaterally)? What was the result? Were the international community's actions justified? Were the international community's actions effective?
- Engage the class in a debate on one of the following questions:
  - » *Is a nation ever justified in attempting to acquire nuclear weapons?*
  - » *Is war justified to stop a nation from acquiring nuclear weapons?*
  - » *Are nuclear weapons inherently bad?*
- Have students write an op-ed piece on the question of commercial fuel rod reprocessing. Do the benefits of the technology outweigh the risks of nuclear proliferation?

### DID YOU KNOW?

To date, eight nations have declared themselves as nuclear-armed powers: the United States, Russia, Britain, France, China, India, Pakistan and North Korea. Israel, which has never publicly admitted having nuclear weapons, has had a nuclear arsenal since 1967 and currently has some 200 nuclear weapons. South Africa tested its first nuclear weapon in 1979 and produced six bombs, but signed the Non-Proliferation Treaty and dismantled its entire nuclear program in 1991 – the only country ever to give up its nuclear weapons program voluntarily.

# additional resources

### CANADIAN NUCLEAR ASSOCIATION WEB PAGES

- **Safety record**
- **Operational safety**
- **Plant security**
- **Safety regulations**
- **Site security**
- **HEU repatriation**
- **Non-proliferation**
- **CANDU technology**

### RELATED TEACHNUCLEAR LESSON PLANS

- **Transporting Nuclear Materials**
- **Safe and Secure: Nuclear Waste Storage**

# background information

**(Retrieved August 2019)**

- **International Atomic Energy Agency**
  The International Atomic Energy Agency (IAEA) is the world's nuclear inspectorate and is responsible for inspections designed to enforce the Treaty on the Non-Proliferation of Nuclear Weapons since the treaty was adopted in 1968.
- **Treaty on the Non-Proliferation of Nuclear Weapons (NPT) – International Atomic Energy Agency**
  The Treaty on the Non-Proliferation of Nuclear Weapons, often known as the Non-Proliferation Treaty (NPT), is overseen by the IAEA's Department of Safeguards, and has been signed by 149 nations.
- **Safeguards and verification – International Atomic Energy Agency**
  The Department of Safeguards is the area of the IAEA in charge of non-proliferation related activities.
- **Canadian Nuclear Safety Commission – Government of Canada**
  The Canadian Nuclear Safety Commission is responsible for all aspects of safety related to nuclear energy, including responsibility for ensuring that Canada's nuclear exports do not contribute to the proliferation of nuclear weapons.
- **Nuclear non-proliferation and disarmament policy – Canada and the world, Government of Canada**
  Information on the Canadian government's efforts to counter nuclear proliferation.
- **The Nuclear Information Project – Federation of American Scientists**
  Extensive information on the world's nuclear forces and the nuclear fuel cycle.
- **The Global Nuclear Nonproliferation Regime – Council on Foreign Relations**
  Highlights the scope of the global non-proliferation challenge and issues around the world.