

MODULE CONTENT

Module Title:**SCIENCE LEARNING & TEACHING 1****Authors:****IAN MITCHELL, STEPHEN KEAST, JOHN LOUGHRAN****Module Description:**

The context of the module is a set of introductory activities for a unit on the topic of light (or the human senses) from upper primary to year 10. The activities focus on identifying students' existing conceptions and using these to promote discussion, debate and practical testing related to the different conceptions. An alternative activity based around the concept of buoyancy is provided. Participants will experience a number of teaching procedures associated with this approach for which they will consider appropriate and inappropriate teacher behaviours.

Summary of Activities:

Title	Min
1. Features of Good Science Lessons	20
2. Probe of Prior Views on Light	25
3. Testing Alternative Conceptions (2-3 Alternative Activity)	65
4. Debrief on Learning	30
5. Teacher and student behaviours	20
Total	160

Module Outcomes:

- Through discussing common features of good science teaching participants get to know each other. It is expected that a theme of high levels of student engagement will emerge from the features.
- Participants become aware of some common alternative conceptions in Science and ways by which students and teachers can identify these.
- Participants are introduced to ways in which teachers can assist students to test the alternative conceptions raised.
- Participants examine the learning outcomes promoted by the activities in the module, the teaching required to promote such learning, and the level of engagement the activities encouraged.
- Further awareness of teaching behaviours that will/will not encourage student learning.

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- OHTs 1.2, 1.4, 2.1, 2.6, 4.2
- Strips of white paper with coloured squares
- Magnifying lens
- Plane Mirror
- Duster
- Aluminium Foil
- Sand paper (if desired)
- See alternative Activity 2-3b for its resources and attachments.

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Activity 1: Features of good science lessons.

Purpose: To generate a need to know for the unit and connect the module to participants' existing concerns. To encourage participants to get to know each other.

Teaching Procedures: Think-Pair-Share

Time allocation: 20 minutes

What to do	FACILITATOR	PARTICIPANT
	<p>1.1 This activity gives an introduction to the program and demonstrates a <i>Teaching Procedure</i>. Teaching procedures will be used throughout the program as examples of good teaching strategies for teachers to adopt in their classrooms.</p> <p>1.2 Ask the question, “In an ideal situation with typical students, what are the features of good science lessons?” Organise and run groups and be sure to set short time limits for each part of this activity, as this is a brainstorming session. (Refer OHT 1.2)</p> <p>1.3 Conduct reporting back from groups – record features. Collect written lists from each group. These lists may be referred to later.</p>	<p>1.1 Individually think of 6 features of good science lessons and rank them. (Give 2 minutes)</p> <p>1.2 Participants to pair up and consider their best 4 features and rank them. (Give 3 minutes)</p> <p>1.3 Participants to form groups of four and consider the best 3 features. (Give 5 minutes)</p> <p>1.4 Report back to the whole group. Each group reports one feature (no repeats) sequentially until list of ideas is exhausted.</p>

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Discuss/Consider:

Refer to OHT 1.4

- It may be helpful to make the following assertion (on which the rest of the module is based)

"Learning depends on a high level of student engagement with the material to be learned."

- Further:

"This is not a course in the CSF, but a course in good science teaching and learning, using the CSF as a context."

- Tips and Tricks:**
- Facilitators categorise the points given by groups as they are written on the whiteboard. It is likely that the quote *"Learning depends on a high level of student engagement with the material to be learned"* will be raised by all the groups. Emphasise that participants' current ideas of what makes a good science classroom are relevant as a foundation for this module.
 - It is important to acknowledge that there are many aspects of good science teaching, however the focus at this stage will be on learning (see first statement in discussion section above).
 - In activities 4 and 5, issues of teaching behaviours and content will be addressed.

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Activity 2: Probe of prior views on light.

Purpose: To introduce the idea that *Alternative Conceptions* exist: these are explanations, apparently sensible to the individual, for phenomena that students experience. To use an activity that enables such views about a phenomena to be identified.

Teaching Procedures: Probe

Time allocation: 25 minutes

What to do	FACILITATOR	PARTICIPANT
	<p>2.1 Display the diagrams using OHT 2.1. Try and forestall any anxiety about the content as much as possible by discussing the diagrams and the reasons students might give for each response.</p> <p>2.2 Ask the questions, "What do you think is necessary for you to see the table? Which of the above diagrams represents your opinion of the way we see an object?" Briefly describe what is meant by each alternative and present these as common and competing explanations.</p> <p>2.3 Organise an eyes closed vote (using a show of hands) for each of the 4 options, A to D.</p> <p>2.4 If you decide it is appropriate (eg. content knowledge anxiety amongst participants), then briefly explain why A is favoured by scientists. Stress that this is not normally done in the classroom</p>	<p>2.1 Consider the diagrams. Choose the diagram that best explains how we see the table.</p> <p>2.2 Vote for the option that, in your opinion, correctly corresponds to the way that we see the table?</p>

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What to do	FACILITATOR	PARTICIPANT
	<p>2.5 <u>Discuss views.</u> It is important in this discussion that participants and facilitator withhold judgement on their option, ie. they do not try to sell their views but discuss them in terms of the reasons students might give for each of the examples. However, when doing this with a class, it is necessary for the students to argue their reasons for believing an option is correct – this gives the students ownership and gives teachers the understanding of the students perspective.</p> <p>One of the reasons for poor student engagement is that teachers do not identify, acknowledge, address or value students' prior views.</p> <p>2.6 Using OHT 2.6 lead discussion of children's alternative conceptions in other topics.</p>	<p>2.3 Debate the alternative conceptions of how we see the table. Defend an alternative not necessarily the one believed to be correct.</p> <p>Consider why students may choose each of the diagrams. Participate in discussion and raise other student views from own experience.</p>

Discuss/Consider:

There is a range of ways of eliciting students' views. In cases (like this) where only a limited number of views are possible/found, giving students alternatives speeds up and simplifies the process of probing. In other cases more open-ended ways are possible. In this situation, another approach which also works well is to have students draw their own lines on a probe which has no light rays on it.

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- Tips and Tricks:**
- It is essential for students to recognise and identify their own views in relation to their thinking about a concept. The level of student engagement comes from students identifying their own conception. Change can only occur after recognition of their present position and then identifying particular problems or concerns with this thinking. Once an understanding has been personally identified then real change in thinking is possible.
 - When working with teachers, some may deride the 'sight from your eye' view as nonsense. It is in fact not easy to find situations to disprove the view, and challenging teachers to do this can be valuable.
 - All teachers learn some more science when they teach a new topic (or an old topic in a new way). This should not be regarded as a type of inadequacy.
 - For understandable reasons (probably related to content knowledge) this issue can loom larger for primary teachers.
 - There are advantages for participants in a PD session in spending part of the time '*in role*,' *ie. as* a learner - one gains a better sense of what a procedure can do and how a teacher might run it.
 - It is also important to move *out of role* and discuss a procedure and or content from the perspective of the teacher
 - If an activity is becoming threatening it is time to move out of role.
 - When to move in and out of role depends on a number of contextual factors, and is a judgement on which the leader and participants should be able to reach consensus.

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Activity 3: Testing alternative conceptions or views.

Purpose: To model the ways teachers can conduct activities that enable students to test and compare the alternative views that they may raise.

Teaching Procedures: Challenge of Ideas
POE

Time allocation: 65 minutes

What to do	FACILITATOR	PARTICIPANT
	<p>3.1 Investigate differences between the diagrams A&B and C&D on OHT 2.1. Describe the competing views and ask the question, "Does light need to travel directly from a light source to the eye so that we can see?"</p> <p>3.2 Ask the question, "Can you think of a situation of seeing an object when light clearly cannot be travelling directly to your eye?" (eg. an object (car) illuminated by a streetlight when you are inside a dark room and cannot see the streetlight directly. Light does <u>not</u> need to travel to the eye directly from the streetlight for you to see the object)</p> <p>3.3 Indicate that this issue is an example of one that students can often resolve; the next one usually needs activities that the teacher suggests.</p> <p>Challenge of Ideas</p> <p>3.4 Return to the next and more difficult issue: "Does light bounce off non-shiny/non-luminous objects and travel to our eyes?" This can lead to: "Do coloured surfaces reflect coloured or white light?"</p>	<p>3.1 Consider the question and the diagrams.</p> <p>3.2 Think of examples, which support or disprove these options? Which of these views A, B, C, and D are not supported?</p> <p>3.3 Consider the questions. Try to think of relevant examples?</p>

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<i>What to do</i>	FACILITATOR	PARTICIPANT
	<p>3.5 Organise and run this activity, (in participant column) – the coloured squares of paper will reflect colour onto a sheet of white paper held close.</p> <p>3.6 Ask the question, "How does this help clarify options A and B?"</p> <p>Possible Extension:</p> <p>Lens Demonstration/Activity: The previous activity demonstrates that coloured light is reflected from coloured objects. Some may think (from the last activity) that this coloured light does not travel far. The following activity tests this.</p> <p>3.7 Organise and conduct the activity in opposite column - light from a 'tree' some distance away travels to the screen. The green (coloured light) of the leaves has travelled from the tree to the screen</p>	<p>3.4 Using the coloured squares of paper reflect light from a bright source on to white paper (or epidiastroscope). What do you see on the white paper? Does the coloured paper reflect white light or coloured light?</p> <p>3.5 Decide which of the views A, B, C, and D are not supported?</p> <p>3.6 Hold magnifying glass up to window and close to a screen. View the image of what is outside the window on the screen (though inverted). Which of the views A, B, C, and D are not supported?</p>

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<i>What to do</i>	FACILITATOR	PARTICIPANT
	<p>POE</p> <p>3.8 Using an overhead projector or slide projector shine a slit of light on the screen. Show mirror and explain where it will be held. Seek predictions. Discuss the participants' predictions. Ask for suggestions and seek the differences in understanding.</p> <p>3.9 Hold mirror on screen as planned.</p> <p>3.10 Discuss the observations – especially how they compared to the predictions.</p> <p>3.11 Seek explanations</p> <p>3.12 Discuss the participants' explanations of their observations. How does this support or contrast with the participants' previous understanding?</p>	<p>3.7 Predict: Will the slit of light appear brighter, duller or about the same if shone on a mirror held on the screen? Write down an explanation.</p> <p>3.8 Observe: Participants observe the outcome of mirror on screen. Write down what observed.</p> <p>3.9 Explain: Participants explain what they saw and why?</p> <p>3.10 Which of the views A, B, C, and D are not supported?</p>

Discuss/Consider:

- Some students will explain this by arguing that light does leave the mirror, but stays on the screen so that we can see it.
- Conceptual change is evolutionary not revolutionary.

- Tips and Tricks:**
- All participants need to observe that from most positions the light is invisible and that only a person(s) in a certain position sees the light as bright. Move the mirror slightly so that the light shines in the eyes of each participant to give them the effect.
 - If the discussion stalls it can be helpful to give a clue: mirrors are smooth, the screen is rough.
 - Make the mirror a little dirty (chalk dust from a duster) and demonstrate how scattering makes the light visible. Compare this to seeing the table, what would all objects look like if no scattering occurred?
 - Surfaces such as Aluminium foil – smooth and then crumpled and straightened, and sandpaper, could be used to help students build a rich understanding of light scattering.

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Alternative Activity 2/3: Probe of views and testing alternative conceptions

Purpose: Working with a similar set of principles to Activities 2 and 3, to provide a group of activities in a different content area and at a different CSF level.

Teaching Procedures: Probe, Interpretive Discussion, POE

Time allocation: 80 minutes

- Content Vehicle:**
- Sinking, Floating and Rising
 - CSF II Physical Science, level 4
 - Substrand: Forces and their effects
 - Outcome 4.2 Describe the motion of objects in terms of simple combinations of forces.
 - Eg. describe combinations of forces which maintain a floating object in equilibrium – describe the action of water in supporting a floating object

- Rationale:**
- Activities that link with a primary level CSF outcome.
 - A topic that lends itself to a range of easily resourced practical activities.
 - A topic about which children have a variety of prior experiences and conceptions.
 - An activity (with liquids and solids) that can be extended to gaseous environments, especially air and the atmosphere.

- Resources:**
- Attachments SciL&T1Att2-3b.1 – 2-3b.6
 - A range of different sized and shaped containers; materials of different densities; small and large pieces of the same buoyant material; string; plasticine; spring balance, weights; foil; balloons; paper towel; plastic wrap, etc

- Procedures:**
- Procedures will not be described in detail as this has been done in Activities 2 and 3, and the sequence/processes for this activity are similar. Refer to Activities 2 and 3 as necessary.

Comparative Sequences:	<i>Activities 2 & 3 (Light etc)</i>	<i>Activity 2-3b (Floating etc)</i>
	1. Printed probe of prior views	1. Printed probe of prior views
	2. Challenge of ideas – testing alternative conceptions	2. Interpretive discussion to established shared meaning
	3. POE conducted by facilitator	3. POEs planned and conducted by participant groups

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What to do:**1. Probe of Prior Views**

- Provide context (CSF II, outcome 4.2, Physical Science, and an overview of the activity).
- Give each participant the printed probe (Att2-3b.1), explain the nature of a probe, seek any clarifying questions and ask to complete the probe individually.
- Tabulate on board or OHT number of 'yes' responses to each drawing using eyes-closed, hands-up technique (see Activity 2).

2. Interpretive Discussion

Refer Activity 2 (with attachments), and PEEL Procedures

One aim is to establish a shared understanding of the scientific meaning of floating, (sinking and rising).

- Seek alternative explanations in situations that show differences in views
- At an appropriate stage, introduce Att2-3b.3 and bring into the discussion (a) and (b), that are common alternative conceptions that are addressed in the probe.
- Seek views on the meaning of the word floating as used in everyday language, and as used in a scientific context
- Work towards the consideration of floating as a situation in which the downward force (pull) of gravity is exactly balanced by the upward force (push) exerted by the fluid, (in this case water). Compare this to the range of contexts in which the word floating can be used in normal language.
- Then consider the meanings of sinking and rising in terms of forces (pushes and pulls)
- Again at an appropriate stage, introduce Att2-3b.4 and consider the scientific explanations for (a) and (b).
- Ask participants to consider the situations represented in the drawings of Att2-3b.2, and any of the other points that may promote discussion and extension. Address issues that arise. These may include: other forces apart from gravity and buoyancy (eg is string exerting force on the bottle, in 14); the concept of density; movement in the fluid (eg. downward forces in swimming, is the speedboat floating if aquaplaning)

3. POEs

- Use the poster Att2-3b.5 as an example of a graphically based POE situation (also used as a probe), which must however be conducted practically
- In groups of 2-4 (depending on total group size), ask participants to develop an actual POE and do it with the group. The POE should preferably be based on c, d, e, or f of the Alternative Conceptions. Participants use Attachments 2-3b.3, 4, and 6. A range of simple equipment will have to be available.
- Groups present POEs which are discussed.

Tips and Tricks: • Refer Activity 2

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Activity 4: Debrief on learning.

Purpose: Debrief the activities covered in the session and the links to learning, teaching and levels of student engagement.

Teaching Procedures: Discussion

Time allocation: 30 minutes

What to do	FACILITATOR	PARTICIPANT
	<p>4.1 Debrief on learning. • Different students construct different meanings from the same set of observations. It is important then to use more than one activity to demonstrate a concept. Multiple explanations reinforce conceptions and assist change.</p> <p>4.2 Stress that this was not a module on light. Ask what it was a module on, discuss OHT4.2.</p> <p>4.3 Debrief on teaching. • Discuss how participants may now use probes in their classrooms. Brainstorm some suggestions in other topics.</p> <p>4.4 Debrief on POEs. • Discuss how participants could use POEs in their classrooms. In this case it was as part of a challenge of ideas. POEs can also be used as an invitation to inquiry.</p> <p>4.5 Discuss existing practice of participants. • In the above discussions try to draw out the existing practice of the participants. Are there participants who already use these procedures or use similar ones they can adapt?</p> <p>4.6 Reinforce the value in risk taking and the risk in anyone giving answers.</p> <p>4.7 Other examples of Children's Science from different probes. Give participants a list of children's conceptions in science (OHT 2.4). This is not a complete set of student misconceptions but rather a useful list of common ones assembled from research.</p>	<p>4.1 Join discussions</p> <p>4.2 Share things they already do (or can think of doing).</p> <p>4.3 Collect the list of children's conceptions in science. Share relevant experiences from their own students.</p>

Tips and Tricks: • If there are two different (student) views of a concept, often the students can come up with the test for alternative conceptions.

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Activity 5: Teacher and Student Behaviour.

Purpose: To explore some examples of both negative and positive teacher behaviours, and how these influence teaching in relation to children's science and encouraging student engagement.

Teaching Procedures: Discussion

Time allocation: 20 minutes

What to do	FACILITATOR	PARTICIPANT
	<p>5.1 Review the session. • Highlight the following: motivation through the increased level of student engagement, students preconceptions of science (children's science) and the implications such ideas have for teachers in classrooms.</p> <p>5.2 Teacher Behaviours. • Ask participants to consider positive teacher behaviours that make use of the ideas discussed during this session. Do the same for negative teacher behaviours.</p>	<p>Consider positive teacher behaviours that make use of the ideas discussed during this session. Repeat for negative teacher behaviours and record in the table.</p>

Negative teacher behaviour	Positive teacher behaviours

Tips and Tricks: • There is no definitive list of positive and negative teaching behaviours.

Between Session Tasks:

1. Participants develop and trial their own POE.
2. Participants trial and or develop their own Probe of Prior Views using the list of children's conceptions in science.

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- Support Materials:** Osborne, R. & Freyberg, P. (1985). *Learning in Science: the implications of children's science*. Auckland: Heinemann.
- Driver, R., (1983). *The Pupil as Scientist?* Milton Keynes: Open University Press.
- Baird, J. & Northfield, J. (1992). *Learning from the PEEL Experience*. Melbourne: Monash University.
- Gilbert, J.K, Osborne, R.J, & Fensham, P.J. (1982). Childrens' science and its consequences for teaching: *Science Education* 66, 623.
- Derry, N. & Loughran, J.J. (1994). Electricity: the challenge of teaching for understanding. *Australian Science Teachers Journal*, 40 (3), 19 - 27.

Readings: Children's Alternative Conceptions in Science

Scientists' Conceptions of Science

Children's Science: A decade of development in constructivist views of science teaching and learning