STEM Activity: Design a wind boat that can carry a load/weight of 500g travelling at a maximum average speed

Grade : 11 **Term: 4** **Number of Groups: 8** **Due Date : Term 4, Week 6**

Assessment: Formative/Summative

Setting the Scene

The activity is to construct a wind boat that can travel fast with a given load. This activity has been chosen for students to think critically and analyse situations based on the current issues on media of people especially on the coast who travel by boat to coastal islands overturned or go missing due to low fuel since fuel price is currently high, boat mechanical problems, tides and current or excessive load on the boat. This activity has been selected as a "hook" to engage students in the integrated STEM activities involved. This STEM activity provides a rich real-world context and will engage students to explore big ideas from more than one STEM discipline.

Students will design and build their wind boat with different materials and with different measurements for each material considering the design challenge. Students in their groups construct the wind boat that meets their expectations/requirements taking into consideration the criteria and constraints. Students will redesign and retest their wind boat until it reaches a maximum average speed with a given load. The aim is to design the wind boat so that it travels faster with the load on.

Students in their groups of four member per group are given five weeks must work through the design process to prepare, design and re-design their prototype or model in time for the school show when they will showcase their models, do a presentation of the information and data collected.

Learning Outcomes/PNG Curriculum(OBC)

Subject	**Learning Outcomes**
Science/Physics	Students can: • estimate the order of magnitude of very, very small and very, very large quantities in suitable and appropriate units • analyse, deal with and minimise the expected errors involved in various measurements and calculations • draw and interpret experimental data • use and convert internationally accepted units of measurement

- demonstrate an understanding of the characteristics of motion
- draw and explain graphs of motion
- define and classify types of forces
- state and discuss Newton's laws of motion
- investigate and describe friction
- conduct experiments on forces
- demonstrate an understanding of momentum and impulse.
- name and describe different forms of energy
- state and apply the Law of Conservation of Energy in terms of the energy transformation to practical situations
- explain how force, energy and work are related and perform a practical exercise
- perform calculations relating work done by an object and the changes involved in kinetic energy and potential energy
- apply the concepts of electrostatics to simple point and continuous charge distributions
- demonstrate an understanding of electromotive force, internal resistance and terminal voltage of cells or batteries
- investigate, analyse and explain that resistance of a conductor is a function of its physical dimensions, material type and temperature
- describe and explain resistance, current, voltage, energy and power, and the relationships between these quantities
- describe different types of electric circuits including series, parallel and network circuits
- demonstrate an understanding of Kirchhoff's circuit laws and apply these laws to network circuits
- discuss the principles of alternating current (AC) circuits
- show experimentally that current generates a magnetic field in a conductor
- describe the forces acting on a current-carrying conductor when placed inside an external magnetic field
- demonstrate and explain, using models, the principle of operation in electric motors
- explain how a current is induced in a conductor when moved inside an external magnetic field or when placed inside a constantly changing magnetic field
- explain the principle of operation in AC and DC generators and identify their basic structure
- discuss how electromagnetic-based electric machines (models, generators and transformers) make a positive impact on Papua New Guinean society.

Design & Technology

Students can:

- use the design process to produce appropriate solutions
- apply safe and appropriate codes and practices in the learning and working environment
- apply knowledge and understanding of processes through identifying, selecting and using various materials and/or systems

- demonstrate a range of skills and techniques
- evaluate the process and product against the design brief
- communicate ideas and information in a variety of ways.

ICT Students can:

- apply advanced skills and concepts in creating solutions to information problems using a range of information software
- develop multimedia presentations using a range of hardware and software devices.

Mathematics Students can:

- use knowledge of numbers and their relationships to investigate a range of different contexts
- identify, interpret, describe and represent various functional relationships to solve problems in real and simulated contexts
- measure and use appropriate techniques and instruments to estimate and calculate physical quantities
- interpret, describe and represent properties of relationships between 2-dimensional shapes and 3-dimensional objects in a variety of orientations and positions
- demonstrate the application of statistical knowledge and probability to communicate, justify, predict and critically analyse findings and draw conclusions
- apply mathematical procedures including technological resources to solve practical problems in familiar and new contexts

Activity Objectives

By the end of the activity, students will be able to:

- Design and build a model of a wind boat that can travel fast with a given load
- Investigate floating and sinking
- Explain Archimedes principal
- Identify the different forces acting on the wind boat when it is not moving and when it is moving
- Explain the different forces on the boat when it is moving and why it is moving forward
- Identify and explain the different forms of energy and energy change
- Explain electricity and electromagnetism
- Observe, measure and record data

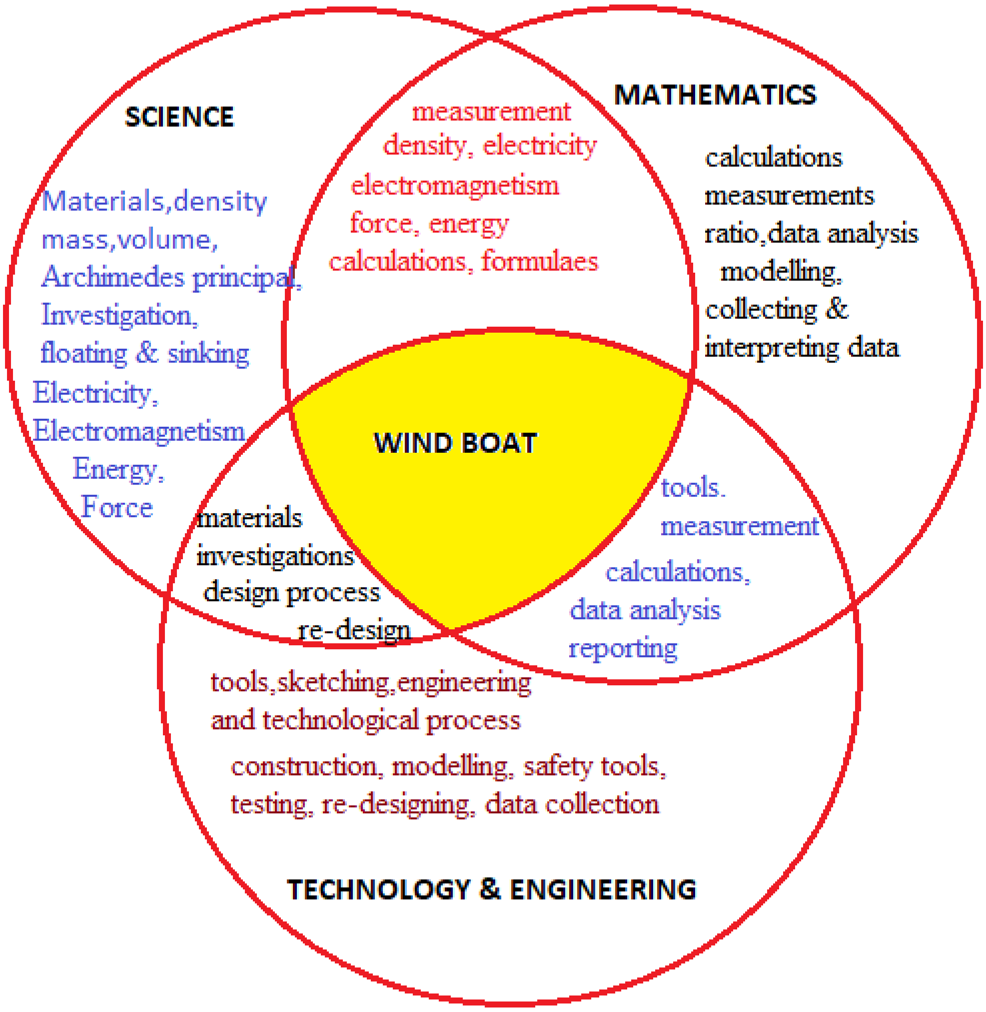
- Communicate clearly and effectively through writing and presentation.
- Effectively use technology to analyze data.

The three objectives above describe the processes while the rest describes the content that relates to main concepts or big ideas from within and different STEM disciplines.

STEM Big Ideas

Most STEM big ideas focussed within each discipline but some STEM big ideas within each discipline have application in other disciplines as well.

Vann diagram showing connections of STEM big ideas within and across STEM disciplines.



KEY/DRIVING QUESTIONS

- ✓ What makes a good boat that can travel fast with load on?
- ✓ What makes the boat float and not sink?
- ✓ What makes the boat move?
- ✓ Why did the boat move forward?
- ✓ How can we make the boat move forward faster?

DESIGN CHALLENGE/PROBLEM

Design a wind boat that can carry a load/weight of 500g travelling at a high speed..

CRITERIA

Each group should use any materials that are cheap with their own measurements, select an appropriate boat designs and construct a wind boat that can carry a load/weight travelling at a maximum average speed.

The selected materials used in the design should consider the following:

- Keep the load/weight and distance boat travel constant for all the wind boat models
- They can vary the following taking into consideration their measurements:
  - ✓ Type of material for their boat design
  - ✓ Shape of the boat
  - ✓ Number of propellers
  - ✓ Size (length & width) of the propellers
  - ✓ Height of the mount for the propeller
  - ✓ Voltage – speed of the propeller
  - ✓ Type of Electric motor
  - ✓ Type of Rudder and its position
  - ✓ Position/direction of the propellers
  - ✓ Size and position of the rudder

Note: The above criteria developed to judge the quality of student work. Students will learn to identify and analyze their own shortcomings, take responsibility for improving them, and gauge their progress as they move forward (North Carolina Department of Public Instruction 1999, online).

CONSTRAINTS

They will use any materials with different measurements. However, the load or weight on the boat is same for all different designs. Other constraints include wind direction and speed, observing, measuring and recording time, position of the wind boat, time given for the project.

Assumptions

- ✓ Neglect wind speed and direction
- ✓ Neglect waves speed and direction
- ✓ Neglect water current
- ✓ Assume (measured) distance in a straight line. The distance the boat will travel is fixed and in a straight line.

Materials

The materials needed for the wind boat project is listed below. These are materials that can be found in their local environment.

- ✓ Electric motor
- ✓ Propeller
- ✓ Polyester / wooden timber/
- ✓ Wire
- ✓ Dry cells
- ✓ Switch
- ✓ Blade
- ✓ Scissor
- ✓ Ruler

Optional Materials

- ✓ Paint
- ✓ Brush

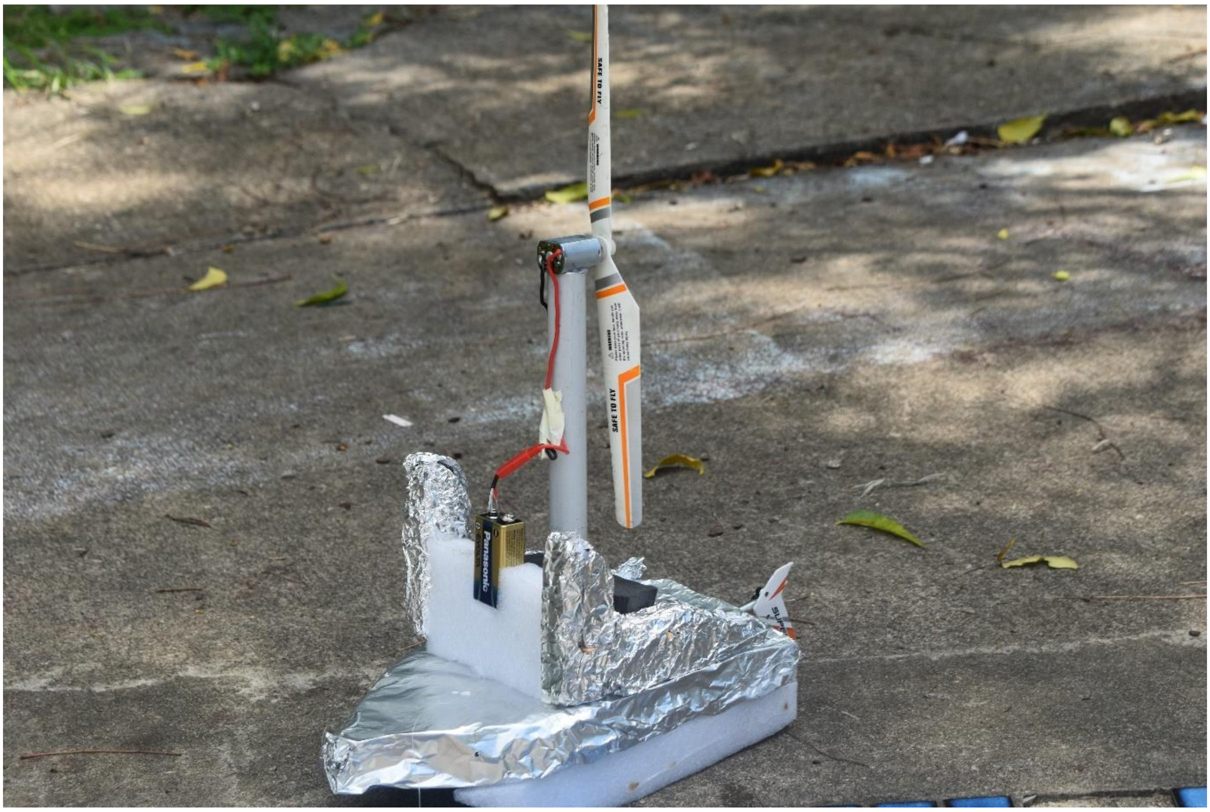
Safety

Students are to take extra care when using or handling of blade/cutter, dry cell, propeller when switch is on.

PRIOR ACTIVITIES

- Teacher identify load/weight for the different models which should be same
- Teacher prepare a basin for the groups to test floating and sinking of their boat models
- Teacher organize class into groups of 3 to 4 students considering gender balance.
- Teacher identify and prepare different materials required for the wind boat models and propellers

MAIN TASKS/ACTIVITIES



The authentic tasks ask students to demonstrate skills that are aligned with the standards and many of the tasks can be modified to be used as formative or summative assessments.

Tasks

Task 1 : Given the design challenge, students watch videos of different boat designs to provide a meaningful context for the activity and understand the problem.

Students are provided with videos of wind boats travelling:

a. with different designs(shape,length,width)
b. with different materials used in the boat construction
c. with different loads
d. against water current and tides
e. having different number and size of propellers, size of electric motor, amount of voltage from the power source.
f. Position of the rudder

Students are presented with the type of readiness questions while watching

a) which boat material is good for a boat design?
b) Which boat design enables the wind boat to travel fast?
c) Does the number and size of propellers, size of electric motor, amount of voltage from the power source affects the speed of the wind boat?
d) which boat design travels fast with the given load?
e) Does the position of the rudder affects the direction of movement?

Task 2 : Students in their teams or groups plan and sketch different boat designs with their own measurements.

Task 3 : From their sketch or designs, using the design process they construct a prototype of the wind boat

Task 4 : They test floating & sinking, connections and current flow, rotation of propeller, direction of movement and speed in a basin

Task 5 : Teams evaluate and modify their model

Task 6 : Students in their groups test their model of the wind boat in a pond where the water is still to make sure it meets the design challenge, criteria, and constraints.

Task 7 : Each group do several tests and collect data on the time taken for the wind boat with the fixed load on to move a fixed distance and calculate the average speed.

Task 8 : teams further develop and then present their final design

During the design process, the teams are required to record in a design journal what they did, what they modified, and what they learned. Each team is required to document in their journals describing

(a) what they have done,
(b) what changes they have made to their design,
(c) what they have learned, and
(d) what they plan to do next if they re-design or they are given an activity extension.

This prepares the teams to make a brief report/presentation and demonstration during the school show.

During the school show each group will demonstrate and present their models and reports considering the effectiveness of the different designs in meeting the design challenge.

For the activities above STEM big ideas have been identified in the core integrated STEM activity that can be explored during science, technology/engineering and mathematics lessons.

These STEM big ideas include:

a. Density, Archimedes principles, Energy and Energy conversion, Force and Newtons Laws of Motion (Science);

b. scale drawings, tools and safety, design process (technology/engineering); and
c. measurement and calculations, data analysis, modelling (mathematics).

We focused this whole-class activity around three questions:

a. What did you do during the STEM activity,
b. What do you think you learned from this STEM activity, and
c. What questions do you have as a result of completing this STEM activity?

However, in order to facilitate in-depth exploration of the targeted big ideas during the STEM activity, the following thinking tools were selected:

a. external representation tools—concept maps, tables and graphs, models, diagrams, and plans;
b. different perspective tools—demonstration and presentation of report; and
c. reflection tools—task reflection questionnaire.

Assessment Strategy

From this STEM activity, the different assessment strategies selected are:

a) design journal - collections of students' works selected to document progress within the given STEM activity and design challenge
b) Presentations, demonstrations, reports, video journals, exhibitions - tools that provide opportunities for students to demonstrate prototypes, describe their design solution and process, and describe the rationale for arriving at their solution
c) concept maps, flow charts, tables and graphs, construction diagrams/ plans - external representations of students' understanding of STEM concepts and processes; and
d) observations, interviews, tests, examination - tools to identify students' understanding of STEM concepts/processes

Many of the Assessment strategies selected can be used for formative, diagnostic, or summative assessment.

Assessment Task Sheet

Note: Given below are more than one assessment ideas for both formative and summative but will only select a few for my assessment task sheet.

Formative

Students will be assessed individually and as a group on the design of each model before and during the design process making sure each model meets the design challenge provided the given criteria and constraints.

They will also be assessed individually on their contributions and on the STEM big ideas which include Density, Archimedes principles, Energy and Energy conversion, Force and Newtons Laws of Motion; data tabulations, analysis, modelling, interpretations.

For the given activity/project, we make sure the assessment task sheet incorporates formative assessment tasks that consist of lots of feedback and opportunities to use since those feedback will enhance performance and achievement.

Some of the formative and authentic tasks also requires peer and self-assessment to encourage students take responsibility for their own learning.

Peer assessment is an important component of Formative assessment and should be encourage more in STEM activities.

Summative

Students will be assessed as a group on the final product or prototype making sure their model meets the design challenge and the given criteria and constraints.

However, students will also be given short summative assessments during the design process which will provide evidence to improve teacher instructions during the design process.

They will also be assessed as a group on their presentations of their report.

Most of the summative assessment tasks mentioned to be used in this activity is to gauge student's progress towards the learning outcomes and producing the best design. The tasks will also provide feedback and feed forward so that teacher can modify teaching and learning activities towards getting the final product from the given activity.

Task Outline	**What students will submit**	**How students can show evidence of achievement?**	**Type of Assessment and requirements** **Note:** students are required to consider the given problem or design challenge, criteria and constrains when submitting their evidence of achievement
Create a mind map about a wind boat	A print-out of the mind map	Use a range of sources to investigate wind boat to inform mind map	**Formative Assessment** Mind map should capture the following concepts indicated below: • What is a wind boat and how does it operate? • Wind boat design with their measurements (shape,length,width) • materials used in the boat construction, tools and safety • boat with a load travelling against water current and tides • number and size of propellers, size of

			electric motor, amount of voltage from the power source. • What are the STEM big ideas captured in the boat design?
Plan and sketch wind boat design with its measurements.	A print-out of the wind boat sketch plan	Boat sketch plan with all the different parts and materials required including their measurements (***a rubric will be developed***)	**Formative Assessment** • Wind boat design with their measurements (shape,length,width), materials used in the boat construction should meet the design challenge • The boat design should consider safety and the availability and cost of tools • number and size of propellers, size of electric motor, amount of voltage from the power source. • Wiring, connections, switch • Position of the rudder **Note:** Peer assessment is involved here since students in each group will have the opportunity to assess the work of the group regarding the sketch plan. They will assess the work of their peers against the given set criteria, constraints, and challenge of the activity. In doing so, providing feedback to their peers and better understand the given criteria. In doing so, students take ownership for their learning and the assessment process thereby increasing their motivation and engagement.
Design or construct a model or prototype of the wind boat that meets the design challenge	A photo of the completed wind boat and a video	Present wind boat design as a labelled diagram using appropriate technical terms explaining function of each part	**Authentic Assessment** • correctly label the boat parts • Explain the functions of each part • video must capture the construction of the boat during the design process

Test floating & sinking	A photo or video, an Observation Checklist & Table of Results	Photo and complete observation checklist and table of results making connections of results obtained to Archimedes principal. Present grid logs on floating and sinking connecting it to Archimedes principal.	**Authentic Assessment** • results in the checklist & table of results contain information from observation, explanation and analysis of results
Assignment on Density, Archimedes principles	Submit their assignment paper	understanding on the concept of Density and Archimedes principles	**Summative Assessment** • students should be able to explain the key concepts on Density and Archimedes principles and justify why things float or sink.
Test connections and current flow, rotation of propeller, direction of movement and speed in a basin	A video and Observation Checklist & Table of Results	understanding on the concept of electricity, electromagnetism, current flow, circuits, types of energy and energy transfer, power, work	**Authentic Assessment** • students should be able to explain the key concepts on current flow, electromagnetism, energy transfer, circuits, power, work done when energy is transferred
Make connections between power source, switch and propeller which is attached to electric motor and test	Formative assessment checklist done by the teacher	Understanding voltage, current and direction of current flow in a circuit which affects the speed and direction of movement of the propeller, electromagnetism,	**Formative assessment** Formative assessment checklist is used to capture all the learning that occurs during discussions, hands-on exploration and collaborative group work
Assignment	Submit their assignment paper	understanding on the concept of electricity, electromagnetism, current flow, circuits, types of energy and energy transfer, force , power, work	**Summative Assessment** • students should be able to explain the key concepts on current flow, electromagnetism, energy transfer, circuits, force, power, work done when energy is transferred
Practical Skills	Practical sheet	i. Students can set up series or parallel	**Summative Assessment**

		circuits as instructed ii. demonstrate safe layout iii. connect ammeter and voltmeter correctly in a circuit iv. measure current and voltage accurately using correct units in a working circuit v. show magnetic effects of electric currents. vi. demonstrate the factors affecting the strengths of an electromagnet.	
test the model of the wind boat in a pond and each group do several tests	Table of Results and graphs And a video or photos	Tabulate a table of results of data on the time taken for the wind boat with the fixed load on to move a fixed distance	**Authentic Assessment** • Measure the fixed distance • Do several test and record time taken to travel the fix distance • calculate the average speed. • Displaying data on the graphs using technology (computer).
Exam	Submit their exam paper	understanding on the concept of Density and Archimedes principles, current flow, electromagnetism, energy transfer, circuits, force, power, work done when energy is transferred	**Summative Assessment** • students should be able to explain the key concepts on Density and Archimedes principles , current flow, electromagnetism, energy transfer, circuits, force, power, work done when energy is transferred
The students presented their final product or model of the wind boat	The students show cased and presented their projects they have been working on during the school show Documentation of the project though	charts, posters, short video, design journals, report, PPP, Tabulated data with their results	**Summative Assessment** • students show case their products/models and posters, short videos to the audience during the show • students present the documentation of the project through Power Point presentation and provide a design journal or report to the teacher

a journal or report	• provide report and analysis of their data collection

RUBRICS

For students to ensure quality in their work based on the STEM challenge, criteria with given constraints were provided in the lesson. The given criteria in the lesson was a guide for the students to produce a quality product that meets the design challenge.

However, quality needs to be ensured throughout the activity by setting criteria for each of the tasks involved in producing the product and there should be clear understanding of the criteria as well as an understanding of acceptable evidence making performance assessment a powerful tool for learning.

The criteria for each assessment task need to be understood well by students to ensure fair, consistent and defensible judgements through moderation with peers at various stages. Moderation will enable the teacher to build confidence in the judgement of evidence and in the feedback given to students about their learning. Moderation can also provide valuable information about the quality of assessment instruments. The information from the assessment task will be captured in the criteria for each task or group of tasks.

That means judgements on the rubric for each assessment task needs to consistent, informed, reliable and of high quality.

RUBRICS FOR THE WIND BOAT PROTOTYPE/MODEL

Wind Boat design Challenge: Design a wind boat that can carry a load/weight of 500g travelling at a high speed.

Criteria		**4 (100 – 75%)**	**3 (74 – 50%)**	**2 (49 – 25%)**	**1 (24 – 0%)**	**MAX. MARKS**
Quality product	X2	Exceptionally attractive and particularly neat in design and layout	Attractive and neat in design and layout	Acceptably attractive but a bit messy and show lack of organization	Distractingly messy or very poorly designed. Does not show pride in work	8
Speed	X4	1st or 2nd point ranking.	3rd or 4th point ranking.	5th or 6th point ranking.	7th or 8th point ranking.	16
Use of materials	X4	Use all materials that are light and repel water	Use most materials that are light and repel water	Use some materials that are light and repel water	Did not use materials that are light and repel water	16

Documentation	X3	Steps for making the wind boat are precise and clearly written	Steps for making the wind boat are clearly written	Some steps for making the wind boat are somewhat clearly but important steps are left out	Steps for making the wind boat are unclear and lack important details	12
Making Changes	X3	Made significant changes that greatly increased the buoyancy and speed of the wind boat	Made changes that improve the buoyancy and speed of the wind boat	Made some changes to improve the boat but did not make the boat travel fast and more buoyant	Did not make any changes or improvements	12
Teamwork	X3	Excellent work from all team member's roles	Work for some of the team member's roles is good and the others is either good or excellent	Work for some of the team member's roles is poor and the others is either poor or good	Work for all team member's roles was unacceptsble	12
				TOTAL MARKS		**76**

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