NANOTECHNOLOGY
PUBLIC ENGAGEMENT

Nanotechnology

A World of New Possibilities

Educator Handbook

science & technology
Department:
Science and Technology
REPUBLIC OF SOUTH AFRICA

NRF National Research Foundation
SAASTA South African Agency for Science and Technology Advancement

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Contents

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LESSON PLAN
Lesson 1: Nanotechnology and Water

SPECIFIC AIMS COVERED IN THIS LESSON:	
Specific Aim 1: Acquiring knowledge of the natural sciences	**Specific Aim 2:** Investigating phenomena in the natural sciences
Specific Aim 3: Appreciating and understanding the importance and applications of natural sciences in society	

OBJECTIVES:	CURRICULUM LINKS (Grade 8):
1. Learners will be introduced to nanotechnology and its importance to society. **2.** Learners will develop the skill of converting between different length units, and will learn about the size of particles used in nanotechnology. **3.** Learners will discover where our water comes from. **4.** Learners will explore the importance of clean water for society. **5.** Learners will discover how nanotechnology could be used to provide clean water to communities.	This lesson links with the following concepts from the Life and Living content area of the Natural Sciences curriculum: • interactions with the environment - micro-organisms and availability of clean water • sustainable use of resources This lesson also links with the following concepts from the Matter and Materials content area of the Natural Sciences curriculum: • particles, elements and compounds - atoms and molecules

LESSON OUTLINE:

This lesson should cover at least four classroom periods of 30 minutes each.

Period 1:

1. **Baseline Assessment**: Ask learners what they know about the term "nanotechnology". Allow some time for class discussion. This will give you an idea of what learners already know about this field of study.
2. Discuss the meaning of the word "nanotechnology" (outlined in learner handouts).
3. Explain the table containing different length measurements with the class. Make sure that the learners understand the relationships between the various units.
4. Discuss the changing sizes in the imagined journey into the nanoworld (outlined in learner handouts).

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Period 2:

1. Briefly review the discussion of the meaning of the word "nanotechnology" and the size of particles used in nanotechnology.
2. **Formative Assessment:** allow learners to complete Activity 1 in pairs.
3. Once the learners have completed the activity, discuss the correct answers with the class. Encourage the learners to assess their own work.

ANSWERS TO ACTIVITY 1

1. If an object measures 15 cm, what is its size in nm? **Answer: 150 000 000 nm**
2. How many millimetres are there in 1 metre? **Answer: 1 000 mm**
3. If you shrink from a height of 1 m to a height of 1 cm (10 mm), how many times smaller are you after you have shrunk? **Answer: 100 times**

Period 3:

1. **Formative Assessment:** Encourage the learners to complete Activity 2 on their own. Allow them to use their handouts when doing this activity.
2. Once the learners have completed the activity, encourage some of the groups to show their diagrams to the rest of the class.
3. Hold a class discussion about the importance of clean water in our daily lives. Encourage the learners to share some of their ideas from their lists of activities where clean water is needed.

Period 4:

1. Discuss how nanotechnology is being used to provide water that is safe to drink.
2. **Formative Assessment:** As a follow-up to the discussion, encourage learners to complete Activity 3 on their own.
3. Once the learners have completed their paragraphs, encourage them to swap their work with another learner. They should read one another's paragraphs and give each other feedback on whether the paragraphs are clear and correct.

If there is enough time, encourage the learners to complete the Classroom Extension Activity worksheet. (This can be done by faster learners who need extra stimulation.)

TEACHERS' NOTES FOR INVESTIGATION ACTIVITY:

If there is a river or a dam near your school, it could be a fun outing for the class to go and fetch their own water samples. Ask them to bring clear glass bottles from home for their water samples.

If your school is not close to a source of water, you will need to collect a few tanks of water from a river or dam yourself. Try to make sure that there is lots of mud and dead plant matter in the water. If possible, it would be great if there were a few small living creatures in the water too.

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Part A: Examining the water

Churn up the water as much as possible before giving the learners their samples. Encourage them to write down all the different objects that they can see in their water samples.

Part B: Cleaning the water

Encourage the learners to build water filters to try to clean their water. Some examples of materials that they could use are:

- Old pieces of fabric
- Cotton wool
- Gauze
- A layer of river sand
- A sieve
- A sock

These materials will filter down to micrometre scale but smaller things will get through.

Part C: Making the water safe to drink

Some ideas for making water safe to drink are:

- Boil the water (this will kill the majority of harmful bacteria in the water).
- Allow the water to evaporate and condense. Funnel the condensed water into another clean container – this water will be pure and safe to drink, as the bacteria will not have evaporated with the water.
- Add a *teaspoon* amount of bleach to a bucket of water – this kills harmful bacteria.

SAFETY NOTE: Learners should not drink their water samples as they might not be safe to drink.

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LESSON PLAN
Lesson 2: Nanotechnology and Medicine

SPECIFIC AIMS COVERED IN THIS LESSON:	
Specific Aim 1: Acquiring knowledge of the natural sciences	**Specific Aim 3:** Appreciating and understanding the importance and applications of natural sciences in society

OBJECTIVES:	CURRICULUM LINKS (Grade 9):
1. Learners will be introduced to nanotechnology and its importance in medicine. **2.** Learners will learn about the heart and circulatory system. **3.** Learners will learn about what cancer is and how it affects the body. **4.** Learners will discover how nanotechnology is being used fight cancer.	Human life processes and healthy living - Relationship between human systems and life processes: • Lungs and breathing • Alimentary canal and nutrition • Heart, blood vessels and circulation • Kidneys and excretion Diseases, disorders related to the above systems

LESSON OUTLINE:

This lesson should cover at least four classroom periods of 30 minutes each

Period 1:

1. **Baseline Assessment**: Ask learners what they know about the term "nanotechnology". Allow some time for class discussion.
2. Discuss the meaning of the word "nanotechnology" (outlined in learner handouts).
3. **Baseline Assessment:** Ask learners to discuss the question "What does your heart do, and why is it so important?" This will give you an idea of what learners already know about the circulatory system.
4. Discuss how blood is moved around in the body and what its functions are (outlined in learner handouts).

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Period 2:

1. Briefly review the way the heart moves blood around in the body.
2. **Formative Assessment**: Encourage learners to complete Activity 1 in pairs. They can refer to their notes while they are answering the questions. This will encourage them to read the text in their handouts.
3. Once learners have completed the activity, discuss the correct answers with the class. Encourage learners to assess their own work.

ANSWERS TO ACTIVITY 1

The blood takes **oxygen** from our lungs to all of the cells in our bodies. It also takes **food** and **water** from our stomach to our cells. Our blood also helps to **clean** the cells of our bodies by taking away the waste products from the cells to the **kidneys**. The blood is pumped through our bodies by the **heart**. Our blood travels through small tubes called **veins** / **blood vessels**.

Period 3:

1. Hold a class discussion about the disease called cancer (outlined in learner handouts). Encourage learners to share their personal experiences if they know of any friends or relatives who have had cancer.
2. **Formative Assessment**: Encourage learners to complete Activity 2 on their own. Allow them to use their handouts when doing this activity.
3. Once learners have completed the activity, discuss the correct answers with the class. Encourage learners to assess their own work.

ANSWERS TO ACTIVITY 2

1 – D; 2 – G; 3 – E; 4 – F; 5 – A; 6 – C; 7 – H; 8 - B

Period 4:

1. Discuss how nanotechnology is being used to treat cancer without affecting the rest of the body (outlined in learner handouts).
2. **Formative Assessment**: As a follow-up to the discussion, encourage learners to complete Activity 3 on their own. Encourage them to write their answers in full sentences.
3. Once learners have answered the questions, take in their work and mark it out of a total of 10 marks.

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ANSWERS TO ACTIVITY 3

1. A malignant tumour is a lump of cells that is cancerous. (2)
2. "Targeted drug delivery" is when drugs travel in the bloodstream and are delivered to the cells of the cancerous tumours. (2)
3. Normal chemotherapy drugs affect other parts of the body, but in targeted drug delivery only the cancer cells receive the drugs, and the rest of the body is not affected. (3)
4. Scientists have designed liposomes so that they become attached to cancer cells. They can unload these drugs directly into the cancerous tumours. (3)

If there is enough time, encourage learners to complete the Classroom Extension Activity worksheet (this can be done by faster learners who need extra stimulation).

SOLUTION TO EXTENSION ACTIVITY:

O	S	T	I	G	M	B	L	D	O	O	L	B	U	A
O	M	B	D	E	L	I	V	E	R	Y	E	O	R	Y
H	A	I	L	L	P	I	D	T	E	O	O	M	P	E
Y	G	O	L	O	N	H	C	E	T	O	N	A	N	D
H	D	A	S	L	O	X	Y	G	E	N	R	L	D	R
G	M	O	S	E	I	D	T	R	A	E	H	I	O	U
S	M	S	B	U	T	M	S	A	H	E	E	G	O	G
E	M	I	C	R	O	M	E	T	R	E	O	N	F	S
S	O	V	S	T	H	R	O	T	R	E	T	A	W	P
Y	C	E	N	T	I	M	E	T	R	E	E	N	U	M
R	E	I	D	H	E	M	U	C	R	E	A	T	L	U
I	L	N	E	H	O	M	S	G	N	U	L	M	O	P
N	L	S	C	N	O	S	T	O	M	A	C	H	T	Y
G	S	A	A	U	C	O	O	R	O	O	C	P	S	M
E	T	N	R	O	E	E	R	L	T	D	I	E	A	M

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LESSON PLAN
Lesson 3: Nanotechnology and Energy

SPECIFIC AIMS COVERED IN THIS LESSON:	
Specific Aim 1: Acquiring knowledge of the natural sciences	**Specific Aim 2:** Investigating phenomena in the natural sciences
Specific Aim 3: Appreciating and understanding the importance and applications of natural sciences in society	

OBJECTIVES:	CURRICULUM LINKS (Grade 7):
1. Learners will be introduced to nanotechnology. **2.** Learners will learn about non-renewable and renewable energy resources. **3.** Learners will learn about solar panels as an example of a device which makes use of a renewable energy resource, namely solar energy. **4.** Learners will discover how nanotechnology is being used in the design of solar panels.	This lesson links with the following concepts from the Energy and Change content area of the Natural Sciences curriculum: • Energy transfers – Energy conservation: designs that save energy – Energy transfers associated with heating and cooling – Chain of energy transfers in providing energy to the community: from the energy source to the end point where it is consumed – Renewable and non-renewable energy resources This lesson also links with the following concepts in the Matter and Materials content area: • Properties of materials – Factors which determine suitability of materials for specific uses – Materials produced in local industries

LESSON OUTLINE:

This lesson should cover at least 4 classroom periods of 30 minutes each.

Period 1:

1. Discuss the meaning of the word "nanotechnology" (outlined in learner handouts).
2. **Baseline Assessment:** Ask learners to discuss the question "Think of all of your daily activities where you need energy. Where does that energy come from?"

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3. Discuss the various energy sources, and how most of these derive their energy from the sun (outlined in learner handouts)..

Period 2:

1. Briefly review the sources of energy that we use.
2. **Formative Assessment:** Encourage learners to complete Activity 1 in pairs.
3. Once learners have completed the activity, discuss the correct answers with the class. Encourage learners to assess their own work.

ANSWERS TO ACTIVITY 1

(a) (i) Energy source = wood / coal

(ii) Energy source = petrol / diesel made from crude oil

(iii) Energy source = electricity made from

(iv) Energy source = batteries / chemicals

(b) (i) Wood is from a plant, which gets its energy from the sun by photosynthesis. Coal was formed by plants that were buried for millions of years. These plants also got their energy from the sun by photosynthesis.

(ii) Petrol / diesel get their energy from crude oil. Crude oil was formed by sea plants and animals that have been buried for millions of years. The animals got their energy from plants, which got their energy from the sun by photosynthesis.

(iii) Electricity gets its energy from coal (or by other means), which was formed by plants that were buried for millions of years. These plants got their energy from the sun by photosynthesis.

Period 3:

1. Hold a class discussion around non-renewable and renewable energy sources (outlined in learner handouts). Encourage learners to share their personal experiences if they know of any way that their community uses renewable energy sources.
2. **Formative Assessment:** Encourage learners to complete Activity 2 on their own.
3. Once learners have completed the activity, discuss the correct answers with the class. Encourage learners to assess their own work.

ANSWERS TO ACTIVITY 2

Renewable energy: solar energy, wind power, hydropower

Non-renewable energy: coal, crude oil, petrol, diesel, wood, electricity, paraffin

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Period 4:

1. Discuss how nanotechnology is being used to build better solar panels (outlined in learner handouts).
2. **Formative assessment:** As a follow-up to the discussion, encourage learners to complete Activity 3 on their own.
3. Once learners have answered the questions, discuss the correct answers with the class. Encourage learners to assess their own work.

ANSWERS TO ACTIVITY 3

1. **Solar** panels are made up of many layers. Some of these layers are made from **carbon** nanotubes.
2. Carbon nanotubes are 4 **nanometres** wide.
3. When the carbon nanotubes absorb sunlight, they convert it into **electrical** energy. This electrical energy can be stored in **batteries**.

If there is enough time, encourage learners to complete the Classroom Extension Activity worksheet. (This can be done by faster learners who need extra stimulation.)

SOLUTION FOR EXTENSION ACTIVITY:

a. Hypothesis could be something like:

"Black plastic is better at absorbing heat from sunlight than white plastic or foil."

Learners can place these in any order, since the hypothesis is an initial guess and does not have to be correct at this stage.

b. Learners need to control the following variables in their investigation:
   - Bottles must all be of the same size and shape
   - Amount of water in each bottle must be the same
   - Starting temperature must be the same
   - Amount of sunlight that falls on the bottles must be the same
   - Amount of time in the sun must be the same
   - Type of thermometer used must be the same

c. Learners should find that the water in the bottle with black plastic should be warmer than the other two bottles.

d. This is because items that are black absorb all light and reflect none. While items that are white reflect all light and absorb none. Because the light is absorbed it is turned into heat energy, which warms the water.

e. Conclusion could be: *"Black plastic is better at absorbing heat from sunlight than white plastic or foil."* The conclusion should be linked to the hypothesis.

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LESSON PLAN
Lesson 4: Nanotechnology and Mining

SPECIFIC AIMS COVERED IN THIS LESSON:	
Specific Aim 1: Acquiring knowledge of the natural sciences	**Specific Aim 2:** Investigating phenomena in the natural sciences
Specific Aim 3: Appreciating and understanding the importance and applications of natural sciences in society	

OBJECTIVES:	CURRICULUM LINKS (Grade 9):
1. Learners will be introduced to nanotechnology. **2.** Learners will learn about mining in South Africa. **3.** Learners will learn about the dangers of mining. **4.** Learners will discover how nanotechnology is being used to make mining more safe.	This lesson links with the following concepts from the Earth and Beyond content area of the Natural Sciences curriculum: • Mining and mineral extraction in South Africa – origins of coal, ore and minerals • Economic, environmental and social cost attached to mining This lesson also links with the following concepts in the Energy and Change content area: • Energy transfers – effect of varying resistance in a circuit

LESSON OUTLINE:

This lesson should cover at least 4 classroom periods of 30 minutes each.

Period 1:

1. Discuss the meaning of the word "nanotechnology" (outlined in learner handouts).
2. **Baseline Assessment**: Ask learners to discuss what they know about mining in South Africa, and what their experiences are of visiting mines. This will give you an idea of what they already know about this.
3. Discuss how mining is done in South Africa (outlined in learner handouts).

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Period 2:

1. Briefly review how mining is done in South Africa.
2. **Formative Assessment**: Encourage learners to complete Activity 1 in pairs.
3. Once learners have completed the activity, discuss the correct answers with the class. Encourage learners to swap their work with a partner and to assess one another's work.

ANSWERS TO ACTIVITY 1

1. Gold is a very **good** conductor of electricity, and does not become **tarnished** (dull or dirty).
2. Gold is mined in South Africa in **underground** mines. Here gold is found in rocks called **ore**.
3. Coal is an important **energy** source.
4. Coal that is near the Earth's surface is mined in **open-pit** mines.
5. The process of mining diamonds from river beds is called **alluvial** mining.

Period 3:

1. Hold a class discussion around the dangers of mining (outlined in learner handouts).
2. **Formative Assessment**: Encourage learners to complete Activity 2 on their own.
3. Once learners have completed the activity, discuss the correct answers with the class. Encourage learners to assess their own work.

ANSWERS TO ACTIVITY 2

The pictures show people breathing poisonous gases, and the people are struggling to breathe. The picture also shows flammable gases catching fire, which can hurt and kill people in mines.

Period 4:

1. Discuss the ways in which nanotechnology is being used to make mining safer (Outlined in learner handouts).
2. **Summative Assessment**: Encourage learners to complete Activity 3 in groups of 4 or 5. Once learners have completed their posters, assess their work using the following criteria:

Poster is colourful and creative	2 marks
Poster shows original ideas	2 marks
Poster is clearly presented	2 marks
Information on poster is informative	2 marks
Groupwork - All learners were included	2 marks
TOTAL	10 marks

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If there is enough time, encourage learners to complete the Classroom Extension Activity worksheet. This can be done by faster learners who need extra stimulation.

NOTES FOR EXTENSION ACTIVITY:

1. Write an investigation question

Learners should write down the question that they will be investigating. This could be something like: "How does the length of pencil lead affect the brightness of a light bulb in a circuit?" or "How does the amount of resistance in a circuit affect the current in a circuit?"

2. Write a hypothesis for your investigation

An example hypothesis could be: "A lower resistance in a circuit causes an increase in the current" or "A shorter piece of pencil lead will make the torch bulb in a circuit glow more brightly than a longer one".

3. Procedure for the investigation

i. The controlled variables are the number of batteries in the circuit, the number of torch bulbs in the circuit, and the type of pencil lead that is used.

ii. Make sure that learners read and follow the steps of the investigation carefully.

iii. In each step they should be reducing the length of pencil lead that is included in the circuit. This will reduce the resistance, which should increase the current and the torch bulb should glow more brightly.

4. Analyse your data

Encourage learners to think carefully through their observations, and to try to find some trend or pattern.

They should notice from their observations that the light bulb glows more brightly with a shorter length of pencil lead in the circuit.

4. Write a conclusion

The conclusion should be linked to the hypothesis, for example: "The lower the resistance in a circuit, the higher the current" or "The lower the resistance of a piece of pencil lead in a circuit, the brighter the torch bulb in the circuit will glow, which means that the current is greater."

Summative Assessment

As part of your continuous assessment programme, you could ask learners to hand in a written report on this practical investigation, and assess it according to the following criteria:

Criterion	Mark
Well written investigation question	2
Hypothesis correctly written	2
Correct controlled variables	2
Investigation steps correctly followed	2
Circuit correctly connected	2
Observations clearly recorded	2
Trends correctly recognised	2
Clear concluding statement	2
Concluding statement links with hypothesis	2
Well structured practical report	2
TOTAL	**20**

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3. What didn't you like about it?

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4. Any other comments?

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_____

_____

_____

Thank you!

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