Embracing an Interdisciplinary learning design to Investigate Light: An accessible and engaging, open-ended enquiry design adaptable for remote learning and classroom learning

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The teaching and learning sequence Investigating Light is the focus of this article and was conducted in Grade 5/6 as part of the Australian Research Council (ARC) funded Interdisciplinary Mathematics and Science (IMS) Learning Project (Tytler, et al., 2018-2021; https://imslearning.org/). This sequence is aligned to the Victorian Science curriculum. In response to the challenge of providing authentic, accessible, and engaging science learning experiences for students during remote learning, this iteration of the Investigating Light sequence was developed in consultation with teachers, to ensure student accessibility in the online learning context. Relatable to students, the activities were adapted from the Deakin University Ideas for Teaching Science P-8 (https://blogs.deakin.edu.au/sci-enviro-ed/early-years/). Reflecting an interdisciplinary focus, this sequence included opportunities for students to investigate with both science and maths in engaging and complimentary ways (See table 1.). For instance, students are challenged to explore angles, rotation and light directionality in their periscope designs, and the relationship between shadow size and the distance from the light source, when investigating shadow puppets in the ‘Shadow Play Investigation’ lesson.

<table>
<thead>
<tr>
<th>Year</th>
<th>Topic</th>
<th>Science</th>
<th>Mathematics</th>
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Table 1: Interrelationships between science and mathematics concepts (Adapted from Tytler et al., 2021). Details of some of these sequences can be found at https://imslearning.org/resources/.

Figure 1. Shadow Puppet investigation lesson: Student representations of their investigation findings “How does torch/light distance affect the size of shadows?”

Interdisciplinary open-ended challenges, within which students employ mathematical thinking to invent, find solutions, make inferences, and draw reasoned conclusions are highlighted in all lessons. The high ceiling and low floor tasks (Sullivan, Walker, Brock, & Rennie, 2015) are also recognised by teachers as enabling variation in responses and providing teacher insight into student conceptual understanding through their representational modelling. Teachers noted that student representations are important for both monitoring and supporting student learning. Teachers supported students through a guided inquiry model. This involved guiding representation review or analysis, collaborative sharing of ideas and
observations, and scaffolding critical reflection and review, to develop their understandings. This is the IMS pedagogical approach (https://imslearning.org/findings/).

Teacher comment: *Problem solving is such a big aspect. I think with open-ended learning you learn more about their [student] learning styles as well as them as learners.*

Although student collaboration is restricted in an online conferencing context, the sharing of student designed puppets, mazes, and periscopes stimulated scientific predictions, observations, and inferences. Supported by guiding questions and prompts, student conceptual understanding and engagement in their learning was evident with many students pursuing further design investigations (e.g. different periscope designs), investigations, and research (e.g. vision illusions), beyond the sequence activities.

Teacher comment: *You can guide them, yes. But in the end, it’s about what the kids are wanting to discuss too... So, all these questions, they’re all coming up with, are good research points as well.*

Many students reported that the sharing of learning extended beyond the online learning context to sharing with their siblings and families, with some students adopting learning journals to accompany their representational work and pursuing further research. This is demonstrated in Figure 2.

![An individual student’s Periscope designs.](image)

**Figure 2.** Multiple

Through situating interdisciplinary science and mathematics learning in an accessible and open-ended inquiry model, students developed their conceptual understanding and also reported high levels of engagement and enjoyment. In interviews both students and teachers identified the creative element of lessons as a key strength. Lessons provided students with opportunities to design, invent, trial, and review their own creations, applying data modelling and representational work. The *Investigating Light* sequence
is currently being further researched, focusing on student critical and creative thinking. The sequence, adapted for remote learning can be found in the following pages.

Acknowledgments
This project was funded by an Australian Research Council Discovery Grant No. DP180102333. *Enriching mathematics and science through an interdisciplinary approach.* Our thanks extend to the schools, teachers, and students who were our research partners.

References


Investigating Light

How do we see things? What does it have to do with light?

Write, draw, record and explain your responses in a book and upload photos to google classroom

In this drawing Abbie is able to see the tree.

Draw in your book Abbie and the tree, using arrows to show how light from the sun enables her to see the tree.

After you’ve drawn, and explained your thoughts to the above questions, watch this video about eyes and how they work and answer the questions below

https://www.youtube.com/watch?v=t3CjTU7TaNA (TED-Ed)

Abbie is in bed at night. The curtains are drawn and the lamps in the room are off so there is no light in the room at all.

Will Abbie be able to see objects in her room without any light? Why? Her cat is also in the room. Can her cat see objects without any light present? Why?

Have your ideas about eyes and how a cat can see at night changed? If you’d like to redraw your response to how Abbie can see the tree, you can do that. Please don’t change or delete your first ideas and drawing though, it is great to look back on your ideas and representations.

(Write your responses in your book. You can use a drawing to help)
Using our stereo vision to judge depth.
You’ll need two pencils, or you could use two, same size, coins

Challenge 1:
Hold your finger in front of you, at arm’s length, in front of a distant set of objects, perhaps at the other end of a room, or across the road.

Close first one eye, then the other. Your finger should jump from one part of the background scene to another.

Move your finger closer and try again. Does it jump more?

Our brain uses this effect with our two eyes to judge how far things are away!

Challenge 2:
With two pencils touch the tips together.

Now do it again with one eye shut

Change, and shut the other eye

What happened? Why?

Challenge 3:
Walking around a room full of objects is easy. Try it with one eye shut.
Can you explain the difference when your eye is shut?
Record what happened, your ideas and/or explanation in your book.

Notice the shadows? We’ll explore them next lesson

Extension 1: Transparent Translucent and Opaque (optional)
Materials: torch or phone light, objects, different things from around the house (see through, partially see through and not see through)

1) Find different materials from around the house to investigate with a torch
2) Take photos of shining a light against them (torch light/phone light)
3) Draw and represent - what is happening to the light when it hits different objects?  
   Tip: Is it going through the object? How could you represent that?
4) Can you categorise the objects into three types – transparent, translucent and opaque?

Interesting: Watch this video to see a living thing that is translucent - the “Glass Frog”, although its name would suggest it is transparent, light doesn’t completely pass through it. It is translucent.

https://www.youtube.com/watch?time_continue=78&v=W5k_S8N0pFo&feature=emb_title
**Extension 2: Eye Tricks** (optional)

After doing activity 1 or 2 (or both if you like) go to the link at the bottom for more challenges and explanations.

1: Visual Illusions Interactive games  
[https://www.magicmgmt.com/gary/oi/index.html](https://www.magicmgmt.com/gary/oi/index.html)  
NB: you will need adobe flashplayer or to allow access once  
Draw and write about one of the illusions.  
You may also like to design your own illusion and make a video or photo sequence.  
(e.g. make your own spinning spiral)

2: The Tricky Eye Maths Challenge (optional)  

**Challenge 2.1**

- Are the lines all forming a square?  
- Measure the lines and check?  
- What are the measurements?

**Challenge 2.2**

- Are the horizontal lines different lengths?  
- What are their measurements?

Draw, write about one of the illusions. You may also like to design your own illusion and take photographs or make a video.

See the below link for illusions and their explanations  
[how-your-eyes-trick-your-mind/index.html](how-your-eyes-trick-your-mind/index.html)
Investigating Light

Lesson 1: Exploring light and how we see

Acknowledgements and Resources (in order)

Drawings & Teacher Support Materials

Video and Night Eyes Image

Video

Interactive Illusions

Illusion images (Helmholtz & Ponzo)

Interactive Illusion Explanation

Acknowledgments
This project was funded by an Australian Research Council Discovery Grant No. DP180102333. Enriching mathematics and science through an interdisciplinary approach. Our thanks extend to the schools, teachers, and students who were our research partners.
In this lesson we’ll be exploring shadows. We’ll investigate how they are made and how to change their size through shadow play. There are extension activities for further exploration and investigation attached.

Focus on: The role that light and materials play in casting shadows

Materials: Ruler, torch or iPad/phone torch and small figurine toys or (if not small figurine toys) card/paper, scissors, sticky tape, paddle pop sticks or plastic cutlery/chopstick

Watch the below video - Hand Shadow Video: https://www.youtube.com/watch?v=J-3fHDUmnf0
Investigate how a shadow is formed using your hands and a torch. What shadows can you make?

Use a figurine or cut out a small monster figure from cardboard (can attach to the paddle pop stick) and use a torch to create a large scary shadow on the wall, or a cupboard or screen. Draw in your books a representation of how the shadow is formed from the light of the torch.

Investigating shadow size

Keep the figure and screen (it may be the wall) in the same position, and change the distance of the torch from the figure.

- What happens to the shadow as the torch gets closer? Why? Represent, with drawings and words how the torch distance changes the shadow size. For different distances of the torch from the figure, record the size of the shadow in your book. Organise the measurements in table, then in a graph show the size of the shadow for different torch distances.
- What do you notice? What happens to the shadow when you halve the torch-figure distance? You may use a table and graph, diagrams and representation and include a photograph of your investigations to explain what is happening.

Extension: Shadow Puppet Play Fun (optional)

OR

Create your own Shadow Puppet Play with puppets or hand puppets, on your own or with your family. Video your Shadow Play if you would like to share it with the class.

Practice your shadow puppets and take a photo of the ones you’ve mastered.

Use your imagine and have fun 😊
Investigating Light

Lesson 2: Shadows

Acknowledgements and Resources (in order)

Drawings and Teacher Support Materials


Shadow Image – Year 6 Research Project Participant image

Video

Shadow Handpuppet Image

Acknowledgments
This project was funded by an Australian Research Council Discovery Grant No. DP180102333. Enriching mathematics and science through an interdisciplinary approach. Our thanks extend to the schools, teachers, and students who were our research partners.
Focus on: The reflection of light in mirrors and how to use this to ‘see around corners’.

Investigation 1 – Making light bend around corners

Materials • a torch • a small cardboard box with a screen glued to its side • two small (10 cm square) mirrors taped to blocks to enable them to stand • an A3/large sheet of paper (or card) with two circles marked A and B as shown in the figure below.

Set up your torch to shine out of the box with a screen on the side of the box (see picture below)

Investigation: Can you use two mirrors so the torch lights up the screen on the side of the box?

Key idea: Mirrors reflect light at an equal angle to the incoming light

Representations: Answer the above questions using diagrammatic drawings in your book

Mirrors are used often to see ‘blind spots’. They are used on ‘blind’ corners so that motorists or pedestrians can see what is coming in shops to give a view of customers hidden down aisles, or. They can be used by magicians to create illusions.
Further Investigation: Mirrors can be tricky – seeing around corners

**Materials:** Toy figure or statuette

**Plus materials as per investigation 1** • a small box • two small mirrors • an A3 sheet of paper with circles marked A and B

**Investigation:**
- Place a small ‘treasure’/figurine behind an upright screen.

  **Why can’t you see it directly?**

  NB: You might say ‘You can’t see around corners’. But can you explain why, by talking about what happens to the light reaching our eyes? Use diagrammatic drawings to explain your answer.

**Challenge**
- Place a mirror in a position so you can see the treasure behind the screen.

  **How many positions can you find?**

  **How does the mirror have to be angled to see your ‘treasure’/figurine a in a box?**

- Arrange two mirrors, placed on the circles A and B, and angle them so that you can see the statue in the mirror at B, from the marked position.

  **How are the mirrors allowing you to see the statue around the corner?**

**Optional challenge task:** Can you set up mirrors in your house to allow you to see what’s happening around a corner? Take a photograph to show how you did it. Draw your explanation.

**Optional Extension: Light Maze**

Exploring with light and mirrors – Creating light mazes

Investigating Light

Lesson 3: Making light bend around corners

Acknowledgements and Resources (in order)

Drawings & Teacher Support Materials


Images

Word Free stock Image – Lego maze

Extension Resource

Acknowledgments
This project was funded by an Australian Research Council Discovery Grant No. DP180102333. Enriching mathematics and science through an interdisciplinary approach. Our thanks extend to the schools, teachers, and students who were our research partners.
Focus on: Light travels in straight lines. Using mirrors to reflect light in different directions and look around corners

Investigation: Making a periscope

Materials:
Two small mirrors (about 5-8 cm) or old CDs/DVDs, a long cardboard tube (clingwrap tube) or cereal box or milk carton, scissors, sticky tape.

What is a periscope? This video helps explain what a periscope is.
https://www.youtube.com/watch?v=_E_SERfmeJk
Watch the video then, can you make your own periscope?

Making Your Periscope
Experiment with your own periscope design.
Use a long tube, cardboard box, or milk cartons to make the periscope.
Cut slits and use tape to fix two mirrors at the right angle to make your periscope.
Experiment to find a way to get the mirror angles right, to be able to see beyond the tube.

Represent how you think light travels through the periscope to enable you to see.
What angles should the mirrors be at?
If the mirrors are not quite at the right angle, what difference will that make?

Draw and explain your periscope design and predicted answers to the above questions.
Record the process and your explanation
- Drawings and/or a pictures/pictures of your completed periscope and making your periscope
- A drawing, with text, explaining how your periscope works (and any changes to your initial responses to the above questions).
- Extension: You might like to upload photographs taken through your periscope.

Periscopes: A periscope is useful if you are in a submarine, or if you want to look over a tall wall, or even if you are in a crowd of tall people and want to see over their heads. Periscope means 'looking around (corners)’
Investigating Light
Lesson 4: Periscopes

Acknowledgements and Resources (in order)

Teacher Support Materials


Images

Student periscope design: Participating IMS Learning Project student design

Periscope: Royalty Free periscope image retrieved from https://www.pngkit.com/downpic/u2q8e6q8u2i1r5u2_periscope-royalty-free-vector-clip-art-illustration-periscope/

Video


Acknowledgments

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Focus on: The image reflected in a mirror/on glass is at a particular position behind the mirror/glass surface

Investigation 1: Figurine trapped in the jar

Materials: a small toy figurine, a torch (or your phone), a glass jar, a perspex or glass screen at least 15 cm × 15 cm (if you don’t have this clear DVD cases can be used)

NB: a way of holding the screen vertically on a bench (e.g. two cups).

Set up: Place the Perspex/glass screen vertically (see image below) between the glass jar and the small toy figurine. Use a torch or phone to light up the figurine and look from the figurine side of the Perspex/glass. NB: The jar is on the other side of the Perspex.

Investigation: Can you move the figurine around so its reflection seems to be trapped in the jar?

Can you explain why the lit figurine seems to be in the jar?

Representation: Answer the above questions using diagrammatic drawings
Investigation 2: Water illusions - Tricky thumb and flipping over water

Challenge 1: Tricky thumb
Focus on: Light may change direction when passing into or out of transparent objects. Light from an object that changes direction after passing through a transparent object can create illusions.

Materials: 1x glass jar/vase (large enough to place your finger in – approx. 3cm wide by 7cm tall, an olive jar is a good size), water

Challenge 1: Tricky thumb
Partly fill the jar with water (approx. half full) and place your finger/thumb into the water.
How does your thumb/finger look? Has it changed size?

It’s blown up bigger! Before you call the doctor though, think about what you are seeing...
Where is the light being bent?

Move your finger/thumb around the jar
Is the distortion always the same?
You can use other objects in the glass jar to see a similar effect e.g. carrot, toothpaste container or something safe to put in water of a similar shape.

Represent what you think is happening

Representation: Use a drawing and words to show what is happening

Challenge 2: Flipping over water
Focus on: (As above) Light may change direction when passing into or out of transparent objects. A curved glass of water can act like a lens and bend the light to create images.

Materials: clear round glass, water, paper/card, pencil/pen and something to prop the paper up on

Challenge 2: Flipping over water
Draw an arrow pointing left on a piece of paper and place upright (prop up against something)

Place a full glass of water in front of the arrow.
Can you move the glass to a position where the arrow changes direction?!

Could you use this glass of water to read some mirror (back to front) writing? Try it, and share what you find using a photograph.

Representation: Use a drawing and words to show what is happening
**Extension: Further Investigation 1 - The hall of mirrors**

**Focus idea: Mirrors can create multiple images**
Perhaps you have been in the changing rooms in a clothing shop, and seen yourself a number of times, from the back and side, in the two mirrors supplied. Well, here’s a way to multiply your pens (a handy thing to be able to do, if you keep losing them) or even your $1 coins!

**Materials:** two mirrors (approx. 14cm) taped together along one edge (see image), pen, paper, ruler *If you only have one small/handheld mirror* – you could hold it upright at different angles to the bathroom mirror.

NB: you’ll need to be able to have a surface between the mirrors though to put the objects on.

**Challenge**
- Join two upright mirrors together at the edge using tape (or hold/prop one mirror at an angel against the bathroom mirror) and stand a pen or a small bottle or figurine in between. How many images do you see in the mirror?

- Change the angle between the mirrors
  How many images can you make?
  What is happening to the light scattered from your pen, to make so many images?

- Explore with drawings and pictures
  Rule some lines on your page, or draw some shapes or a word, and look what happens when the two joined mirrors are placed over them. (You should be able to arrange some interesting and complicated shapes)
  Use pictures and words from a book or magazine to create some mirror artwork.
  If you use words, can their images be read? Can you work out a pattern?

- Changing the mirror positions
  As you bring the mirrors together, so that the angle between them gets smaller and smaller, you would expect to get an ever-increasing number of images.
  Of course, as the angle approaches zero (together), you can’t see what is happening. Unstick the mirrors and stand them up facing each other with your pen in between, and peek over the top, you will see the effect.
  What would you expect to see?

**Representation:** Use a drawing and words to show what is happening
Extension: Further Investigation 2 - Peppers Ghost Illusion

Focus idea: Light travels in straight lines and reflects off surfaces

Have you ever wondered how ghost effects are created? Peppers ghost is an illusion that has been used in stage plays since the 1800’s to characters a ghost like appearance.

Have fun created your own ‘peppers ghost’ illusions

Materials: iPad/mobile phone, Perspex/glass/DVD or CD clear case and a black backdrop, protractor (challenge)
Optional – dolls house or create your own set

Websites https://www.generationgenius.com/videolessons/light-reflection-and-vision-video-for-kids/ Activity explanation and example from 8 minutes – fun with your iPad

Video 2: Instructions and examples
https://www.youtube.com/watch?v=TcqyoYfHIFM&feature=youtu.be

Draw what you think is happening to be able to see the ghostlike image in the set?

Challenge: What angle does the Perspex/glass work best? Measure it with your protractor

Representation: Use a drawing and words to show what is happening
Investigating Light

Lesson 5: Illusions – Fun with light

Acknowledgements and Resources (in order)

Teacher Support Materials


Multiple Mirror Image
Year 6 IMS Learning Project student

Drawings

Website

Website & Peppers Ghost Image

Video

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