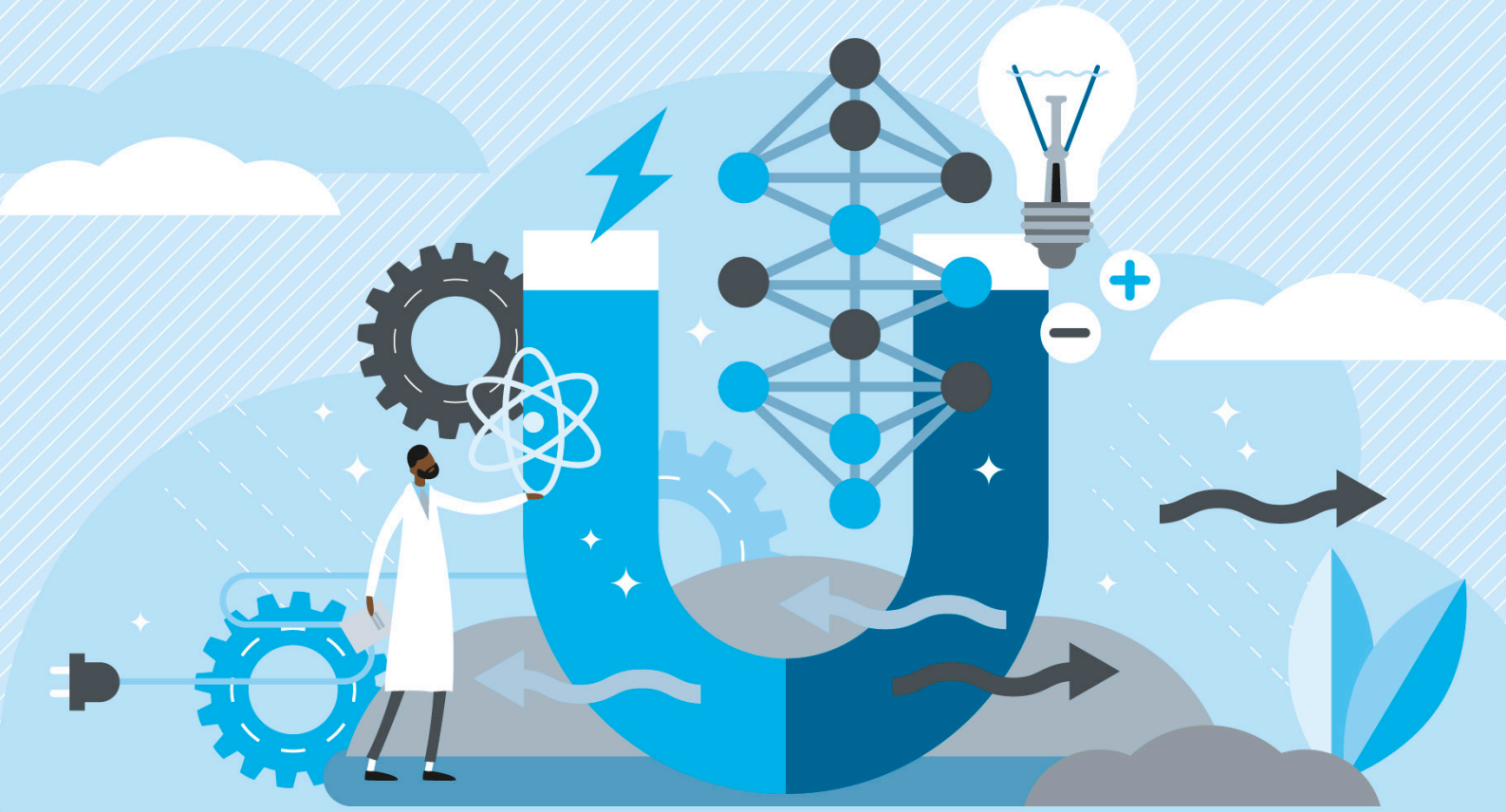
FACILITATOR'S GUIDE

2019 TRAINING WORKSHOP NO.3

PHYSICAL SCIENCES



GRADES 10-12

PILO
IMPROVING LEARNER PERFORMANCE

education

Department:
Education
PROVINCE OF KWAZULU-NATAL

FET
Just-in-Time Training
Workshop
2019: No. 3

Facillitators' Guide

Physical Sciences

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what I do matters

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Improving Learning Outcomes in Physical Sciences

Workshop Purpose

This workshop has been designed to help HODs and lead teachers develop tools that will help teachers to develop activities and homework questions for learners to help them develop conceptual thinking in different topics of Physics and Chemistry. The content focus of this workshop is on Electricity and Magnetism. Links to Electrochemistry are explored in Session 3.

Rationale for the focus on Conceptual Thinking

The diagnostic report on the 2018 NSC for Physical Sciences identified learners' ability to answer questions that required conceptual thinking as an area of weakness. The report encourages teachers to develop activities and questions for learners to do in class and for homework regularly so that these learners will be better prepared for future examinations.

Methodology of the Workshop

In this workshop, we will take time to developing learning activities and assessment questions for topics to be taught in term 3 in Grades 10 - 12.

Note to Facilitator:

After you have welcomed the participants and given them the pre-workshop activity. They will need no more than 15 minutes for the Pre-workshop activity. If the finish before time ask them to read pages 2 – 4.

While the participants are completing the pre-workshop activity, make sure you distribute candles, paper plates and matches around the room. You need the participants to work in groups no bigger than 6. This will ensure that all participants are engaged in Activity 1.

The introduction to the Thinking Skills framework described on the next pages does not need a detailed discussion - move quickly into Activity 1 which is designed to illustrate the framework.

You can highlight the process shown in the graphic and give the meanings of the key words summarised below:

- ***Meta-cognition** – thinking about thinking*
- ***Cognitive conflict** – an idea that seems to oppose the evidence*
- ***Bridging** – application of a concept to other contexts*

While the participants are following the instructions for Activity 1, ask them to consider what step in the sequence they are on as they answer different questions. This activity is a model that can be applied to any topic in Science. Try to keep the participants focused on the model and not totally absorbed by the detail of the Chemistry involved in the burning of a candle!

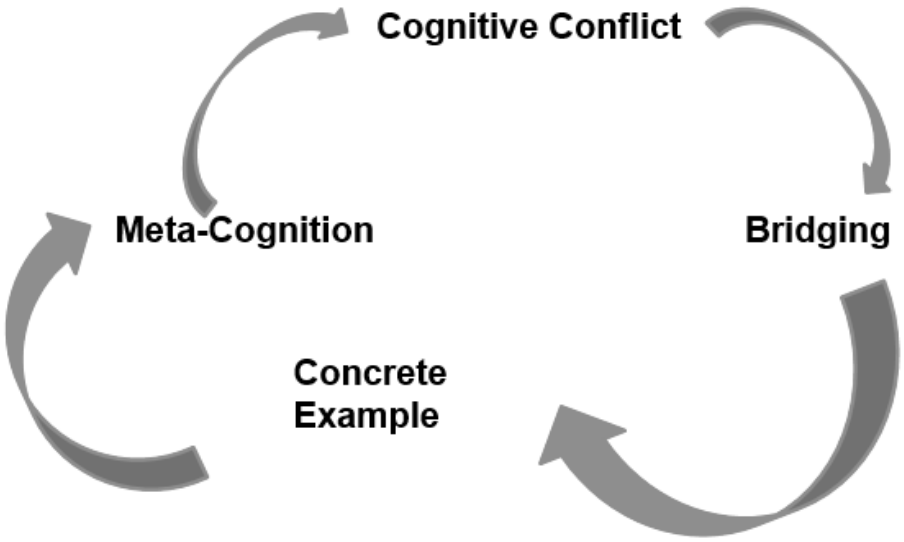
Session 1: A framework to promote conceptual thinking

Introduction **10 min**

One of the most successful interventions in improving learners' ability to answer exam questions that target higher order, abstract concepts was originally conducted by Michael Shayer and Philip Adey in the 1990s in the UK. They designed a programme called CASE (Cognitive acceleration through Science Education). In a long term, longitudinal study learners who were part of the programme improved their thinking skills compared to similar learners who were not part of the intervention. The value of this intervention is not only in the specific activities but in the general approach to teaching Science – especially content that has lots of abstract mathematical concepts in it – as it explicitly focuses on the development of thinking skills. The thinking skills approach used in CASE has been adopted in many countries and similar results have been reported. In this session we will explore the thinking skills approach as a useful framework for teaching Science content.

The Thinking Skills Approach

There are four distinct features of a thinking skills lesson as shown in the graphic below.



It is important to understand the type of activities and questioning that needs to be included in each stage. A summary of these is given below. Activity 1 is designed to demonstrate these stages explicitly.

Concrete Examples

Young children learn by playing. Before they develop ideas they need to interact with concrete objects. Unfortunately, many people rush through this concrete stage of learning.

Even older learners need to have the chance to touch and interact with objects. The interactions with Science activities can create curiosity and "Wow!" or "Ah ha!" moments. These learning experiences are powerful hooks to motivate and consolidate learning.

While this sort of interaction is taking place, teachers need to guide learners to talk about what they see and experience. The development of vocabulary about Science concepts needs to be linked to objects that illustrate a concept. Based on a concrete scenario teachers need to ask learners to solve a problem or explain what they are observing. You can even ask learners to develop questions they would like to find answers to.

Meta-cognition

The second stage takes time to develop but even younger learners can become experts at this process. Here we ask learners to explain their thinking. We say we think about our thinking. In this stage the answer to a problem is not the most important objective but the explanation of how someone arrived at the answer is. The most powerful thing about meta-cognition is that people arrive at the same answer in different ways. So in this stage of a lesson we need to teach learners to listen carefully to other people's ideas.

Cognitive Conflict

The third stage of the thinking process requires a teacher or another learner to challenge an idea presented during meta-cognition. If possible, the source of cognitive conflict needs to be illustrated by a concrete example.

Bridging

The fourth stage asks learners to confirm their ideas by looking for other examples that they come across in their daily lives. Although bridging is about applying an idea to a different context and is a higher order thinking skill, it does link learners back to a concrete example and so consolidates their ideas.

Note to Facilitator:
After you have shown the participants the graphic of the framework explain to them that you will be modelling the process in an activity. However you may need to clarify the meaning of the following terms very briefly:

Activity 1: Candle Investigation 40 min

A candle is something very familiar to most people. But not many people have taken time to observe what happens when a candle burns.

Note to Facilitator:
For this activity allow the participant to work in groups of no more than 5. You will need to have a candle, surface to secure the candle, a plate or glass and a lighter or matches for each group.

Guide the participants through the instructions and give them time to discuss the questions. Listen in to the discussions in each group and summarise key ideas before moving on to the next question.

Monitor the time carefully - only 40 minutes have been allocated to the activity. Try and get the participants to move through answering questions 1 – 10 in 30 min so that you have time to link the stages of the Thinking Skills framework to the questions in the activity

Instructions:

1. Observe the candle you have been given. Discuss what you see and make a few notes in the space below:

2. Light the wick of the candle and melt some wax onto the small paper plate. Stick the base of the candle onto the hot wax so that the candle can stand upright.

3. Carefully watch the candle burning. Discuss what you see and make a few notes.

   Ideas participants could come up include observations about heat and the colour of the flame.

4. In your discussion what Science terminology did you use?

   Participants could mention that the wax is melting, that heat and light are a form of energy, a chemical reaction is taking place (combustion).

5. When a candle burns are there chemical or physical changes?
   Explain your thinking steps that helped you decide.

   To guide you, think about the following questions:

   - What are the reactants? *Wax (hydrocarbon) and oxygen*
   - What are the products? *Water and oxygen*
   - Are the properties of the products different to the properties of the reactants? *Different*
   - Has there been a change in energy? *Yes – heat & light*

6. Hold a glass or ceramic plate above the candle flame.

   - What do you observe? *Black soot forms on the plate*
   - Can you explain your observation? *Black soot is unreacted carbon*

- Does your observation provide evidence for you to rethink your answer to question 5? *Black soot confirms that there is a chemical reaction taking place.*

7. Look carefully at the base of the wick. A liquid forms there while the candle is burning. A learner seeing this liquid suggests that this is water, a product formed in the chemical reaction. How do you respond to the learner? If possible back up your answer with evidence and show why water is a product of this chemical reaction.

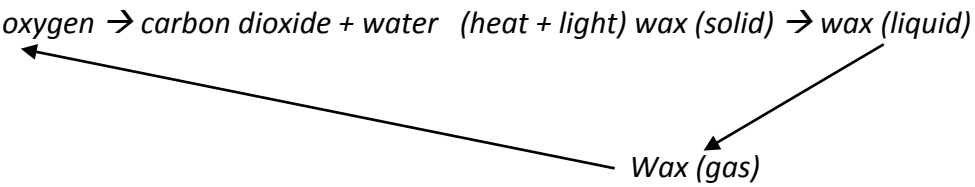
   If you pour the liquid onto the paper it will change to solid wax. You could also pour the liquid into water. The wax will float on the surface of the water.

8. Blow out the candle (but not the match!) Quickly bring the burning match in the smoke trail of the candle but keep it a few centimetres away from the candle. Watch what happens. Can you explain your observations?

   The candle re-ignites. The flame jumps from where you light the smoke onto the wick.The liquid wax evaporates and combines with oxygen in the air to keep the flame burning.

9. Can you identify any other chemical or physical changes taking place while the candle is burning?

   Draw a flow diagram to show all the processes taking place illustrate your thinking.



10. Identify two other chemical and physical changes you see around you.

    Combustion in a car's engine (Chemical change)
    Condensation of exhaust fumes on cold air (Physical change)

Reflect on the activity you have completed and link the questions / activities to the stages of the Thinking Skills framework.

In pairs, identify the key steps of the Thinking Skills framework that can assist teachers to support learners in developing their conceptual thinking.

Note to Facilitator:
The first four steps of the activity were focused on a concrete object / event – the burning candle. The instructions in this stage are aimed to help participants discuss what they are observing. This stage is a critical part of language development.

Step 5 and 6 are focused on linking the concrete to more abstract concepts as participants are asked to explain or interpret the evidence they have observed. The process also requires them to reflect on how they arrived at their conclusion. They are engaging in meta-cognition.

Step 7 & 8 seek to challenge the concepts discovered in the previous steps. This is an example of cognitive conflict.

Step 9 reviews the whole process and asks participants to summarise or represent their thinking in a different format. This translation process is crucial in Chemistry. You may need to remind participants about Johnstone's triangle – in Chemistry we move from a macroview based on observations to a micro or sub-microview to explain our observations and then we summaries these in a Symbolic system of chemical formulae, equations and graphs. Explaining the links between these viewpoints of Chemistry requires participants to justify their thinking which is a clear example of meta-cognition.

Step 10 is an example of bridging. Remember bridging is about application of concept or relationship observed in the activity to other contexts that are relevant to the participant. In this activity the candle burns in oxygen (a chemical reaction)and the wax melts (a physical change). The question is asking is if the participants can suggest other changes they see around them. For example they could say ice melting or water boiling (physical changes) or wood burning or an egg cooking or a nail rusting (chemical changes).

Activity 2: Electric fields simulation 20 min

In the previous activity we used a very simple concrete tool to encourage higher order thinking. It is not always possible to find a concrete starting point but simulations can assist us. The emphasis in this activity is not on the software or technology but on developing questions that will promote meta-cognition & cognitive conflict.

Note to Facilitator:
Phet simulations are examples of Open Education resources (OER). They are available for free and you are allowed to share them too. The Html 5 simulations are easy to download from the Phet site. The files are small and can be shared via Bluetooth or WhatsApp. The files open on any tablet or phone that has an Internet browser like Chrome. You do not need to be online to engage with these simulations.

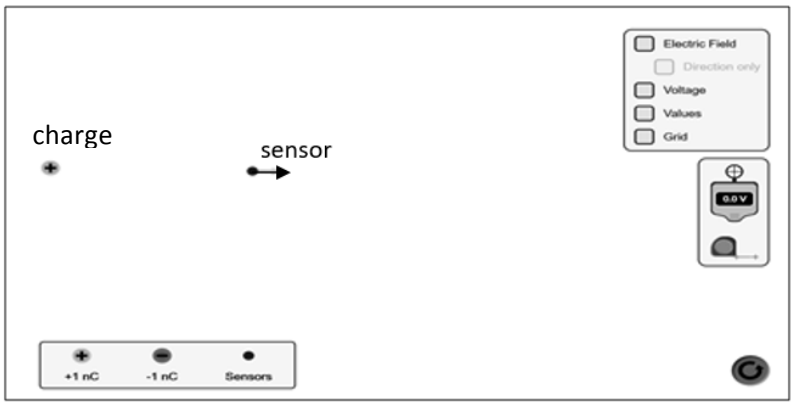
The focus of the activity is to show the importance of ask questions that will encourage conceptual thinking. The Phet site does have a teachers section where you can download or upload activities to share with colleagues.

Instructions

Use the Phet simulation: Charges and fields

https://phet.colorado.edu/en/simulation/charges-and-fields

The screenshot below shows a sensor a distance away from a positive charge and the arrow next to the sensor shows the Electric Field Strength (E).



A simulation like this one encourages "play". Unstructured play can be rewarding for some learners as they will make their own discoveries. But other learners may need more explicit guidance. In both these scenarios conceptual thinking is best developed by asking questions about relationships between the variables identified in the simulation.

Thinking Questions

1. What changes would you like to make to:
    - The sensor(s)
    - The charge(s)

Note to Facilitator:

In this part of the "play" encourage participants to change the position of a sensor or add in more sensors. They can change the charge too. Add in a charge and place it on top of the initial one. They could also add in charges in different positions

2. What did you observe when making changes to:
    - The sensor(s)
    - The charge(s)

Note to Facilitator:

This is a very important part of the "play"as it formalises evidence collected. You could guide participants to looking at the effect distance from a charge has on the electric field strength and also the size of the charge.

3. Based on your observations what relationships exist between the charge, distance and the Electric Field Strength (E). Explain your thinking.

Note to Facilitator:
This is a part of the activity encourages meta-cognition. It may be useful to ask the participants "What if…" questions. The need to provide evidence for any relationship they have discovered.

4. Is the electric field strength inversely proportional to the distance?

Note to Facilitator:
Based on qualitative measurements participants can see that the electric field strength decreases as the distance increases. To check if the relationship is inversely proportional they could use the ruler to collect data and test the values for a few points. What sort of graph do you predict you will get if you plot the values of E and $\frac{1}{r}$*? This question is designed to create cognitive conflict!*

5. Reflect on questions that promote meta-cognition or cognitive conflict.

Note to Facilitator:
During each of the question, a facilitator could ask a participant to explain their thinking. This thinking about how they arrived at the answer is a meta-cognitive activity. In the note on question 4, it is suggested that participants consider the graph of E and $\frac{1}{r}$*. This is asked to create cognitive conflict.*

Session 2: Electrodynamics

Introduction

The topic of Electrodynamics combines the concepts of electric fields, magnetic fields and force. Although we can see evidence of this theory in action, it is does involve abstract concepts that many learners struggle with. It is important to see the development of the concepts starting in the Senior Phase through to Grade 12. The activities in this session trace a developmental pathway from the magnetic effect of current through to electric machines.

Activity 1: Magnetic Effect 45 min

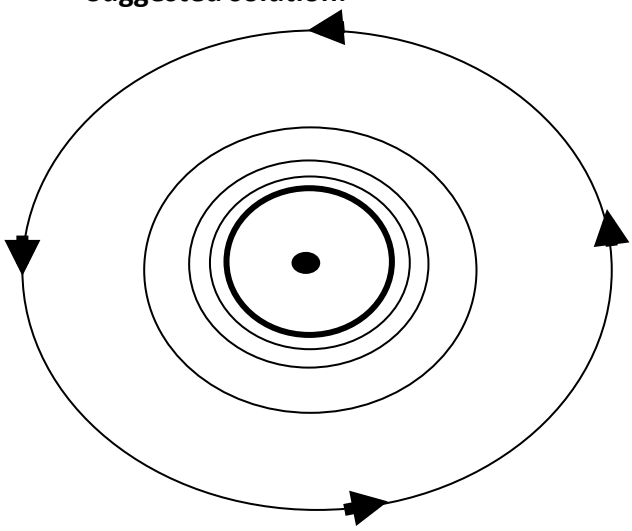
The discovery of the relationship between a moving charge (current) and a magnetic field was a major breakthrough in the development of scientific knowledge. However it does pose a challenge in teaching because the current and associated field are in two different dimensions that are perpendicular to each other. One way to help develop learners' conceptual thinking on this topic is by drawing diagrams.

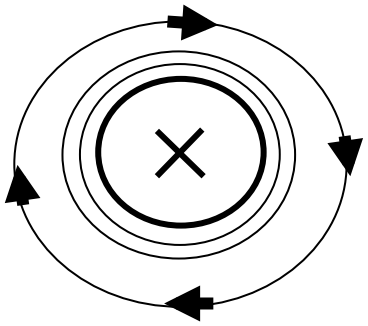
Note to Facilitator:
Allow participants to work in pairs. This activity is abstract as it deals with symbolic representations of things that we cannot see. It must be stressed that when teaching this topic t it is very important to support learners in making the transition from a concrete object – a conducting wire to an abstract representation. Many learners struggle to make the connection between a symbolic

representation and the real thing because they are not explicitly told how to visualise. It does help to talk about a cross section and longitudinal section view.

Instructions

1. Complete the diagrams showing a cross section of a straight conductor, where the current direction is out of the plane of the page and into the page.
   Use the right hand rule to show the direction of the magnetic field around the conductor.
   Suggested solution:





Current direction:
Out of the page

Current direction:
Into the page

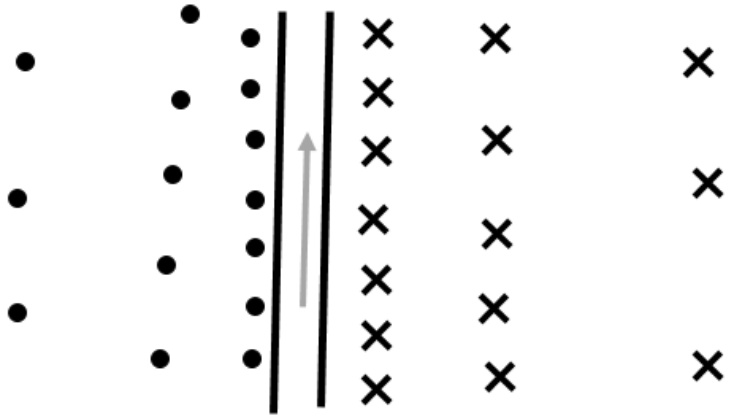
Thinking Questions

- How does the strength of the magnetic field change as you increase the distance from the conductor?
- Does your diagram illustrate this relationship?

Note to Facilitator:
The magnetic field around a single current carrying conductor is not uniform. Field lines should be close together near the conductor but far apart further away. There are fewer field lines far away from the conductor too!

2. Draw a diagram to show a longitudinal view through a straight conductor and indicate the magnetic field associated with the conductor. Show the direction of current using an arrow pointing to the top of the page.

Suggested solution:

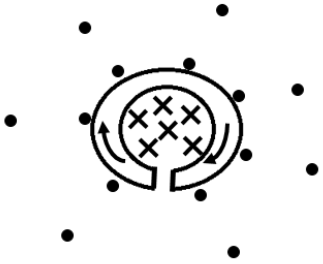


Note to Facilitator:

In this drawing we use the cross – dot convention to show the direction of the magnetic field. Check how many dots and crosses there are and how evenly they are distributed. This leads very easily into a discussion about magnetic flux. By introducing the concept earlier it is helps learners deal with Electromagnetic Inductions / Electrodynamics better.

3. Draw a diagram to show what happens to a straight conductor (show in longitudinal view) is bent into a single loop.

Suggested Solution:



Note to Facilitator:

In this drawing we use the cross – dot convention to show the direction of the magnetic field. Check how many dots and crosses there are and how evenly they are distributed. It is worthwhile discussing the meaning of a pole while referring to this diagram. A pole is where there is a high magnetic flux.

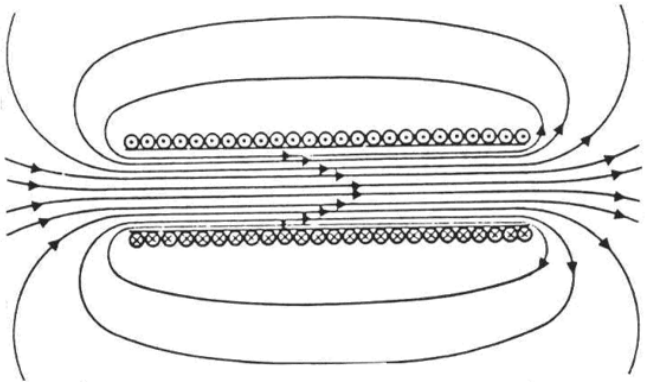
Thinking Questions

- Is the magnetic flux uniform?
- Does the view you have drawn represent a North or South pole?

In this drawing we use the cross – dot convention and see that the direction of the magnetic field is into the page inside the loop but out of the page outside the loop. Hence this side of the loop represents a South pole. The other side of the loop would be a North pole.

4. Draw a diagram to show the direction of current through a coil (side or top view) and the magnetic field surrounding the coil.

Suggested Solution:



Thinking Questions

- Is the magnetic flux uniform?
- Explain how you decided which end of the coil is a North pole?

Note to Facilitator:

In this drawing we use the cross- dot notation to show the direction of the current and field line to show the magnetic field. The magnetic field is not uniform. The area where the field lines point away from the coil is the North pole. Use the right hand solenoid rule.

Discussion

Which of the above activities or thinking questions could you include in developing conceptual understanding of the magnetic effect of a current?

Note to Facilitator:

Allow participants to ask questions and to clarify their own understanding of the relationship between the movement of charges and the associated magnetic field by sharing their ideas in pairs then in a bigger group. The purpose of this discussion is to contrast the difference in the depth of learning when learners are told information and when they have to answer questions that require them to engage with concepts and create meaning through discussion.

Activity 2: Electromagnetic Induction **45 min**

Note to Facilitator:

This is one of the most difficult concept to understand. The simulation helps participants to visualise fields and to identify factors that affect the induced emf. Divide the participants into 4 groups of equal number.

Ask the groups to discuss the different factors and then allocate one of the following to each of the groups:

- *the number of turns,*
- *the size and direction of the meter reading,*
- *the direction the magnet moves in,*
- *the speed at which the magnets are moved.*

If the groups are bigger than 8 then divided the groups so there can be more participation.

The participant will use the Faraday's Law simulation to investigate what effect a change in the factor they have been given will have on the induced emf.

Give each group a sheet of flip chart paper so that they can record the steps of the investigation using the simulation and the questions that will encourage conceptual thinking.

Instructions

Use the Phet simulation: Faraday's Law
https://phet.colorado.edu/en/simulation/faradays-law

Design a guide for using this simulation to develop the concepts required for learners to have a good understanding of electromagnetic induction. The simulation is simple but it does allow you to try different things and observe the results.

Here are some suggestions to help you:

- Identify three or four key words that learners need to know based on a previous section
- Formulate a question or design an activity that uses these words in a way that you can check that learners have the required prior knowledge
- Pose a question or state a problem that requires learners to test their thinking using the simulation given. There should be more than one way of finding the answer or even multiple answers.
- Ask two questions about the activity that will encourage learners to explain their thinking (meta-cognition) and one question that will challenge or contradict their thinking (cognitive conflict).
- Help learners think about how the ideas they have discovered in the simulation can be applied to other scenarios.

Notes to Facilitator

After 20 minutes ask each groups to present the details of the activity they have designed as shown on the flip chart paper. This needs to be about a 2 min presentation per group. You need to manage the time allocate carefully. After all groups have presented ask the participants to evaluate the effectiveness of each of the investigations by focussing on the questions asked. Will learners be engaged in meta-cognition, cognitive conflict or any bridging activities?

Activity 3: Electric Machines **40 min**

Note to Facilitator:
This is an additional activity that can be useful in developing conceptual thinking for Grade 12 teachers. There is a tendency to teach this topic by rote. This can be very confusing to learners because there are many points of confusion. The basic structure of the motor and generator are the same but the energy transfers are opposite. There is also the difference between D.C machines and A.C machines. The result is that there are four different machines that all produce a different output but they are all very similar and operate on the same core principle – magnetic fields!

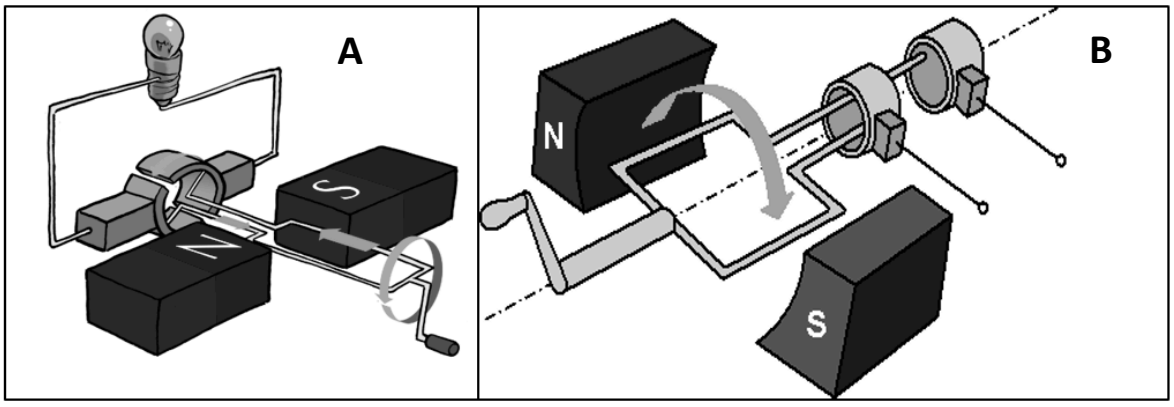
In this activity allow participants to discuss their answers in pairs. Then have a large group discussion and ask for suggestions on how to develop conceptual thinking when teaching this topic.

You may like to introduce this Activity by showing participants the following video made Edison Tech by the Edison Tech Centre:

https://www.youtube.com/watch?v=UL_ryxub-RA

Instructions

1. Carefully examine the two diagrams below:



Thinking Questions

1. Identify the components of these two machines.
2. Tabulate differences and similarities between the machines.
3. How are these machines different to motors?

Suggested solutions

1.

Machine A: DC Generator

- A crank – device to turn the armature
- A single coil or armature
- A split ring commutator
- A permanent magnetic field
- An output device – light bulb

Machine B: AC Generator

- A crank – device to turn the armature
- A single coil or armature
- Slip rings
- A permanent magnetic field
- An output device – light bulb

2. Comparison of a DC Generator and an AC Generator

	D.C Generator	**A. C Generator**
Similarities	Converts mechanical energy to electrical energy Rotate a coil in a permanent magnetic field Used to light the bulb	
Differences	A split ring commutator	Slip rings
	Output of direct current of changing magnitude	Output of alternating current which changes in magnitude and direction.

3. Motors use electrical energy to produce mechanical energy or work on an object.

DC Generators have the same structure as DC Motors

AC Generators have the same structure as AC Motors

Note to Facilitators

The focus in this activity has been on the two types of generators. These are electrical machines that convert mechanical energy to electrical energy. Electric motors are similar in construction to generators but they convert electrical energy to mechanical energy. This is an example of ***converse thinking****.*

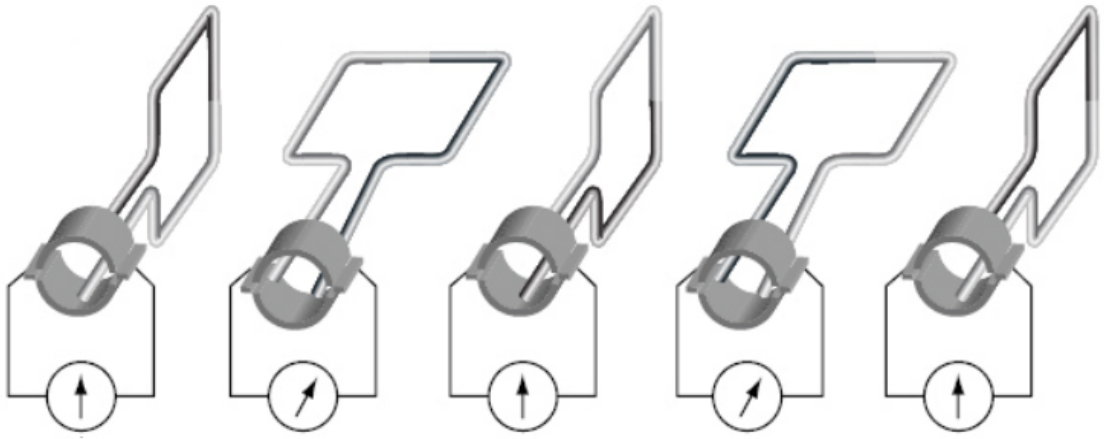
Learners tend to struggle with this type of thinking, but it does help to make it explicit. Another example of converse thinking is to compare the magnetic effect (used in motors) and electromagnetic induction (used in generators)

Magnetic effect *- a moving charge produces a magnetic field around the conductor.*

Electromagnetic induction *- a moving magnet induces an emf or current in a conductor.*

Instructions

2. Carefully examine the diagram below, showing the armature in different positions



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Thinking Questions

1. Explain why the needle on the meter is changing as the armature is moving in the magnetic field.
2. Draw a sketch graph to show how the induced emf changes during each rotation if the brushes are connected to a split ring commutator.
3. How would your graph be different if the split ring commutator was replaced with slip rings?

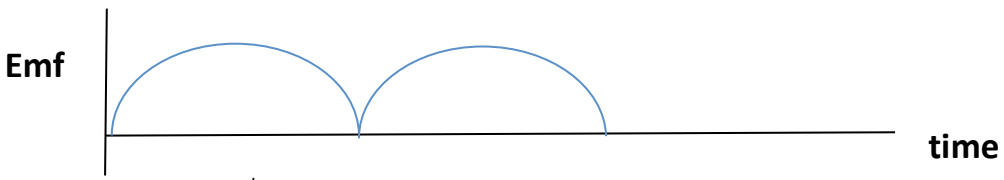
Suggested solutions

1. The induced emf across the ends of the coil changes depending on the direction of motion of the coil relative to the permanent magnetic field.

   In positions 1, 3 and 5 the darker shaded half of the coil is moving parallel to the permanent magnetic field. No emf is induced in the coil.

   In positions 2 and 4 the darker shaded half of the coil is moving perpendicularly to the permanent magnetic field. The emf induced in the coil is at a maximum. Both these are positive values as the galvanometer is connected to the coil via a split ring commutator.

2. Draw showing induced emf for a DC generator for one cycle.



3. In the 2nd half of the cycle, the induced emf would have a negative. The direction of the current changes during the cycle.

Session 3: Electrochemistry

Introduction

In this session we investigate the relationship between chemical reactions and electricity. When introducing the two types of electrochemical cells is useful to compare them to generators and motors. Galvanic cells use chemical reactions to produce electric energy (similar to generators) while electrolytic cells use electric energy to produce chemical reactions (similar to motors). By highlighting the links between the electrochemical cells and making the converse relationship explicit helps learners organise these concepts better and gives them the ability to apply converse thinking to solve problems.

A key concept that links Physics and Chemistry is potential difference and its relationship to energy. The Table of Standard Reduction Potentials gives relevant data about the potential of different half cells compared to the Standard Hydrogen Electrode (Reference Cell). This table is often misinterpreted and used in a procedural routine. It would be better to develop activities that promote thinking rather than routines. It is also important to give learners tools to help them remember key concepts and definitions, which can easily be confused.

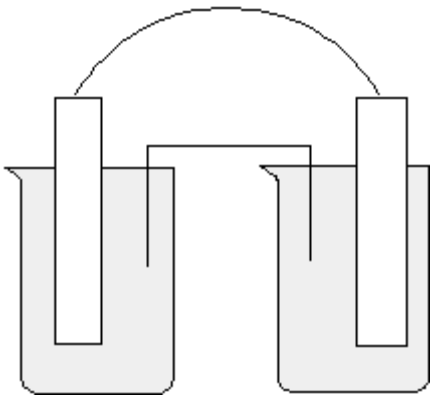
Activity 1 Galvanic Cells **30 min**

Note to Facilitator:

The activities in this session may need to be used in a separate workshop as there will not be time to complete all the activities in this guide. Allow participants to work in groups of no more than 5. Ask them to work in different group to the previous session.

Instructions

- Work in groups of 3 or 4
- Identify the key concepts learners require before starting this topic
- Identify the concepts involved in this topic by referring to CAPS or the tracker and planner for Term 3.
- Draw a concept map to show how the concepts link together.
- Design a short activity that makes use of the diagram below:



  - Include questions to stimulate discussion of terminology

- A problem that needs to be solved
- Two questions that encourage meta-cognition
- A question the engages learners in cognitive conflict

- Record your activity on a piece of flip chart paper
- Be ready to present your ideas to other participants.

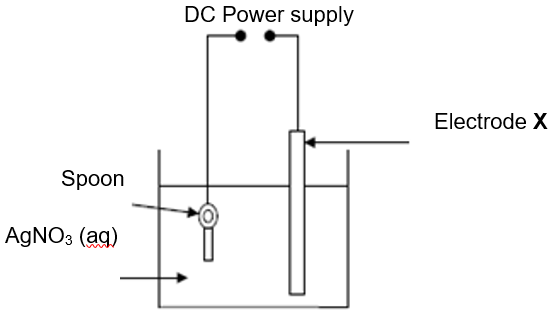
Note to the Facilitator:
Encourage the participants to give a series of instructions for learners to following when engaging with the diagram of the galvanic cell. The questions need to be carefully sequenced too. A good starting point could be for learners to reflect on terminology or definitions. It may also be a good idea to think of an open ended question for learners to solve. For example you could ask learners to determine which galvanic cell will give you the highest emf given the following half cells:
magnesium, zinc, lead, copper and silver
They would need to explain their thinking in making their choice.
A question that can create cognitive conflict is to ask if you could replace the cathode of the selected cell with another half cell, could you achieve a greater emf?
Also remind the participants to make links between the macroview, microview and symbolic view when looking at galvanic cells.

Activity 2 Electrolytic Cells **30 min**

Electrolysis is used in many different industries. Electrolytic cells may look different but they all operate on the same principle. In this activity you will examine an exam question and identify the core concepts learners need to know to be able to answer the questions.

Question 7

The diagram below represents a simplified electrolytic cell used to electroplate a tin spoon with silver. The spoon is continuously rotated in a saturated solution of silver nitrate during the process of electroplating.



7.1 Which electrode is connected to the positive terminal of the power supply? (2)

7.2 Why does the solution conduct electricity? (2)

7.3 What would you observe happening to electrode X if the cell operated for more than 30 minutes? (2)

7.4 Write down the half reaction, including the state symbols, that occurs at the spoon. (2)

If the voltage of the DC supply is increased to 1V, bubbles of hydrogen gas appear on the tin spoon. Water is reduced to form the hydrogen gas.

7.5 Write down the equation of the half reaction that produces the hydrogen gas (2)

7.6 What other substance is involved in this reaction? (2)

Electrode X is made of silver but also contains some zinc impurities.

7.7 By making specific reference to the E° values in the standard electrode potential table, explain why it can be said that the spoon will still only be coated with silver and not zinc. (4)

7.8 At the end of the experiment, where would one find the impurities? (2)

Memo Question 7

7.1 Electrode X✓✓

7.2 The solution is an electrolyte. There are positive (cations) and negative (anions) ions in the solution that can move freely. ✓✓

7.3 Electrode X would decrease in size✓✓

7.4 $Ag^+(aq) + e^- \rightarrow Ag(s)$ ✓✓

7.5 $H_2O(l) + 2e^- \rightarrow H_2(g) + OH^-(aq)$ ✓✓

7.6 Ag in electrode X ✓✓

7.7 Zinc is a strong reducing agent with an E^0 value of -0,76V✓ compared to copper which has an E^0 value of +0,34V. ✓At the low voltage this cell needs to operate at there is insufficient electrical energy✓ to cause zinc to form ions or deposit onto the tin spoon. ✓

7.8 The zinc impurities would remain in the solution as a precipitate. ✓✓

Note to the Facilitator:

In this activity the participants will look at the questions and memo of an exam question and work from these to establish the core concepts learners will need to know to answer this question. Participants may use CAPS or the planner and tracker to assist them. The list below is a guideline of the concepts they should include:

- *Electrolytes – ions in solution, dissociation*
- *Redox reactions – oxidation, reduction, spontaneous, non-spontaneous*
- *Cathode, anode, electroplating*
- *Standard reduction potentials, interpreting of E^0 values, reactivity, selective oxidation / reduction*

TABLE OF STANDARD ELECTRODE POTENTIALS

Half –reaction			E°/volt
$Li^+ + e^-$	⇌	Li	-3.05
$K^+ + e^-$	⇌	K	-2.93
$Cs^+ + e^-$	⇌	Cs	-2.92
$Ba^{2+} + 2e^-$	⇌	Ba	-2.90
$Sr^{2+} + 2e^-$	⇌	Sr	-2.89
$Ca^{2+} + 2e^-$	⇌	Ca	-2.87
$Na^+ + e^-$	⇌	Na	-2.71
$Mg^{2+} + 2e^-$	⇌	Mg	-2.37
$A\ell^{3+} + 3e^-$	⇌	$A\ell$	-1.66
$Mn^{2+} + 2e^-$	⇌	Mn	-1.18
$2H_2O + 2e^-$	⇌	$H_2(g) + 2OH^-$	-0.83
$Zn^{2+} + 2e^-$	⇌	Zn	-0.76
$Cr^{3+} + 3e^-$	⇌	Cr	-0.74
$Fe^{2+} + 2e^-$	⇌	Fe	-0.44
$Cd^{2+} + 2e^-$	⇌	Cd	-0.40
$Co^{2+} + 2e^-$	⇌	Co	-0.28
$Ni^{2+} + 2e^-$	⇌	Ni	-0.25
$Sn^{2+} + 2e^-$	⇌	Sn	-0.14
$Pb^{2+} + 2e^-$	⇌	Pb	-0.13
$Fe^{3+} + 3e^-$	⇌	Fe	-0.04
$2H^+ + 2e^-$	⇌	$H_2(g)$	0.00
$S + 2H^+ + 2e^-$	⇌	$H_2S(g)$	+0.14
$Sn^{4+} + 2e^-$	⇌	Sn^{2+}	+0.15
$SO_4^{2-} + 4H^+ + 2e^-$	⇌	$SO_2(g) + 2H_2O$	+0.17
$Cu^{2+} + 2e^-$	⇌	Cu	+0.34
$2H_2O + O_2 + 4e^-$	⇌	$4OH^-$	+0.40
$SO_2 + 4H^+ + 4e^-$	⇌	$S + 2H_2O$	+0.45
$I_2 + 2e^-$	⇌	$2I^-$	+0.54
$O_2(g) + 2H^+ + 2e^-$	⇌	H_2O_2	+0.68
$Fe^{3+} + e^-$	⇌	Fe^{2+}	+0.77
$Hg^{2+} + 2e^-$	⇌	Hg	+0.79
$NO_3^- + 2H^+ + e^-$	⇌	$NO_2(g) + H_2O$	+0.80
$Ag^+ + e^-$	⇌	Ag	+0.80
$NO_3^- + 4H^+ + 3e^-$	⇌	$NO(g) + 2H_2O$	+0.96
$Br_2 + 2e^-$	⇌	$2Br^-$	+1.09
$Pt^{2+} + 2e^-$	⇌	Pt	+1.20
$MnO_2 + 4H^+ + 2e^-$	⇌	$Mn^{2+} + 2H_2O$	+1.21
$O_2 + 4H^+ + 4e^-$	⇌	$2H_2O$	+1.23
$Cr_2O_7^{2-} + 14H^+ + 6e^-$	⇌	$2Cr^{3+} + 7H_2O$	+1.33
$C\ell_2(g) + 2e^-$	⇌	$2C\ell^-$	+1.36
$Au^{3+} + 3e^-$	⇌	Au	+1.42
$MnO_4^- + 8H^+ + 5e^-$	⇌	$Mn^{2+} + 4H_2O$	+1.51
$H_2O_2 + 2H^+ + 2e^-$	⇌	$2H_2O$	+1.77
$F_2(g) + 2e^-$	⇌	$2F^-$	+2.87

Increasing oxidising ability ↓

Increasing reducing ability ↑

Final Reflections

Note to Facilitator:
The post workshop activity must be given time. After participants have answered the questions, discuss the answers with them. It is vital that they recognise the value in revisiting a question and reflecting on how an answer can be changed or improved. This is a tool that can be used with learners too.

Suggested answers to Pre & Post Workshop Activity

Question 1

B X shows that magnetic field direction is into the page.

In a magnet, the field line direction at South pole is into the magnet on the inside of the magnet and towards the pole around the outside of the magnet.

Question 2

B A current can only be induced in the conducting loop if there is a change in magnetic flux cutting through the coil, in each small time interval on the motion. For (a) and (e), the coil is not passing through the magnetic field. There is no change in magnetic flux. For (c) the field is uniform and the velocity is uniform. There is no change in magnetic flux. Only at (b) and (d) is there a change in magnetic flux.

Question 3

A The diagram shows a generator with slip rings. We can see that there is no power supply or battery connected to the coil – there is a crank link to the coil that can turn. A generator which converts mechanical energy into electrical energy. When the coil moves through a cycle the current changes in magnitude and direction. The one side of the coil is connected to a slip ring and the other side of the coil is connected to the second slip ring. This means the current produced in the external circuit will change in magnitude and direct just as it is in the coil. We call this type of current alternating current (A.C.).

Question 4

B The diagram includes a voltmeter and no source of electricity so this is a galvanic cell. Zinc is the more reactive metal. It is a better reducing agent than copper and reduces the hydrogen ions in the solution to form hydrogen gas. Zinc atoms on the electrode form zinc ions in the solution (oxidation). This is the anode. In this galvanic cell, copper remains inert.

Question 5

D To get the highest E^{O}_{cell} value you need to combine the most negative E^{o} (anode) and the most positive E^{o} (cathode) values for the half cells. The half-cell with the most negative E^{O} value has the best reducing agent. The metal will be oxidised to form ions at the anode. The anode is the electrode with Z. The ions of the equation with the most positive E^{O} value are the best oxidising agent (X^{2+}).

Question 6

In the initial scenario the net electric field strength at R is found by adding the electric field strength from charge Q and charge P. Remember electric field strength is a vector!

Let the electric field strength from Q be: $E_Q = \frac{k(X)}{r^2}$ √

The electric field strength from P with then be $E_P = \frac{k(3X)}{(3r)^2} = \frac{3\,k(X)}{9r^2} = \frac{1}{3}E_Q$ √ …….(1)

(Note the direction is opposite to the direction of E_Q as the charge of Q is positive but P is negative.)

$E_{net\ at\ R} = E_Q + E_P = E_Q - \frac{1}{3}E_Q = \frac{2}{3}E_Q$ = E N.C^{-1} (E_{net} was given!) √

In 2nd scenario, E_Q remains the same but E_A is 4 times bigger the E_P.

The charge does not change but the distance from the charge at A to R is half (AR = 6 cm) the distance from the charge at P to R (PR = 12 cm).

So applying the same reasoning as (1) we can find an expression for E_A in terms of E_Q:

$E_A = \frac{k(3X)}{(\frac{3}{2}r)^2} = \frac{12\,k(X)}{9r^2} = \frac{4}{3}E_Q$ but in the opposite direction √

(Alternatively we can reason that since the distance is halved the value for E_A in terms of E_Q must be four times what it was in (1). Hence we get $E_A = 4 \times \frac{1}{3}E_Q = \frac{4}{3}E_Q$ ut in the opposite direction √)

Hence:$E_{net\ at\ R} = E_Q + E_A = E_Q - \frac{4}{3}E_Q = -\frac{1}{3}E_Q$ = ½ **E** N.C^{-1} toward Q √

Steps for post-test:

1. Recognise that the net electric field strength is a vector made up of the electric field strength of both charges.√

2. Find an expression for the electric field strength of each of the charges√

3. Show how the electric field strength changes when the charge that was at P moves to A. Since AR = 6 cm and PR = 12 cm, the distance has halved and the E_A is 4 times greater than E_P √ ($E_A = 4E_P = \frac{4}{3} E_Q$)

4. Recall the charges are opposite in sign so the electric field strength vectors will be opposite in direction. √

5. Find the new net electric field strength by adding E_Q and E_A. Recognise that the direction and magnitude has changed √ (5)