Entertaining Light (Subtractive Colour Theory) Lesson 5

Critical Learning

- Different media reflect, transmit, and absorb light differently.
- A wide range of technologies utilize the properties of light and colour.
- Structure and function focus on the interrelationships between the function or use of a natural or human-made object and the form that the object takes.

Guiding Questions

- Why do we see colour differently?
- How can we explain how we see colour?
- Which technologies use subtractive colour theory?

Curriculum Expectations

Scientific Investigation Skills and Career Exploration

A1. Demonstrate scientific investigation skills (related to both inquiry and research) in the four areas of skills (initiating and planning, performing and recording, analyzing and interpreting, and communicating)

- A1.1 formulate scientific questions about observed relationships, ideas, problems, and/or issues, make predictions and/or formulate hypotheses to focus inquiry and research
- A1.5 conduct inquiries, controlling some variables, adapting or extending procedures as required, and using standard equipment and materials safely, accurately, and effectively to collect observations and data
- A1.6 gather data from laboratory and other sources, and organize and record the data using appropriate formats, including tables, flow charts, graphs, and/or diagrams
- A1.8 analyze and interpret qualitative and/or quantitative data to determine whether the evidence supports or refutes the initial prediction or hypothesis, identifying possible sources of error, bias, or uncertainty
- A1.12 use appropriate numeric, symbolic, and graphic modes of representation, and appropriate units of measurement

E1. Analyze how properties of light and colour are applied in technology and the impact of these technologies on society

- E1.1 analyze how additive and/or subtractive colour theory are applied in technologies used in everyday life [AI, C]

E2. Investigate, through inquiry, properties of light, and predict its behaviour in mirrors and as it passes through different media

- E2.1 use appropriate terminology related to light and optics including but not limited to: angle of incidence, angle of reflection, angle of refraction, centre of curvature, focal length, luminescence, magnification, principal axis, radius of curvature, and vertex [C]
- E2.6 predict the effect of shining coloured light on objects of different colours, and test their predictions through inquiry [IP, PR, AI, C]

E3. Demonstrate an understanding of characteristics and properties of light, particularly with respect to reflection and refraction and the addition and subtraction of colour

- E3.5 use additive colour theory to predict the results of combining primary and secondary light colours
- E3.6 use subtractive colour theory to describe the effect of colour filters on white light
- E3.7 explain how the colour of an object is determined by reflection, absorption, and transmission of colour
- E3.8 explain how the properties of light or colour are applied in the operation of an optical device

Learning Goals

Students will be able to:

- describe the additive primary and secondary colours and their role in detecting coloured light
- predict the effect of coloured light on the appearance of coloured objects.
- describe the impact of colour in technologies and the arts.
- demonstrate investigation skills:
  - observing
  - gathering data
  - analysing
### Entertaining Light (Subtractive Colour Theory) Lesson 5

#### Grade 10, Science, Applied SNC2P

#### Instructional Components and Context

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<tr>
<th>Readiness</th>
<th>Terminology</th>
<th>Materials</th>
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<td>• Light interacting with matter (Lesson 2,3)</td>
<td>From previous lessons:</td>
<td>• Intense light source (spotlight, laser, strong flashlight)</td>
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<tr>
<td>• Electromagnetic spectrum (Lesson 5)</td>
<td>• Transmit</td>
<td>• Water sprayer or chalk board eraser to produce dust</td>
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<tr>
<td>• Additive Colour Theory RGB (Lesson 5)</td>
<td>• Absorb</td>
<td>• Coloured squares of paper (construction or card stock) including black and white</td>
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<tr>
<td>• Drawing ray diagrams (Lessons 2,3,4)</td>
<td>• Additive primary and secondary colour</td>
<td>Note: check that the appropriate results will be obtained – there will be some mismatches – students should understand that colour filters are not perfect.</td>
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<tr>
<td>• Interpreting data</td>
<td>• Monochromatic light</td>
<td>• Ray boxes</td>
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<tr>
<td>• Group work norms and skills, e.g., taking roles, taking turns, disagreeing agreeably, coming to consensus</td>
<td>• Additive colour theory</td>
<td>• Red, green, and blue primary filters</td>
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<td>• Subtractive primary and secondary colours</td>
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<td>• Contrast</td>
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#### Terminology
- From previous lessons:
  - Transmit
  - Absorb
  - Additive primary and secondary colour
  - Monochromatic light
  - Additive colour theory
- New terms:
  - Subtractive colour theory
  - Subtractive primary and secondary colours
  - Contrast

#### Materials
- Intense light source (spotlight, laser, strong flashlight)
- Water sprayer or chalk board eraser to produce dust
- Coloured squares of paper (construction or card stock) including black and white
- Note: check that the appropriate results will be obtained – there will be some mismatches – students should understand that colour filters are not perfect.
- Ray boxes
- Red, green, and blue primary filters

#### Resources
- Determining the Colour of Objects
  - Interactive software: Subtractive Colour Gizmo
    - [http://www.explorelc.com](http://www.explorelc.com)
    - Subtractive Colour v2 (Located in 9-12, Physics, Waves, Sound and Light)
  - Information on Colour Printing and Subtractive Colour Theory
    - [http://hyperphysics.phy-astr.gsu.edu/hbase/vision/filter.html](http://hyperphysics.phy-astr.gsu.edu/hbase/vision/filter.html)
  - Colouring movies
    - [http://www.widescreenmuseum.com/oldcolor/additive-subtractive.htm](http://www.widescreenmuseum.com/oldcolor/additive-subtractive.htm)
  - Professional Printing and Colour Systems
    - [http://www.optimalprint.co.uk/en-GB/color_guide](http://www.optimalprint.co.uk/en-GB/color_guide)
    - [http://www.image-specialists.com/ink_int_injet_printer.aspx](http://www.image-specialists.com/ink_int_injet_printer.aspx)
    - [http://www.graphic-design-employment.com/4-color-process.html](http://www.graphic-design-employment.com/4-color-process.html)
  - Colour Mixing
    - [http://home.comcast.net/~rtruscio/colors.htm](http://home.comcast.net/~rtruscio/colors.htm)
**Entertaining Light (Subtractive Colour Theory)**  Lesson 5

**Minds On (Elicit, Engage)**

**Small Groups/Whole Class ➔ Reviewing Concepts and Vocabulary**
Distribute cue cards, each with a different concept, (e.g., additive primary and secondary colours, monochromatic, RGB, additive colour theory) per card, to each student in the group. Each student takes on the role of expert for their concept, reviews notes, and prepares a brief oral summary on the concept to share with the group. Following the summary sharing, the group generates unanswered questions about the concept and the expert records. Continue the process until all students have assumed the role of the expert. Debrief by reviewing the questions generated in each group. Note commonalities and patterns for the questions as a whole. Address any questions which may be barriers for students’ understanding.

**Small Groups/Whole Class ➔ Using the Predict-Explain-Observe-Explain Strategy and Drawing Conclusions**
Review safety procedures for mixing chemicals. Distribute two different paint colour, (e.g., red and green) and a predict-explain-observe-explain recording graphic organizer to each group.

Groups predict the outcome of mixing the two colours and record on the graphic organizer. A representative from each group shares predictions. Note connections between the groups, particularly where different colours were used. Groups then mix their colours, and observe and record the outcome. Groups discuss and record explanations for their observations. Debrief by asking groups to share observations and explanations. Note any shifts in thinking evident between predictions and observations.

Pose the question: *Why is this a different colour than we found when we used green and red light?* Create a Venn diagram which compares and contrasts observations of light colour and paint colour. Share the learning goals and guiding questions.

**Action! (Explore, Explain)**

**Small Groups ➔ Mining for Information**
Students use a resource, such as Additive and Subtractive Colour Theory (SNC2P, Unit 4: Physics – Light and Applications of Optics, Activity 6 OERB ELO1229720), to develop an understanding of subtractive colour theory.

Review co-constructed criteria for a ray diagram from Lesson 3. Highlight any criteria with specifics related to this lesson. Review the ray diagrams for filters. Based on the modelling, ask students what additional criteria needs to be added.

**Whole Class ➔ Exploring an Application Colour Theory to Explain Sight**
Using a resource, such as Determining the Colour of Objects (SNC2P, Unit 4, Activity 7 OERB ELO1229730), demonstrate how the eye sees coloured objects.

Demonstrate one or more application of subtractive colour theory (See Resources list above). For example, use a personal photo printer or prepared coloured overheads to demonstrate colour printing in action. Point out any related terminology, (e.g., K stands for black in CYMK). Discuss how colour is used, (e.g., how colour affects mood in visual arts or space in interior design).  

**Consolidation (Elaborate, Evaluate, Extend)**

**Individual ➔ Comparing Additive and Subtractive Colour Theories**
Students use a Venn diagram to compare additive and subtractive colour theories for their notes.

**Whole Class/Individual ➔ Gathering Information for Culminating Task**
Review the anchor chart listing the various technologies (from Lesson 1). Add any additional technologies, if necessary. Pose the questions: Which of these technologies use subtractive colour theory? How does it use it? Indicate which parts of the spectrum the various technologies fall under. Students jot notes and any questions for their assigned technology in their project log.

**Pause and Ponder**

**Quick Tip**
Reinforce effective listening strategies during the group activity. See Listening Guide.

**A=L L** Note any unanswered questions, and support student understanding by clarifying information, re-teaching or reviewing concepts, and/or assisting students to locate sources to answer questions.

**Quick Tip**
Circulate and monitor by posing questions which require students to make connections with additive colour theory. Model using the language to describe observations.

**Quick Tip**
As an extension, invite a paint specialist from a local paint store.

**Quick Tip**
Show how Venn diagrams use lists within the organizer. See Strategy Implementation Continuum to support strategic use of Venn diagrams.

**A=L L** Use the learning goals and guiding questions as prompts to introduce the Action! and to provide opportunities to reflect on learning throughout the lesson. See Metacognition Guide.

**Quick Tip**
Since filters are never perfectly matched to ink colours, check filters and change the colours to ensure the maximum match so that only one message is seen by red or blue filters.

**A=L L** Use information from the Venn diagrams to inform instruction and plan guided practice.

**A=L L** Use the project logs to inform instruction and assess progress toward the culminating activity.
Vocabulary

Effective vocabulary-building practices include the following:

- Knowing a definition is not synonymous with understanding a word.
- Word knowledge is built incrementally.
- Limit words to those essential to the unit and to those students will use during teaching-learning activities.
- Include proper names.
- Students need to hear words used in context and to practise using words themselves in context about a half-dozen times.
- For multi-syllabic words, pronounce words clearly while cueing students to word parts visually so that students both hear and see words.
- Associate words with visual symbols and with words students already know.
- Use color and clustering, e.g., concept maps and mind maps, to show connections between words.
- Gradually build understanding of the multiple meanings of words.
- Use semantic maps to focus on related words, explanations, what it isn’t, word roots, and prefixes and suffixes, word history (how it came to mean what it does).

Resources for vocabulary building:

Safety Procedures

Teachers must model safe practices at all times and communicate safety expectations to students in accordance with school board and Ministry of Education policies and Ministry of Labour regulations. Teachers are responsible for ensuring the safety of students during classroom activities and also for encouraging and motivating students to assume responsibility for their own safety and the safety of others. Teachers must also ensure that students have the knowledge and skills needed for safe participation in science activities.

To carry out their responsibilities with regard to safety, it is important for teachers to have:

- concern for their own safety and that of their students
- the knowledge necessary to use the materials, equipment, and procedures involved in science safely
- knowledge concerning the care of living things – plants and animals – that are brought into the classroom
- the skills needed to perform tasks efficiently and safely

Students demonstrate that they have the knowledge, skills, and habits of mind required for safe participation in science activities when they:

- maintain a well-organized and uncluttered work space
- follow established safety procedures
- identify possible safety concerns
- suggest and implement appropriate safety procedures
- carefully follow the instructions and example of the teacher
- consistently show care and concern for their own safety and that of others

Various kinds of health and safety issues can arise when learning involves field trips. Out of-school field trips can provide an exciting and authentic dimension to students’ learning experiences. They also take the teacher and students out of the predictable classroom environment and into unfamiliar settings. Teachers must preview and plan these activities carefully to protect students’ health and safety.

The Ontario Curriculum, Grades 9 and 10: Science, 2009
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Predict-Explain-Observe-Explain

Predict-Explain-Observe-Explain is a strategy used during the investigation of a scientific phenomenon. It prompts students to make predictions prior to a demonstration, thereby helping them make more careful and focused observations. It is also motivates students to want to find an answer. Students share their predictions with their peers, think about their own learning and construct new understanding. During observation, students note what they see and/or hear, feel. When students explain, they are encouraged to think metacognitively by sharing any shifts or discrepancies between their predictions and the observations.

The P-E-O-E graphic organizer below is structured so that students can see how their predictions compare with their final explanations.

<table>
<thead>
<tr>
<th>Predict</th>
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</tr>
<tr>
<td>Explain</td>
<td>Observe</td>
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</table>

See Predict-Observe-Explain Recording Sheet

Venn Diagram

Venn diagrams and other advance organizers are effective tools for individual students to organize and represent their thinking. The Venn diagram, which usually consists of two or more circles, visually represents the similarities and differences between two concepts or objects. Typically, the similarities are listed in the intersection between the two circles, and the differences are listed in the areas of each circle that do not intersect. However, depending on the extent of the comparison, Benten and Rolheiser point out that Venn diagrams do not have to overlap or may be one circle within another circle.


Consolidation (Elaborate, Evaluate, Extend)

Anchor charts

An anchor chart is a strategy for capturing students’ voices and thinking. Anchor charts are co-constructed. By making students’ thinking visible and public, they “anchor,” or stabilize and scaffold classroom learning. Anchor charts should be developmentally appropriate and clearly focused, accessible, and organized.
**Predict-Explain-Observe-Explain Recording Sheet**

- **BEFORE:** Look carefully at the objects. Make your predictions before the demonstration:
  What will happen when you mix the 2 colours? Explain your predictions.
- **DURING:** Record your observations during the demonstration.
- **AFTER:** Recalling what you already know, explain your observations.

<table>
<thead>
<tr>
<th>Mixing two paint colours</th>
<th>Predict</th>
<th>Explain</th>
<th>Observe</th>
<th>Explain</th>
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<tbody>
<tr>
<td>Paint colour 1:</td>
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<td>Paint colour 2:</td>
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