

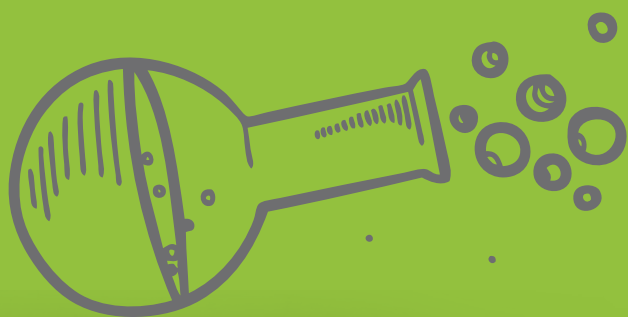


SCIENCE GUIDE BOOK

Your guide to a great science/engineering project

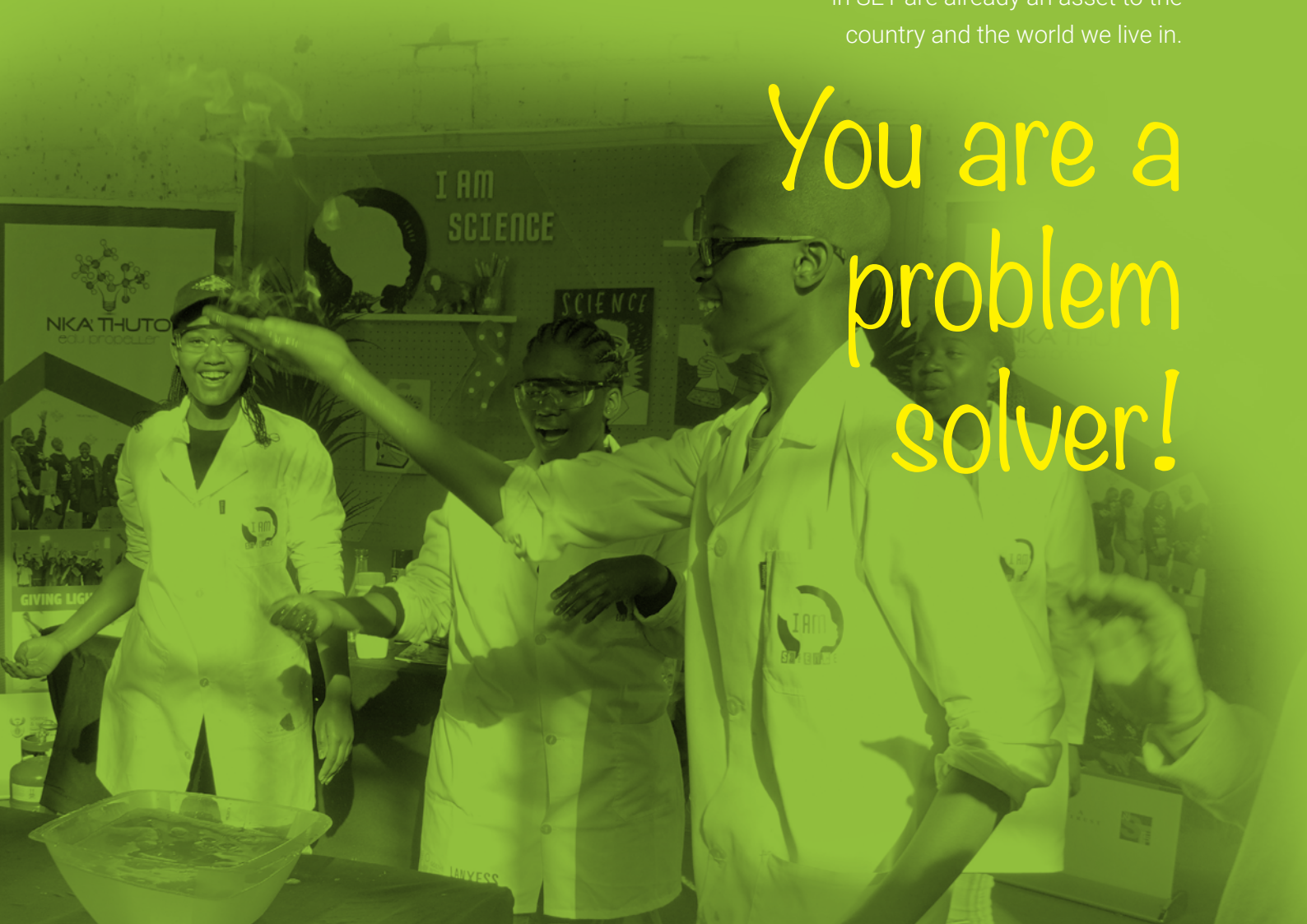


Dear young science enthusiast



Science, engineering and technology (SET) are very exciting fields but what makes them very important is that they hold the key to solving some of the world's greatest problems. You, as a young person with an interest in SET are already an asset to the country and the world we live in.

You are a problem solver!



Meet professional problem solvers

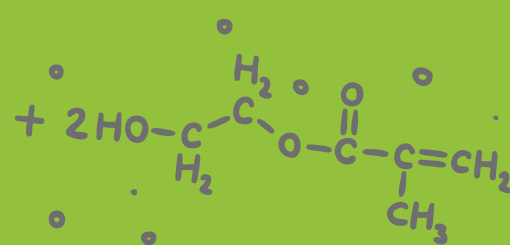
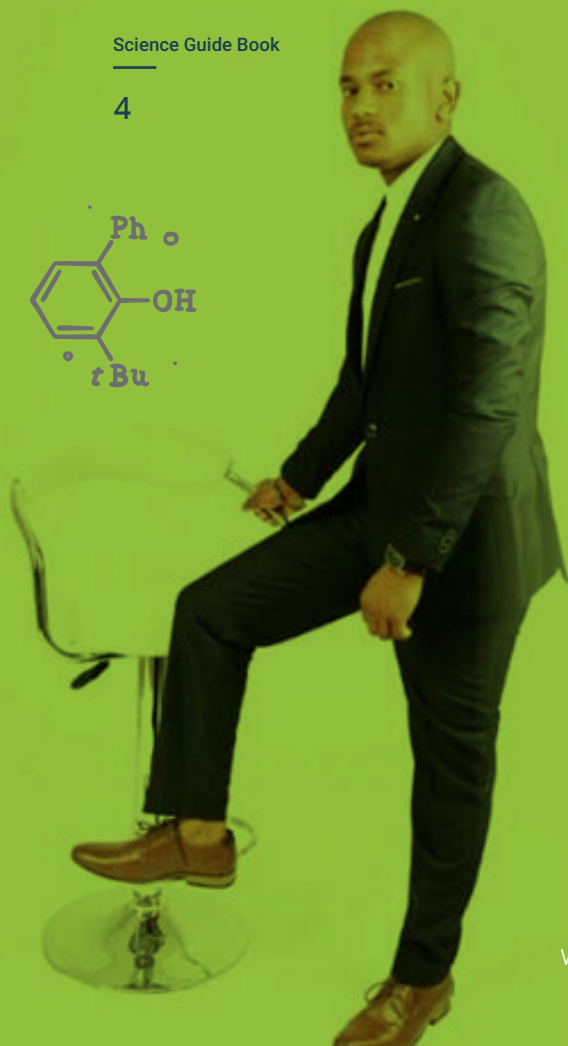
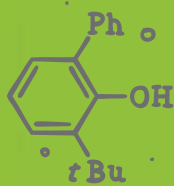
Ms. Lindelweyizwe Manqele

Ms. Manqele is an electrical engineer / computer scientist from KwaZulu Natal. She is passionate about improving waste management in communities through a field of engineering called the INTERNET OF THINGS.

How?

She used programming and mathematics to develop a system where the waste collectors can be notified when the dustbins are full without physically going to check them. This is an efficient way of making sure the waste is collected in time and the communities are kept free from waste pollution.





Mr Mphulaphuli Komani

Mr Komani is an agronomist from Tshwane University of Technology. His interest lies in ensuring food security by using alternative methods of growing plants or crops despite the presence of climate change.

How?

He developed a smart automated Hydroponics system where plants can be grown without the soil, but instead using a solution containing important mineral nutrients. When there are changes in pH, water levels and temperature, the system reports in a form of an SMS and these changes are dealt with remotely. This system is an innovative way of ensuring plants still grow anywhere even when climatic changes such as drought and global warming occur.

Mr Minenhle Dlamini

Mr Dlamini is a Candidate (ECSA) Electrical Engineer who graduated from the University of KwaZulu Natal (UKZN), he is currently busy with his Master of Science in Big Data Analytics with deep focus in Predictive analytics. The problem he is trying to solve is the high Engineering discipline drop-out rate at the UKZN.

How?

He created an innovative model that will predict which Engineering discipline will have the highest dropout rate at UKZN in future years. This will help the faculty to know which discipline will have the highest dropout rate in future years, so that they can allocate more resources in that discipline thus preventing the high drop out rate.



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How do you know what problem to solve?

How do you decide on a topic?

Think about something you are interested in

- Think about how it works or what it is about
- Think about the challenges it has
- Think about how you can solve the challenge, or
- How you can improve it.
- Look at the list of categories for the Nka'Thuto science projects and their descriptions,
- this might also help you find a topic for your science project.

You might get some inspiration by looking around in:

- Television shows
- Browsing the internet
- Magazines, newspapers, books, textbooks
- NB: Remember, you are not allowed to do a project that already exists in your textbook because your project must be completely original.
- You can also look at problems in your classroom, school, community and even in the country or the whole world.
- Also, talking to people around you including friends and family members about some problems that they have that you can find the scientific solutions for.



2. Criteria for a winning project

Originality and Novelty

- The solution to the problem you choose for your project should be yours and no one else's.
- The solution to the problem you want to solve should not exist already, it has to be a new solution.

For example, your project can be one of the following:

- An innovative (creative, new or improved) and smart solution to a problem
- The development of a new device to solve a problem
- Identifying ways to make an existing device even better
- Developing a smart phone app that addresses an unmet need
- Perform an investigation that has never been done before

DO NOT do the following:

- A dangerous project
- A project where you work or do experiments directly on humans, animals and insects.
- Some plants and animals are protected by Nature Conservation laws. Do not do experiments or projects involving such plants or animals.

Now that you have decided on the topic for your science or engineering project. You need to put together a research plan.



3.

Writing your research plan



3.1. What is a research plan?

A research plan, as the name suggests is a detailed 2-4-page document which shows:

- What your research is going to be about?
- A viable (doable or capable of working successfully) and reasonable research problem
- Why you have chosen that topic?
- Why the topic is relevant?
- How you will do your research?
- What will the outcomes of your research be?
- Will the research be completed in time?

3.2. Sections in your research plan

- Title
- Abbreviations
- Statement of your research problem

- Describes the research problem you identified
- This is very brief, 1 sentence to a paragraph
- Background/literature to the research problem
- Clearly describes the area of the problem
 - » Describe what the problem is
 - » Why is it a problem?
 - » Describe whether there are existing solutions to the problem and state the challenges these solutions have (limitations).
 - » This is important to highlight the need for new research or solution you are suggesting
- Why is it necessary for the research to be done?
- Includes in depth information about your research question.
 - » Clearly explain in detail what your research/ solution is
 - » How will it work if it's a device?
 - » How will it solve the problem?
- Hypothesis or research question
- This is the starting point of your research which states what you believe the outcome, or the answer of your research question will be
- Objectives of your research
- Research design and method
- Timelines
- What resources will you need?

Research!



3.3. Doing your research

The process of doing your research:

1. Preparing your introduction by gathering information
2. Materials and Methods for collecting data
3. Showing your results
4. Discussing your results
5. 5Conclusions

3.3.1. Introduction

- This is often also referred to as a literature review because it is based on existing information about your topic or the problem you plan to solve.
- This information can be obtained from books, articles and from the internet
- Just remember to record all the details of where you obtained the information for your reference list or bibliography.

An introduction is basically an essay that does the following:

- The introduction aims to convince the reader that there is a need for your research.
- Introduces your topic and finds evidence for the topic. Evidence for the topic for example is a quotation.
- The introduction aims to convince the reader that there is a need for your research.
- If the problem I want to solve is that there is no cure for HIV, the evidence for the need of a cure can be a statistic about HIV.

Example: "According to the World Health Organization, South Africa has the highest reported infection of approximately 7 million people".

More about showing evidence for the need of your project:

Summary:

- Here you would summarize a piece of evidence obtained from your source and rewrite it in your own words while making it shorter.
- Remember that you are not allowed to copy information written by someone else (this is plagiarism), you have to rewrite it according to how you understand it.

Analyze:

- This is your project and you have your own ideas about it, and you need to show this in your introduction.
- Don't doubt that you can contribute your thoughts about the information you collected, we are interested in your opinion and we want to hear it.
- Describe the information by answering these questions; What? Who? Where? How?
- And then answer the question: SO, WHAT?

Example of analyzing: "The soccer team from Orlando in Soweto has lost 10 games in a row since the beginning of the year. The coach of the team has been Thulile Khanyile since 2015"

- What? The soccer team has lost 10 games
- Who? Team in Orlando, Thulile Khanyile
- Where? In the soccer tournament, this year, the team is from Soweto
- How? By not scoring goals and not winning
- SO WHAT? Maybe they must change the strategy from the one they are using to another one. OR Maybe they should find new players. OR Maybe the coach must be changed. OR Maybe the team must be closed.
- Your introduction essay must also include a conclusion:
- This part has what you propose will solve the problem.

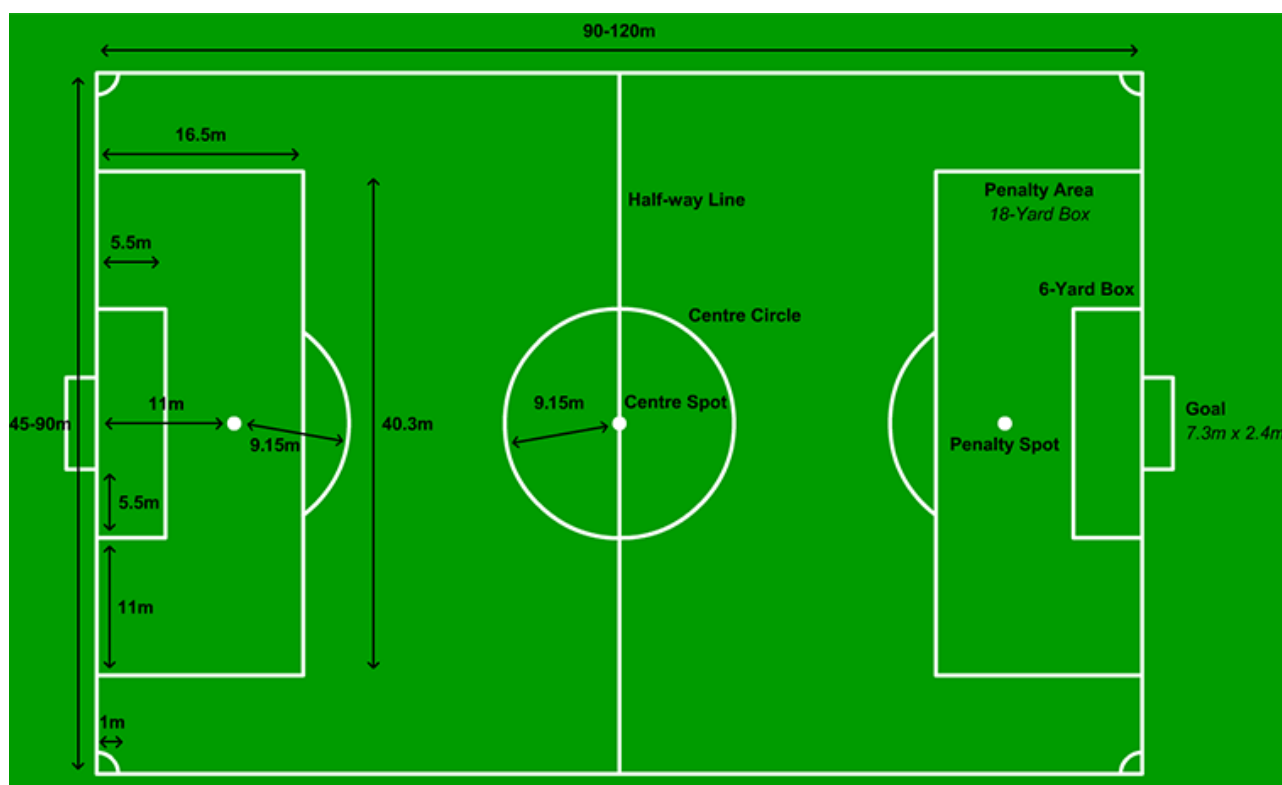
For example, looking at the soccer example you may say, "In conclusion the solution I propose to the challenge being faced by the soccer team from Orlando is that the coach is changed. I believe that this will make a difference as the players of the team have said that they are unhappy with the way the coach treats them. The players also believe that a new coach might be better for the team"

3.3.2. Hypothesis or engineering goals

Now that you have made a conclusion about what you think will fix the problem, you will need to make an educated guess about what the findings of your project will be. This will be your hypothesis!

- So, in the soccer example, following your concluding statement you may say,
- "I hypothesize that by finding a new coach for the team, the team will be able to win more games and may also be able to win tournaments like the PSL".
- For engineering projects:
- Set the engineering goals
- These should state how you think your prototype or model will be able to solve the problem you have identified.
- So, in the soccer example you may say; the goal of this project is to build a proper





Picture 1: A 2D design of a proper soccer field with well-structured goal posts

soccer field with well-structured goal posts. This will make the players get used to playing under professional settings and improve their chances of winning outside tournaments.

3.3.3. Study aims and objectives

The main aim of your study or the purpose of your study communicates what you intend to do and briefly, how you intend to do it.

For example, looking at the soccer team you might say, "The aim of this project is to find a more experienced coach with an excellent history of winning tournaments and games to replace the current coach Thulile Khanyile".

Unlike the Aim, the objectives are simply short-term goals or steps you need to take in order to reach the long-term goal which is the Aim.

So, given the Aim in the soccer example, your Objectives may be:

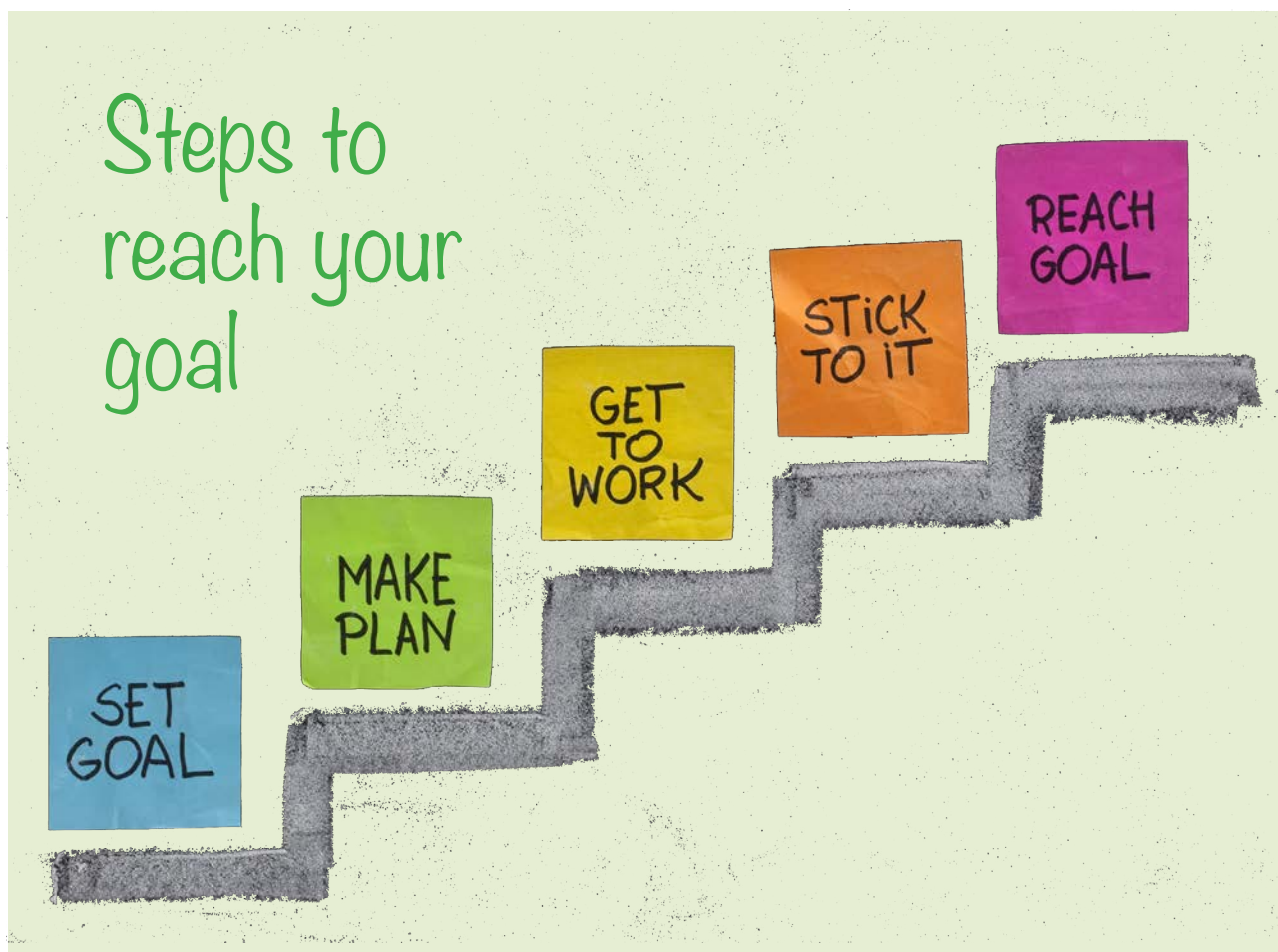
1. To create a job description for the proposed coach.
2. To advertise the position of the coach.
3. To look at the profiles of all the coaches who applied for the job and make a shortlist.

4. Interview the short-listed candidates and decide on the best person to coach the team

For engineering projects:

Using the soccer example where your engineering goal is to build a soccer field with well-structured goal posts, your objectives may be;

1. To create a design of the soccer field
2. To conduct a cost analysis i.e. research on the type of materials needed to build the soccer field and compare costs
3. Build the soccer field model



3.3.4. Materials and methods: data collection

For a science project:

- Write out the steps you will take to test your hypothesis.
- In other words, you need to show the steps that you need to do to show the outcome you are expecting.
- The methods must lead to your solution to the problem you want to solve.
- Remember to do the steps more than once to show that your results were not a mistake. To show that they are a result of your educated planning.
- Remember that when you write what you did it must be in past tense and written in 3rd person.

Looking at objective 1 of the soccer example, which is to create a job description of the proposed coach. To do this you need to look at the duties of the coach, which includes training, and developing strategies that will make the team win games. So, your materials and methods section will be written like this:

For an example: “The job description was developed by writing a list of the duties that the coach will need to do”.

For an engineering project:

- Record the design of your prototype or model using sketches or photos.
- For instance, looking at the soccer example for engineering projects where you are meant to be building a soccer field, Picture 1 below would represent a design of your prototype.

NB. Remember your designs should be clearly labelled and the functions should be mentioned

- You should also build a model of your prototype to show what it will look like at the end and to demonstrate how it will solve the problem you identified.

For survey-based projects:

- Design a questionnaire that aims to address the problem you identified.
- Looking at the soccer team example, if you were conducting a survey to find out why the soccer team has not been performing well in the past, in the questionnaire you may ask the players these questions;



- » How many strong players are in the team?
- » How often do you train or practice for the tournaments?
- » Does the coach use the same strategy for the games?
- » What strategy do you suggest can be put in place in order to improve the team's performance?
- Find no less than 100 people to interview using your questionnaire.

3.3.5. Keeping a journal

- A journal is your personal book which has all your notes.
- It shows all your activities:
- What you plan to do.
- How you may have needed to change something.
- How you may have had to repeat something and how you did it.

This journal is very important because when you reach your fantastic solution you will need to remember all the steps you took to get your desired outcome.



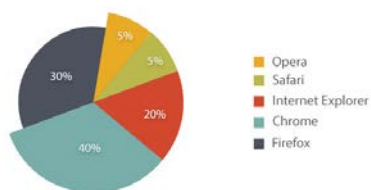
For example, every journal entry will have the date, accurate notes, the resources you need, where you can get them from, who you need to contact to get the resources, even the details of the people who help you are needed. This is because when you need to do it again, you will need to know exactly where you got everything you needed and how you did the project.

- This can be a hand-written booklet and it does not have to be neat. It is just for you, if you can make sense of it then it's perfect.

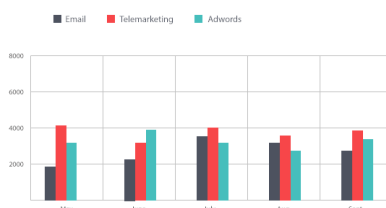
3.3.6. Results

- Don't go into detail or explain the data.
- Simply state what the data is telling you.
- It is best to present your results or data in the form of a photo, a graph, a list or a table.
- Make sure that all the photos, graphs, lists and tables that present your results have captions or headings.
- For engineering projects, record the results from testing your prototype.

Graph Types



Pie Graphs



Bar Graphs



Line Graphs

3.3.7. Discussing the results

- Results are normally discussed in the form of a statement that explains or interprets the data.
- Interpreting the data involves comparing different sets of the results. Remember to reference your figures from your results section.
- Observe the trends and patterns in your results.
 - » Mention the similarities and differences observed
 - » Where there are differences explain what could have led to those differences
- Discuss the limitations of your project.
- Discuss the errors and challenges that you encountered. It is also advisable to discuss how you could address the errors and challenges if you were going to continue with the project beyond the science expo.
- For engineering projects; discuss the results of your final prototype.

3.3.8. Conclusion

For scientific projects:

- State whether or not the results you got support or do not support your hypothesis.
- Your conclusion must be linked to your results as well as your hypothesis.
- Your conclusion can also let the reader know how you can make the project better:
- If your results didn't match your hypothesis, say what you would do differently in future. This could also be trying to figure out why the results don't agree with the hypothesis if you have not figured it out yet.

For engineering projects:

- State whether or not the results of your prototype match the engineering goals you set at the beginning of the project.
- If not, state what you could do differently next time to ensure that your results speak to your engineering goals.

You are done with the project...

- Now you must write a report based on all the sections we have gone through.

4. Writing your research report

Writing your research report

- You must say whether you did a science or engineering project.
- Cover Page: Title that is simple, scientific and descriptive
- Content Page
- Introduction (includes background and literature review)
- For science projects: Problem statement/Aim and the objectives

For engineering project:

- Engineering goals
- Materials and Methods:
 - Must be numbered accordingly
 - Must be written logically in order of how they were done, in past tense and in 3rd person
 - Remember to describe all your variables
 - Variable are the elements of your project. Some of the variables will be constant (they will not change), these are called independent. Some of the variables will change and these are called dependent variables.
- Results
- Discussion and data interpretation
- Conclusions
- Bibliography or references: This is a list of all the books, journal articles, internet sites that you used to get important information for your project.
- Also remember to reference all the images that you use that were not generated by you. All images that you get from books, the internet and magazines for example.
- Acknowledgements: This is a list of all the people or organizations that helped you to do your projects. This may also include people that encouraged and motivated you to continue when you felt like giving up or like things were not working your way.

Now that you have written your fantastic report...

Use it to write your abstract...

5. Writing your abstract

An abstract is a brief summary of your science project. It should not be more than 250 words in length. It should be written in a way that will make the reader more interested in your project. It should include the following sections:

- Your details
- Category
- Title
- Aim
- Procedure/ Material and methods
- Results
- Conclusions
- You can use the template provided for your abstract.

Preparing your poster presentation!!

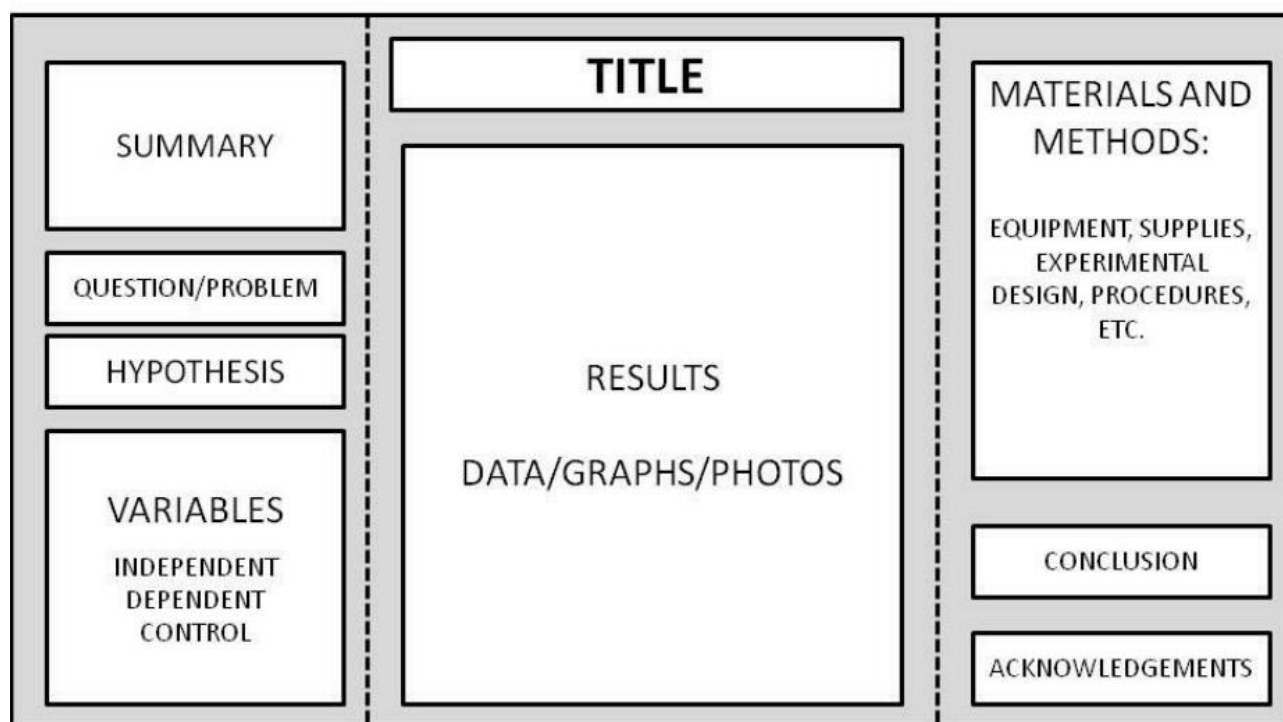


Figure 1: Image showing the format of a science expo display board.

The display board will be provided

- Poster:
- All information must be printed on A4 pages
- Make your poster catchy so that it looks good to the judges and the audiences

To give you a better idea of how the poster should look like, here's a poster from an Nka'Thuto Alumni



Engineering models or prototypes;

- These must not be bigger than 50cm in length
- Have your journal displayed
- Have your written report and abstract on display

Now that you are aware of the sections included in a scientific report, let's make things practical by using the following scientific example to write a report.

Lindokuhle Mthethwa is a teenage boy living in Alexandra who is very concerned about the environment in his community. There is too much garbage around the streets because the municipality Pick-it up workers have been on strike and refuse to clean the streets. As a result of this, some of the garbage end up in the rivers and pollutes the water systems.

He says he tried to address this problem with his community leaders who thought burning the garbage would reduce the land pollution. However, burning it would cause more harm than good, as it would cause another problem of air pollution.

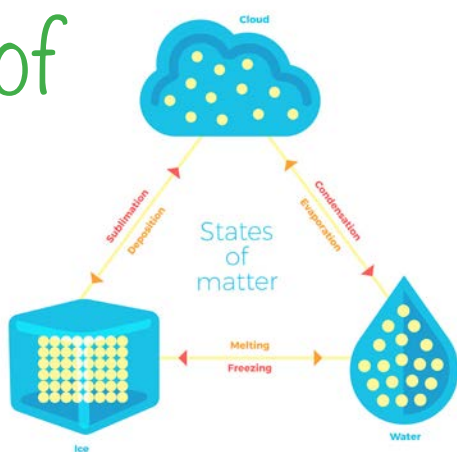
Since the community still struggled to come up with a sustainable and safe solution to this land pollution problem, Lindo decided to take matters into his own hands and use Science, Engineering and the principles of matter to solve the problem with creative ideas!



POLLUTION

He has learnt from his science classes that matter is anything that occupies space and has mass (physical sciences grade 10, Siyavula). In addition, matter exists in three states i.e. liquid, solid and gas which can be converted from one state to another using either heat or the process of dissolving as shown in the picture below.

States of matter



Since the garbage in Lindo's community has mass and also occupies space which in this case is the land, Lindo concluded that this garbage is also matter and principles of matter can be applied to it.

He further realized that a high percentage of the garbage is made up of paper cups and takeaway plates which are made from a material called polystyrene

So, bearing in mind that these polystyrene cups and plates (paper cups and takeaway plates) are solid matter which can be converted into liquid by dissolving or heat, the young man suggested that since polystyrene is recyclable, it should be collected, dissolved in a non-harmful chemical (Acetone) and molded into useful products such as chairs and tables as illustrated in the diagram below. That way, the garbage is eliminated and the community benefits from selling those products!



Acetone



Polystyrene cup
dissolving in Acetone



Molding dissolved
polystyrene into chairs and
tables

Below is a step by step break down of this example (Lindo's solution) into a scientific report

NB. Remember when you write a report, you are giving us feedback about what you have already done, so you should write it in 3rd person and past tense. Example; The coffee was warmed up in the micro oven NOT I warmed the coffee in the micro oven.

1. Problem;

The Alex community faces a huge challenge of land pollution with the community members littering takeaway cups and paper plates.

2. Background/ literature review;

Land pollution is defined as the act of damaging the land as a result of our daily irresponsible activities. The most common irresponsible human activity leading to this land pollution is littering and has been proven to negatively impact on our health. Therefore, to save both the environment and human health, there is a need for new innovative solutions of managing waste in order to prevent land pollution. This solution involves recycling polystyrene cups and plates from the litter and changing them into useful products by using a chemical called Acetone.

3. Hypothesis;

Acetone will dissolve polystyrene cups and plates

4. Aim;

The aim of this project is to recycle and dissolve polystyrene (paper cups and plates) in acetone, so that it can be converted into useful tables and chairs.

For engineering projects.

- Your engineering goal may be: To build chairs and tables from dissolved polystyrene

5. Objectives;

- To find out how much Acetone will be needed to dissolve the polystyrene
- To find out how long the polystyrene will take to dissolve
- To investigate how quickly should the polystyrene be molded into chairs and tables after the dissolving process
- To create a design of the chairs and tables that will be build

6. Materials and Methods

- Polystyrene (paper cups and plates)
- Acetone
- Measuring cylinder
- Bowls
- Gloves
- Scissors
- Watch
- Shaper



- Polystyrene cups and plates were collected and cut into smaller pieces
- About 10, 15, 20 and 25 ml of Acetone was measured using the cylinder and poured into separate bowls
- Thereafter, the polystyrene cups and plates were added into each bowl
- The timer was put on to measure the amount of time it took the polystyrene to dissolve in each bowl. This was recorded in a table
- The dissolved polystyrene was then placed inside a desired shaper to build the chairs and tables
- Molded chairs and tables were left to air dry

7. Results

- The time it took various amounts of Acetone to dissolve the polystyrene cups and plates was recorded in the following table.

Time it takes to dissolve (min)	Amount of acetone (ml)
25	10
20	15
15	20
10	25

8. Discussion

- Remember in the discussion you interpret your results i.e. tell us what they mean, mention the disadvantages (limitations) of your project and suggest how you could improve the project in future.
- So, looking at the Results in Table 1 of Lindo's project, in the discussion we may say;
- The time it took polystyrene to dissolve decreased with the amount of acetone added into the bowl. This means that when more Acetone was added, the polystyrene dissolved quickly. However, using a high concentration (amount) of Acetone can be harmful as inhaling too much of it causes headaches, nausea and eye irritation. To overcome this limitation, the dissolving process could be done in a well air conditioned (aerated) environment to quickly circulate the evaporating Acetone outside and prevent the negative side effects.

9. Conclusion

- In conclusion, the findings in this research supported the hypothesis because Acetone successfully dissolved polystyrene cups and paper plates, which were then molded into useful products (tables and chairs) that Lindo's community could use. The rate of dissolving depended on the amount of Acetone that was added.

EXERCISE; Time to use those brain cells!!

- As previously mentioned, Results can be represented in various formats, including different types of graphs (linear, bar graph, histogram, pie charts), diagrams and pictures.
- So, as part of your exercise, use the information in the above Table to represent Lindo's results in different formats and briefly describe the results in words.

Edu Propellers, now that you know how to write a scientific report, have a look at an Engineering (Fourth Industrial Revolution i.e. 4IR) example below.

Challenge yourself by writing a report on it !!

Solving real life problems using Engineering and Computer science

With the high rise of emerging technologies, such machine learning, big data analytics, cyber security, robotics and block chain as part of what is called fourth industrial revolution(4IR), it is important that organizations try to keep up with this technologies to maintain good competitive advantage. It is also important that organizations equip their employees and local youth with the necessary skills needed such as coding (both hardware and software).

At Nka'Thuto Edu Propeller, all the employees and Edu propellers have such skills which have enabled them to create a floor scrubbing (Cleaning) small robot. The robot that they created is a mobile phone-controlled robot which can detect obstacles and is an important product which will help people maintain a clean environment while busy with other duties. The robot consists of a scrubber underneath which cleans the floor.

This technology has made it possible for people to be able to clean their room, tables etc. while sitting down watching tv or even drinking coffee. The cleaning robot has also proved to be user friendly and has also the effects of reducing stress to the user because it is funny and exciting to play with.

Once you are done with all the sections of your report, you need to write an Abstract to sell your idea to someone who has not read your report before.

Below is an exercise to help you write your Abstract excellently.



ABSTRACT EXERCISE

- An abstract is simply a brief summary (200-250 words) of your research or project.
- It should be straight to the point but specific enough to give the reader a general idea of what your research is about without them reading your entire report.
- It should include 6 summarized important sections namely problem/research question, background/introduction, aim, methods, results, discussion and conclusion.
- To make sure these sections are included, here are relevant questions you need to ask yourself;
 1. What is the problem in my community?
 2. Why is it a problem i.e. how is it affecting the community?
 3. What solution or research are you proposing?
 4. What is the aim of this research?
 5. How was this research done i.e. what materials were used and how were they used in your research?
 6. What major findings did you get? NB. Here you describe the main result you obtained or observed during your research
 7. Are your findings what you expected and what do they mean? Why are these findings important?
 8. What are the limitations of your research and how can you improve them in future?

Once you have answered all those questions, fill in the missing words using your answers to construct a full Abstract below

ABSTRACT TEMPLATE

Project category: _____

Project title: _____

Student name: _____

Grade: _____ School: _____

Region: _____

The problem in _____ is that _____

This is a major issue because _____

As a solution to this problem, my project will _____

and the aim of this project is to _____

The research was conducted, or prototype built using (materials and methods)

While conducting the research, our main finding (results) was _____

Interestingly, the results indicated that (trends/patterns/ limitations/errors/challenges)

In conclusion, the findings in this project approves or disapproves (underline one that applies) the hypothesis which stated that _____

will be done to improve the accuracy of these findings in future. The impact of this project and its finding is _____

Appendix 1: Plagiarism declaration

1. Plagiarism is using another person's work as if it is your own work. I know that this is wrong.
2. Where other people's work has been used in my project, I have acknowledged them and listed the sources of information in my reference list.
3. This project is entirely my/our own work.
4. I/we do not allow and will not let anyone else use my/our work as their own. In the event that someone uses the content of my/our project, they will have to reference my/our work accordingly.

Name/s:

Signature/s:

School: _____

Date: _____

THIS PLAGIARISM FORM MUST BE SIGNED AND PLACED AT THE FRONT OF YOUR REPORT. THIS FORM WILL BE CHECKED BY THE JUDGES BEFORE THE SCIENCE EXPO.

WITHOUT THIS DECLARATION FORM THE NKA'THUTO SCIENCE EXPO ORGANISERS HAVE THE RIGHT TO TERMINATE YOUR PARTICIPATION IN THE EXPO.

Appendix 2: Science Expo categories

Agricultural sciences _____

Animal/ veterinary sciences, marine animals and animal ecology Chemistry

Computer sciences _____

Earth science (geography, geology and oceanography) _____

Energy that is non-renewable (fossil fuels and the use of electricity)

Energy that is renewable (solar, biofuels, wind, wave, geothermal and other alternative energy sources)

Energy efficiency and energy conservation Engineering: electronics and electrical

Engineering (Chemical, metallurgical, mining, Civic and architectural, Mechanical, aeronautical and industrial)

Environmental management _____

Studies looking at the interactions between humans and the environment (waste management, deforestation, land management and bioremediation).

Environmental science: Studies looking at changes in the environment (pollution, climate change, carbon emissions)

Food science, food technology and healthy eating Health care and sports science

Housing and settlement studies

Indigenous knowledge systems: studies looking at the use of using plants as therapy

Innovation and technology for recycling and recycled materials Mathematics and statistics

Medical sciences _____

Studies looking at the human body (anatomy, genetics, physiology)

Studies looking at diseases, disease-causing organisms and medicine)

Microbiology and biochemistry

Physics, astronomy and space science

Plant sciences including marine plants and plant ecology Social and psychological sciences

NAME: _____

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2. Hypothesis or engineering goals:

3. Materials and methods:

4. Discussion of results:

5. Bibliography (5 most important ones):

Feedback from mentor/teacher:

Signature and date by mentor/teacher:

NAME: _____

[illegible]

3. Aim

4. Objectives

5. Materials and Method

6. Results

7. Discussion

8. Conclusion

9. References

10. Acknowledgements



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