Laser Maze Security System — Grade 10 Optics

Lesson Plan

Cross Curricular	French as a second language
Safety Notes	Laser light can lead to eye injuries, avoid shining the lasers at others.

Big Ideas
- Light has characteristics and properties that can be manipulated with mirrors and lenses for a range of uses

Overall Expectations
- Investigate, through inquiry, properties of light, and predict its behaviour in mirrors and as it passes through different media
- Demonstrate an understanding of characteristics and properties of light, particularly with respect to reflection and refraction and the addition and subtraction of colour

Specific Expectations
E2.2 use an inquiry process to investigate the laws of reflection; use these laws to explain the characteristics of images formed by converging, and diverging mirrors; and draw ray diagrams to illustrate their observations

E2.7 construct an optical device that uses a variety of mirrors

E3.3 explain the laws of reflection of light, and identify ways in which light reflects from various types of mirrors

Description
In this lesson, students will learn about the laws of reflection through an inquiry based introduction activity and then apply what they learn to create a laser maze. In the main portion of the lessons, students will be tasked with building a laser system that can be used to protect 9 precious gems in an exhibit hall. Their goal will be to plan, design and build a system of mirrors that reflect a single laser beam to ensure that each of the gems is protected from theft. Students will be asked to demonstrate their laser maze and present how it is used to protect their gem collection. This lesson supports the grade 10 science curriculum and includes a variety of vocabulary strategies that will support FSL learners.

Materials
Introduction
- Plane Mirror
- Light box or laser pointer

Action
- Plane mirrors
- Small clothespins or binder clips
- Concave Mirror
- Light box or laser pointer
- Large sheet of paper and cardboard
- 8 precious stones (plastic jewels)
- 1 blue diamond (plastic jewel)

Accommodations/Modifications
- To make the activity more accessible, you can provide groups with the location of the laser and sensor, the mirrors, or the gems and get them to progress with that as a starting point.
- To challenge stronger students, modify the number or types of mirrors that they can use

FSL Activities
- Anticipation Guide
- Imagine-Refine-Predict-Confirm
- Recall in Order of Importance

Introduction

FSL Activity: Anticipation Guide

Anticipation guides are used to reactivate student's previous learning and to engage them by making connections to what they already know. This activity also serves as a sort of diagnostic assessment to gauge what student's know about the topic. To complete this activity, simply provide each student with the Optics Anticipation Guide and have them decide if they agree or disagree with each statement, then justify why they made that decision. Once each group has completed the anticipation guide you can lead the students through a small group or whole class discussion so that students can share and reinforce their ideas prior to the next activity. (Macceca & Brummer, 2010)

The answers to the anticipation guide are:

1. All reflected light follows the law of reflection: **True** (The angle of the incident ray will always equal the angle of the reflected ray, regardless of the surface)
2. The law of reflection states that the angle of incidence is perpendicular to the angle of reflection: **False** (The angle of incidence is equal to the angle of reflection)
3. Light is reflected any time it hits the interface between any two materials: **True** (Light will always be reflected, regardless of the material, what changes is how much is reflected)
4. The amount of reflected light at the interface between two materials is always the same: **False** (the amount of reflected light varies depending on the materials)
5. Convex mirrors reflect light inwards to meet at the focal point: **False** (Concave mirrors reflect light inward to meet the focal point. Convex mirrors reflect the light outwards)

Science Activity

Students will develop the Law of Reflection in this guided inquiry activity. In order to do so, each group will need a mirror, a source of light such as a light box or laser pointer, a protractor, a pencil and the '*Law of Reflection*' handout. Using the diagram provided on the handout, students will place a plane mirror and use the light source to project rays of light at different angles. The rays of light being projected are called the incident rays. The plane mirror will reflect those rays to create reflected rays. Using a protractor, students will measure the angle of both the incident and the reflected rays and compare them to develop the Law of Reflection. There are four scenarios in this exercise to help them better understand he law.

The **Law of Reflection** states that the angle of reflection is equal to the angle of incidence. Both angles are measured with respect to the normal of the mirror and both rays lie in the same plane as the normal.

Action

FSL Activity: Imagine-refine-predict-confirm

The imagine-refine-predict-confirm strategy helps students gain a more thorough understanding of the content by combining mental imagery and predictions. The activity allows students to use their imagination which leads to greater motivation and interest in the subject.

For this activity, you'll start with the imagine portion. Students will have seen what happens to light when it reflects on a plane mirror, but in the next section, they'll be introduced to a **concave mirror**. As such, have the predict how light will reflect off of a concave mirror and draw their prediction in the provided space. In the refine portion of the activity, get students to walk around the classroom and discuss their prediction with their peers. Once they have had the chance to talk to a few other students, get them to redraw what they think will happen. Based on their two images, students will then write what they think will happen in the prediction box. When they create their laser maze and integrate a concave mirror, students will want to keep this prediction in mind. Finally, once they have completed the laser maze activity, get the students to confirm their prediction and make any adjustments based on their results. (Macceca & Brummer, 2010)

Note that the two rules of reflection for concave mirrors are that:

- Any incident ray travelling parallel to the principal axis in the direction of the mirror will pass reflect back through the focal point
- Any incident ray travelling through the focal point in the direction of the mirror will reflect back parallel to the principal axis

Science Activity

The goal of this activity is for students to conceive, build and present an laser security system for Science North that can be used to protect eight precious gems and one central blue diamond in their new exhibit hall. Each team will be scored for their security system using the '*Laser Maze Scoring*' handout and the highest scoring team will be hire by Science North to create their security system in the exhibit hall. The overall requirements for the laser security system are presented in the '*Laser Maze Activity*' handout. This project is completed in five stages:

1. Company Creation

Students will start the project by creating their company profile. They will have to design a company logo, think of a company name and provide a brief company slogan. Encourage them to be creative and have fun with their new company.

2. Planning

In the planning stage, students will be required to draw a sketch of what their security system will look like. They will start by lightly drawing the location of their laser, the sensor, their 8 gems and the Oppenheimer Blue Diamond. Once they have an idea of their starting locations, they'll have to use a protractor and ruler to draw the path of the laser beams. Students are encouraged to try a variety of configurations that best fit the requirements for the exhibit hall. Once they are confident with their design, students will be required to use a coloured pencil or marker to indicate the final location of the components as well as the laser path.

Students should note that they have to create a scale model of the 26m x 34m exhibit hall. The schematic provided for the planning is 13cm x 17cm.

3. Building

Once the students have developed a plan for their security system, they will have to create a scale model of their system. Provide students with a large sheet of white paper for them to draw the outline of their exhibit hall, keeping the dimensions in mind. Once the exhibit hall is built, they can place their laser, the gems and the mirrors according to their plan. Plasticine is effective for keeping the laser in place, whereas small clothespins or binder clips can be used to keep the mirrors and sensor in place. The sensor can be made of cardboard. Encourage students to move their gems, mirrors, laser or sensor as required. The engineering design process is ongoing as it is always possible to improve the design.

4. Final Design

Once the students have built their model using actual building material, they'll have a better idea of how their laser security system will operate. To reflect this, they'll be required to draw their final design on the provided schematic that shows the location of each of the required components. Be sure that they use a ruler and protractor to identify how the law of reflection is applied to the laser reflecting off each of the mirrors.

5. Presentation

The final step is for students to make a short 1-minute presentation about the virtues of their security system, highlighting why they should be hired for the job. Some things that they can consider in their presentation are the features of the security system, why it's effective, why it's unique, what it costs and why Science North should hire them above any other team. Encourage students to use some of the science vocabulary learned as part of this exercise.

Consolidation/Extension

FSL Activity: Recall in Order of Importance

The Recall in Order of Importance activity is used to summarize and evaluate what students have learned. Students are asked to write one very important idea, one idea of medium importance and one less important idea, all based on what they learned about the law of reflection and the activities completed in this lesson. By getting them to rank what they learned, it helps students recognize the main idea and what ideas support this main thought. To complete this activity, simply provide each student with the cut-out sheet and get them to fill in the three categories. Lead a discussion regarding the results and ask students to justify their choices. This activity can be used to assess what students learned in this lesson. (Macceca & Brummer, 2010)

Assessment

Use the "*Laser Maze Scoring*" handout to assess the science components of this project.

Teachers can also evaluate French with this same project so long students are informed on what they're being evaluated on. Ensure that the French component is assessed as a French mark and that the science component is assessed as a science mark. Students should not lose science marks for improper use of French or vice-versa.

Additional Resources

The following documents are required for this lesson:

- Law of Reflection handout
- Laser Maze Activity handout
- Laser Maze Scoring handout
- Laser Maze Presentation

Works Cited

Macceca, S., & Brummer, T. (2010). *Stratégies de lecture en mathématiques, en sciences et en sciences sociales.* Montréal, Québec, Canada: Chenelière éducation.