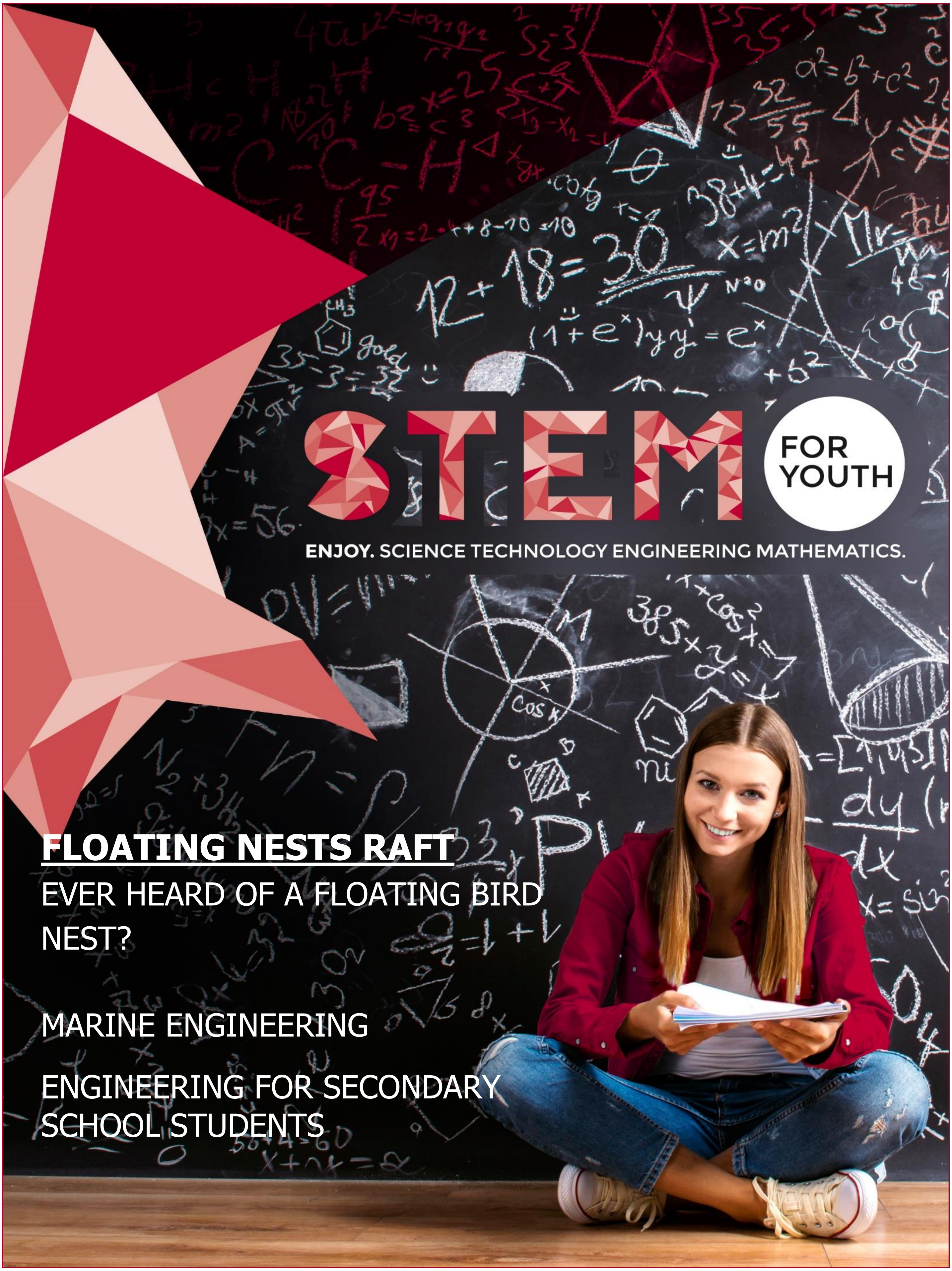

FLOATING NESTS RAFT

EVER HEARD OF A FLOATING BIRD NEST?

MARINE ENGINEERING

ENGINEERING FOR SECONDARY SCHOOL STUDENTS

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PROJECT DETAILS

PROJECT ACRONYM	STEM4YOU(th)
PROJECT TITLE	Promotion of STEM education by key scientific challenges and their impact on our life and career perspectives
GRANT AGREEMENT	710577
START DATE	1 May 2016
THEME	SWAFS

DELIVERABLE DETAILS

WORK PACKAGE NO. AND TITLE	WP5 – CONTENT CREATION, TOOLS AND LEARNING METHODOLOGY DEVELOPMENT
DELIVERABLE NO. and TITLE	**D5.1 MULTIDISCIPLINARY COURSE- ENGINEERING SUB-COURSE**
NATURE OF DELIVERABLE AS PER DOW	R=Report
DISSEMINATION LEVEL AS PER DOW	PU=Public
VERSION	**FINAL**
DATE	**JULY 2018**
AUTHORS	**EUGENIDES FOUNDATION**

INDEX

INTRODUCTION

In this challenge, students explore marine engineering as they design a floating nest for lakes or rivers in order to entice water birds to build their nests there, protecting them from seasonal floods or other risks. They learn to use the scientific principles of balancing forces, more specifically of buoyancy, density and weight and will get acquainted with the science investigation process.

Overview of the challenge:

Participant age: 12-15	Number of participants: Groups (3-4 students)	Module length: App. 1,5 hours to 4 hours
Level of knowledge: intermediate, advanced	No. and type of personnel: teacher / external science experts/science museum staff/students	Type of venue: Classroom / outdoors/science museum
Technological needs: internet / computer/ tablet /	Topic as per formal curricula: sinking, floating, mass, volume, density, weight, stability, balanced forces, buoyancy	Estimated cost: Low (200 € per 5 teams) All the materials are reusable.
Specify learning methodology (D3.1): Engineering Design Process (EDP) Inquiry Based Learning (IBSE)	Engineering Field: marine	Type of activity: Hands on activity

General Objectives: In this challenge students will

- understand the principal role of the materials and their properties in engineering solutions
- get interested in phenomena found in daily life
- develop the ability to predict and verify results
- realize how buoyancy works
- understand how ships float
- realize the difference between natural and man-made objects
- conceive that goals are achieved by collaboration among scientists and engineers
- experience the importance of teamwork as well as individual responsibility as a member of the team
- experience the satisfaction of success
- discover and experience the relationship between theory and practice
- develop a spirit of inquiry
- develop the ability to accomplish a task from start to finish
- develop design skills
- develop the ability to turn designs into reality
- acquire technical skills on using tools properly and safely
- get familiar with the process of finding means to overcome difficulties and problems
- develop the ability to perform experiments and interpret results

Activity 0-What is engineering?

Duration: 40 minutes (max)

Objectives: In this activity students will:

- discover the differences between engineering and technology
- associate things, activities or other terms with engineering and technology
- familiarize with different engineering fields
- apply the Engineering Design Process in order to design and construct a paper table

General Context

This first activity is intended to encourage thinking about what engineering and technology are and to challenge the misconceptions that students may have about the field of engineering or the work of an engineer. This activity aims to disentangle the concepts of engineering and technology and develop the

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understanding that man-made objects are designed for a purpose and that technology, in a very broad sense, refers to any object, system or process that has been designed, constructed, modified in order to solve a problem or to meet a certain need. Finally, in this first activity, students are introduced to the process that engineers follow in order to find solutions to the problems they are dealing with. Student teams try to find and construct a solution to a simple problem following the same process as engineers do.

- **Small groups**

Teacher arranges students into of 3-4 person groups, preferable mixed gender and aptitude (teams should be kept the same through the entire challenge). Each group is asked to discuss and interpret the concepts of engineering and technology and try to associate things, activities or other terms with these concepts. Students are asked to answer to the following questions and write down their answers:

i) What is engineering?
ii) What is the work of an engineer?
iii) Can you give some every day examples of engineering and technology?
iv) What is the difference between engineering and technology?

After that, the teacher writes student team's answers on the board and initiates a discussion about engineering and technology. He/she seizes the opportunity to introduce the Engineering Design Process (EDP) steps and initiate a quick discussion about each individual step. Finally, the teacher asks student teams to construct a laptop table out of paper, by applying the EDP.

What is engineering?

The word engineering is of Latin origin; its root is "ingeniere" which means to design or to devise.

Engineering is the application of scientific knowledge (natural sciences, mathematics, economic and social), practical knowledge and empirical evidence in order to solve everyday life problems. More specific, the purpose of engineering is to invent, innovate, design, build, research and improve structures, machines, tools, systems, components, materials, processes and organizations under specific constraints. The field of engineering is very broad and encompasses a great range of more specialized fields [1], [2] such as:

- Aerospace & Aeronautical Engineering
- Agricultural Engineering
- Architectural Engineering
- Biochemical Engineering
- Biological Engineering
- Biomedical Engineering

- Chemical Engineering
- Civil Engineering
- Computer Engineering
- Electrical Engineering
- Environmental Engineering
- Geoscience Engineering
- Industrial Engineering
- Marine Engineering
- Materials Engineering
- Mechanical Engineering
- Metallurgical Engineering
- Ocean Engineering
- Petroleum Engineering

What is the work of an engineer?

Engineers identify a problem, and come up with a solution – often creating something completely new in the process.

"Scientists investigate that which already is; engineers create that which has never been." (Albert Einstein)

The most famous engineering fields, in more detail [1], [2], are the following:

Aerospace engineering: the field of engineering is concerned with the development of aircraft and spacecraft. Aerospace engineers design, develop, test, and supervise the construction of aerospace vehicle systems. Such systems are aircrafts, helicopters, space vehicles and launching systems.

Architectural engineering: the field of engineering that uses engineering principles to the construction, planning and designing of buildings and other structures. Architectural engineers work in several areas such as: the structural integrity of buildings, the design and analysis of light, heating and ventilation of buildings, energy conservation issues.

Biological engineering (bio-engineering): the field that applies concepts and methods of biology, physics, chemistry, mathematics and computer science to solve problems which are related to life sciences. Bioengineers solve problems in biology and medicine by applying principles of physical sciences and engineering while applying biological principles to create devices such as diagnostic equipment, biocompatible materials, medical devices etc. In general, bioengineers try to mimic biological systems in order to create products or modify and control biological systems.

Chemical engineering: the field of engineering that applies physics, chemistry, microbiology and biochemistry along with applied mathematics and economy in

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order to transform, transport and use chemicals, materials and energy. Traditionally chemical engineering was linked to fuel combustion and energy systems, but today's chemical engineers work in medicine, biotechnology, microelectronics, advanced materials, energy and nanotechnology.

Civil engineering: the engineering field that deals with design, construction and maintenance of constructions such as roads, bridges, dams, buildings, tunnels. Civil engineering is probably the oldest engineering discipline which deals with the built environment. Civil engineers use their knowledge on physics and mathematics to solve society problems.

Computer engineering: the discipline that integrates electrical and electronic engineering and computer science in order to design and develop hardware, software, computer systems and other technological devices. Computer engineers embed computers in other machines and systems, build networks to transfer data and develop ways to make computers faster and smaller. Furthermore, computer engineers have expertise in a variety of areas such as software design and coding and are trained to design software and perform and integrate that software with hardware components.

Electrical engineering: the field of engineering that deals with the study and application of electricity, electronics and electromagnetism. Electrical engineers conceive, design and develop circuits, devices, algorithms, systems and components that can be used to sense, analyze and communicate data. Electrical engineers work on a variety of projects, such as computers, robots, cell phones, radars, navigation systems and all other kinds of electrical systems.

Materials engineering: the field that involves the discovery and design of new materials. Material engineering incorporates physics, chemistry, mathematics and engineering. Materials engineers develop process and test materials used to create a wide range of products such as computer chips, medical devices, aircraft components etc. Materials engineers are concerned with the structure and properties of materials used in modern technology so they study the properties and structures of metals, ceramics, plastics, nanomaterials and other substances in order to create new materials that meet certain mechanical, electrical or chemical needs.

Mechanical engineering: the engineering discipline which applies the principles of engineering, physics and mathematics for designing analyzing manufacturing and maintaining mechanical systems. Mechanical engineers create machines used in manufacturing, mechanical components of electronics, engines and power-generating equipment, vehicles and their components, artificial components for the human body, and many other products.

Ocean (Marine) engineering: the branch of engineering study that deals with the design and operations of manmade systems in the ocean and other marine

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environments. Ocean engineering includes the engineering of boats, ships, oil rigs and any other marine vessel or structure. Ocean engineers apply their engineering (mechanical, electrical, electronic engineering) and scientific knowledge in order to design and develop systems and structures in marine environments. An ideal ocean engineer has to achieve a proper tandem between the marine eco-system and the developed human world.

Robotics: the interdisciplinary branch of engineering and science that deals with designing, constructing, programming, controlling, operating and using robots. Robots are used in a wide range of applications which include industrial, military, agricultural, medicine robots etc.

- Industrial robots - take over work that is dirty, dangerous and degrading to the human spirit (e.g. arc welding, grinding, sanding, polishing and buffing, palletizing etc). Typically, these robots are articulated arms particularly created for applications like- material handling, painting, welding and others.
- Medical robots – robots that are employed in medicine and medicinal institutes such as surgical robots, rehabilitation robots and biorobots.
- Do mestic or household robots – These types of robots are used at home and consist of robotic pool cleaners, robotic sweepers or robotic vacuum cleaners.
- Military robots – These types of robots are used for offensive or defensive purposes and include bomb discarding robots, ballistic shield robots, inspection robots, attacking drones etc.
- Space robots - Robotic devices used to aid, augment, or substitute astronauts in order to do difficult or rote tasks such as exploration or repairs in dangerous environments (e.g. space station robotic arms, Mars rovers Spirit and Opportunity).
- Deep Sea robots – Robots that have long-term presence in the deep ocean and carry equipment to measure various parameters that scientists are interested in (e.g. Benthic Rover).

➢ Engineering Misconceptions

- Plumber
- Electrician
- Carpenter
- Auto Mechanic
- PC (Personal Computer) Technician
- Welder
- Machinist

What is technology?

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Engineering and technology are intertwined terms in society. In order to disentangle the two terms, one needs to understand what their meaning is. Engineering is both a field of study as well as application of scientific knowledge to create or produce something. On the other hand, technology is the collection of techniques, skills, methods and processes used in the production of goods or services or in the accomplishment of objectives, such as scientific investigation. Technology can be the knowledge of techniques and processes, or it can be embedded in machines, computers, devices, and factories, which can be operated by individuals without detailed knowledge of the workings of such things.

Engineering Design Process

The teacher introduces the EDP steps to the students. A short description of the Engineering Design Process follows.

The Engineering Design Process (EDP) is a series of steps that engineers follow when they are trying to solve a problem they are facing and consists of a methodical approach. However, there is no single design process which is universally accepted. In general, each individual design process begins with identifying the problem and its requirements and ends up with a proposed solution. The intermediate steps, however, can vary. It is very important to point out that EDP is not a linear process. Since, engineering problems can have numerous correct answers; the process may require backtracking and iteration. The solution to an engineering problem is usually subject to unexpected complications and changes as it develops. In this project we propose a series of steps which are described below.

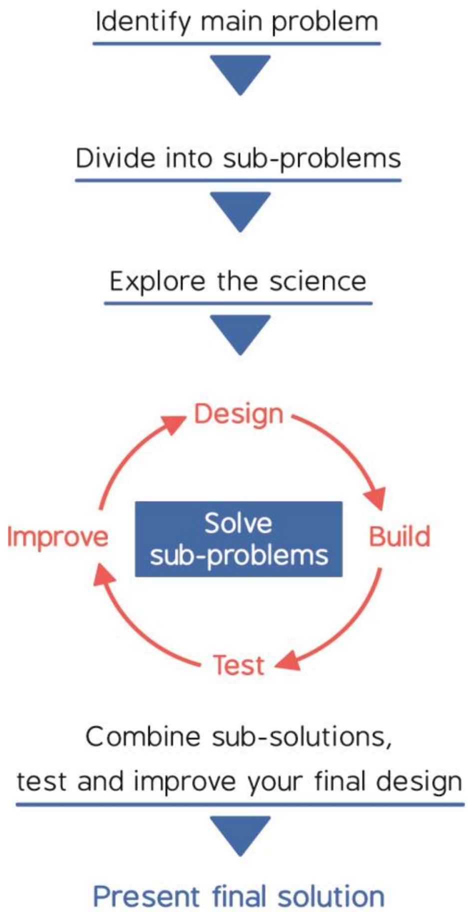

Figure 1: EDP steps

1. **Identify the problem**

   Engineers ask critical questions about the problem and what they want to create, whether this is a space station, a skyscraper, a car or a computer. These questions include:

- *What is the problem?*

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- *Define the problem in specific terms. Be as specific as possible.*
- *Which are the available materials?*
- *What do we need to know in terms of scientific principles that underlie the problem?*
- *What are the constraints of the problem? (Budget, time etc.)*
- *Which are the criteria that must be met so that the solution is acceptable?*

2. <u>Divide problem into sub-problems</u>

   Usually big problems consist of a series of sub-problems. So, engineers analyze the problem in order to plan their work.

- *Is the solution to the main problem straight forward?*
- *Does the main problem consist of smaller and simpler problems?*
- *Engineers do not attempt to plan the whole thing at once. Large projects have many variables that you do not know and can affect the whole plan.*
- *Engineers set smaller goals. Instead of trying to plan everything from the beginning, they figure out the first obvious step and then move to the next one.*

3. <u>Explore the science</u>

   After dividing the main problem to the sub-problems it consists of, engineers investigate the scientific principles that underlie each sub-problem. The fundamental background science is essential for solving sub-problems and designing the optimum solution.

   - *What areas of science cover my project?*
   - *Which are the scientific principles that underlie each sub-problem?*
   - *Research background theory*
   - *Perform experiments-tests to understand the theory's applications*

4. <u>Solve sub-problems</u>

   Generate as many solutions as possible by brainstorming and examine the advantages and the disadvantages of each possible solution. Evaluate all the solutions in order to identify the optimum.

- *Design: Design the application of the chosen solution, carefully and with as much detail as possible. Draw a diagram of the solution and make a list of materials you need.*
- *Build: Follow your design and develop your solution of each one of the sub-problems.*
- *Test: Test whether the solutions of individual sub-problems are compatible with each other.*
- *Improve: Make the necessary corrections and improvements.*

5. <u>Combine sub-solutions, test and improve</u>

   Combine the different components that will provide you the final, integrated solution to the main problem.

Test and if necessary improve your final design

- *Does it work?*
- *Does it solve the need?*
- *Does the final design meet the criteria set?*
- *Analyze and talk about what works, what doesn't and what could be improved.*
- *Discuss how you can improve your solution.*

6. **Present final solution**
   Review and evaluate your work and present your final solution in front of an audience.

Preparatory activity - Strong Paper Table

This activity is designed as a way to introduce students to the EDP in order to have a common understanding of how it works and help teachers who are not familiar with engineering and technology in their classrooms.

Can you build a newspaper table that won't collapse under the weight of a laptop?

Student teams are asked to follow the design process to build a sturdy and steady laptop table out of paper. Find a way to make paper support weight and prevent the legs of the table from buckling (see Fig. 2 for possible solutions).

Criteria

- The table must withstand a weight of 2-3 kg.
- The table must be sturdy and stable.
- The table's surface must be inclined to make the use of keyboard easier.
- The table's surface must be ventilated, to prevent laptop from overheating.

Constraints

- The available materials are 5 newspapers and 50 A4 sheets of paper.
- The available tools are duct tape and a pair of scissors.
- The available time is 30 minutes.

-Tip: *From the criteria the main problem can be divided into sub-problems*

- *Stability and durability of the table*
- *Inclination*
- *Ventilation*

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Figure 2: Possible Solutions

Activity 1-Identifying the problem (what is the engineering problem?)

Duration: 20 minutes

Objectives: In this activity students will

- familiarize with materials and tools such as pliers, screw drivers, ropes, zip ties etc.
- reflect the role of materials in designing a solution to their problem
- specify the constraints they have
- determine the criteria that their solution must meet
- describe the problem by writing a problem statement

General Context

In this activity the teacher sets the engineering problem that students have to face. Student teams ask questions concerning the problem they are facing and discuss with their teacher the criteria that their solution must meet as well as the constraints they have. Afterwards, each team prepares a problem statement i.e. a brief description of the issues that need to be addressed by a problem solving team and should be presented to them (or created by them) before they try to solve a problem.

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Finally, student teams discuss with their teacher about materials that could be appropriate for their challenge. Different types of materials and tools are provided to student teams and the teams explore and become familiar with the materials.

❖ Working in groups

The teacher briefly introduces the Engineering Challenge: "Each team has to design and construct a floating platform which will serve as a nesting area for wildlife". The teacher states that engineers who face and deal with problems such as the one under study are called *Ocean (Marine) Engineers*. (Description of this field is provided in Activity 0).

The teams are encouraged to ask questions concerning the problem:

- What is the problem or need?
- Which are the criteria that their solution must meet?
- What are the constraints of the problem?
- Which are the available materials, tools, resources and technologies?
- Which are the scientific principles behind the problem?
- Which every-day materials that can be found at home or at a local hardware shop that can be useful for solving the problem?

Each team is asked to prepare a problem statement. A good problem statement should answer these questions:

1. What is the problem? This should explain why the team is needed.
2. Who has the problem or who is the client/customer? This should explain who needs the solution and who will decide the problem has been solved.
3. What form can the resolution be? What is the scope and limitations (in time, money, resources, technologies) that can be used to solve the problem?

The problem must be specific enough to allow each team to design a solution.

The teacher then provides student teams with different materials (the teacher can provide student teams with extra materials that are not appropriate for the final design) and tools. Student teams are given some time to become familiar with the materials and tools and then discuss with their teacher possible uses of them. The teacher should encourage student teams to ask questions concerning the criteria that their solution must meet and the constraints of the problem.

<u>Constraints</u>

- Available materials
- Available tools
- Available time
- The Platform's (nest's) size
- Cost
- Security Issues

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Criteria

- The nest must float.
- The nest must withstand as much load as possible given the size constraints.
- When loaded, the nest's clearance above the water must not be less than 10 cm.
- Stability, so that the raft is not tipped or spun by current, waves or wind.
- The nest area must be high enough not to be swamped by storm waves.
- Harmonious blending with the surroundings if possible.

Activity 2 – Divide into sub-problems

Duration: 15 minutes

Objectives: In this activity students will

- brake the main problem to simpler problems
- organize their goals
- schedule their work and set time limits
- draft a plan how they will work

General Context

In this activity, student teams move to the second step of the Engineering Design Process which is to divide the main problem into sub-problems. Student teams try to analyze and divide the bigger problem to smaller and easier to handle sub-problems. They also try to match materials to each sub-problem. Student teams write down and justify their thoughts. The teacher reminds the criteria and constraints that should be met.

❖ **Working in groups and whole class discussion**

Teacher initiates a discussion about the fact that an easy way to deal with a large project is to break it into smaller tasks which are more manageable and easier to face. However, he/she should point out that the task of getting a large goal divided into smaller and achievable ones is not very easy and in fact it can be something quite hard to do. The teacher can propose some simple guidelines that if followed can make the process of breaking the problem, easier. After that student teams should be prompted to propose possible sub-problems.

Guidelines

- Do not attempt to plan the whole thing at once. Large projects have many variables that you do not know and can affect the whole plan.
- Set smaller goals. Instead of trying to plan everything from the beginning, figure out the first obvious step and then move to the next one.

- Do not hesitate to re-divide. If you procrastinating on any of the smaller task, do not hesitate to analyze to simpler ones.
- Set time limits. Usually, when engineers deal with a complex problem, apart from the problem itself they have to face time limitations. So in order to be effective manage your time as good as possible.

The main problem can be divided into three sub-problems:

1. The body of the floating raft
2. The stability of the raft
3. The nest area

Activity 3- Explore the science

Duration: 50 minutes

Objectives: In this activity students will

- perform experiments concerning the principles floating and sinking
- organize and classify their observations
- predict and verify results
- familiarize with the third step of the Engineering Design Process

General Context

The purpose of this activity is to get students in touch with the **process of exploring the science behind the problem and/or sub-problems.** Student teams start to think about the necessary knowledge they need in order to solve the engineering problem. Student teams are encouraged to pose investigative questions which if answered will help them in the process of dealing with the problem. They perform specific experiments that will guide them answer their questions about the science that underlies the problem. Student teams are guided through the process of acquiring the necessary scientific knowledge they need for solving the problem. As this activity progresses, students discuss with the teacher the science that underlies the problem. In addition, students organize their observations/ answers.

❖ **Working in groups**

The teacher's goal is to introduce students to the third step (Explore the science) of the EDP and to motivate them start thinking about the scientific knowledge they need to know and to start brainstorming on how this knowledge can be applied by imagining possible solutions to the engineering problem. Teacher should focus on the scientific principles that underlie the challenge.

Student teams are asked to brainstorm and pose questions concerning the science behind floating and sinking.
The key questions which are important to investigate and are the focus of this activity are:

- What prevents an object that floats from moving towards the bottom of the sea?
- Does water exert force on any objects we immerse in it? If so, on what does this force depend?
- Is there a relationship between the mass of an object and its volume so that the object can float?

➢ The science behind Floating and Sinking (Experiments)

Student teams are asked to perform (or discuss) the following experiments, which will guide them through the basic physical laws and principles they need to know in order to find a solution to the problem they are facing. ***Note**: The following experiments are recommended or optional. Teacher may skip some of them or execute other. The challenge takes into account the realities of a teacher's life such as limitations of time, and equipment/materials, the amount of flexibility they have within their curricula, and other particular constraints imposed by their curricula.*

1. Have student teams use a dynamometer to weigh four different fishing weights outside and within water. Before performing the measurements, have them predict whether the indication of the dynamometer will be the same, smaller or larger. After experimenting, have them try to explain the difference indications of the dynamometer.
   The indication of the dynamometer will be smaller when the objects are immersed in the water. This can happen only if an upward force is exerted on the object from the water (buoyant force). In both experiments we have a downward pull exerted on the dynamometer's spring by the object's gravity (weight). However, in the second experiment, we also have an upward push exerted from the water to the object (buoyancy).

2. Have student teams inflate a balloon and try to push it under water. Have them predict what will happen if they inflate the balloon until it gets twice the initial volume. Have them perform the test and try to explain it.
   As one pushes the inflated balloon in the water, he/she can feel the upthrust from the buoyant force. The more inflated the balloon, the harder you need to push in order to immerse it. This reveals the fact that the upward force which the water exerts becomes greater. We can thus conclude that the buoyant force depends directly on the amount of an objects' immersed volume. So, the greater the objects' immersed volume, the greater the buoyant force becomes.

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3. Provide each team with a plastic watertight container and about 10 small fishing weights. Have them fill the container with weights and predict what will happen if they place it in water. After testing, ask them to remove gradually weights and each time have them predict and test whether the container will sink or float. Have them write down their predictions, observations and their opinion about which variable of the problem they gradually changed.
   When the container is full of fishing weights it will sink because the container's weight is greater than the buoyant force, which is exerted by the water on the container. As fishing weights are removed from the container, the container's weight is reduced, while the volume of the container remains constant. There will be a point (when enough fishing weights are removed) when the buoyant force will equal the container's weight and that is when the container will float. However, one may think that the buoyant force will need to be greater than the container's weight in order for the container to float. In this situation, the teacher should ask: If buoyancy (upward force) is greater than the object's weight (downward force) then why isn't the object ejected out of the water?

4. Provide each team with the following materials: balloon, 4-5 fishing weights, baking soda, and paper napkin. Ask them to put the fishing weights inside the balloon and add some water in the balloon. Have them place a tea spoon of baking soda on the napkin, fold carefully, place it in the balloon and seal tightly the balloons nozzle. Ask them to place the balloon in the water and observe what will happen. Ask them to identify the parameter that has changed and to explain the outcome of the experiment.
   The stuffed balloon will initially sink because its weight is greater than the buoyant force exerted on the balloon by the water. As the napkin gets wet, a chemical interaction takes place between water and baking powder. This interaction produces gas which inflates the balloon. As a consequence, the balloon begins to inflate (increasing its volume) and the buoyant force gradually getting bigger and bigger. When the buoyant force becomes greater than the balloon's weight, the balloon begins to move towards the water's surface. When the balloon reaches the surface, the amount of the balloon's immersed volume becomes smaller and so, therefore, does the buoyant force. At some point, the buoyant force becomes equal to balloon's weight and that is when the balloon floats (weight = buoyancy and hence floating occurs).

Activity 4 - Solve sub-problems

Duration: 50 minutes

Objectives: In this activity students will

- solve each sub-problem based on their plans

- use tools properly and safely

<u>**General Context**</u>

In this activity students are introduced to the core of the Engineering Design Process and apply the corresponding steps of EDP to face their challenge. After completing Activities 1, 2, and 3 they move to the construction process. In order to face and solve each sub-problem they follow the circle: design-build-test-improve. As a part of the whole EDP process students need to recall the scientific knowledge they gained in Activity 3.

❖ **Working in groups**

The teacher summarizes the conclusions of Activities 1, 2 and 3. As student teams have already defined the individual sub-problems, the teacher encourages and guides student teams to gradually solve each one of the sub-problems that the main challenge has been divided into. Student teams are also asked to classify the available materials according to the sub-problem they believe that are suitable for. The teacher encourages the teams to draft a plan of their work and a simple design illustrating the different components of the final design. ***Note****: This activity must be performed taking into consideration the construction instructions (see related part below).*

The teacher should take into account the following:

- Sub-problem 1: The body of the floating raft (student teams will use pvc pipes in order to construct the frame of the raft).
- Sub-problem 2: Floatation and stability (student teams should experiment with different materials that will provide the necessary buoyant force and stability to the floating raft)
- Sub-problem 3: The nest area (student teams should design the nest area is such a way that it will be high enough not to be swamped by storm waves)

Activity 5 – Combine sub-solutions, test and improve

<u>**Duration**: 45 minutes</u>

<u>**Objectives:** In this activity students will</u>

- combine solutions of individual sub-problems to end up with the final design
- use their design to probe whether the criteria are met or not
- make all the necessary changes to improve their design
- have fun with their design

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General Context

By the end of Activity 4, student teams are supposed to have constructed the main body of the floating raft, the nesting area and have chosen the materials that will provide buoyancy and stability to the raft. The next step is to combine the different components that will compose the final device. Student teams test their construction in order to confirm that it is functional and meets the criteria set in previous steps. In the case that the final design has any problem, student teams are encouraged to perform improvements and then test again their design.

❖ **Working in groups**

The teacher initiates a discussion about the compatibility of the different components of the final design. Student teams are prompted to fit pieces together in order to construct the final artifact. Teacher prepares an open area where a container full of water is placed which student teams will use to test their designs. Have each team place its design in the container. Load the raft with weights and place them on different areas of the raft's surface to test the stability. The teacher can also produce, using his/her hand artificial waves to test the stability of the raft and its ability to protect the nest form the waves. If one or more of the criteria are not met, then each team should perform modifications in order to improve their designs.

-Tip: *From an educational standpoint, it's important to allow the children to participate in setting up/cleaning up the room.*

Activity 6 – Present Final Solution

Duration: 20 minutes

Objectives: In this activity students will

- organize their presentation as a team
- present their team work in front of an audience

General Context

The purpose of this activity is to help students realize that they used the same process that engineers use in solving problems. Students also realize that they posed questions and investigated the science that underlies a problem and used already existing technology (tools and materials) in order to imagine, design and construct the final solution to their problem. Student teams, prepare a power point which presents the whole process they followed in order to conclude and construct the final design. Finally they present their work in front of other people.

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❖ Plenary

The teacher initiates a discussion about how important it is to present your work in front of an audience. It is very important for an engineer to make a clear and comprehensible presentation to an audience who can easily be his/her employer. The teacher should point out that in order to explain something to others you must understand it in depth firstly. Have student teams to prepare a presentation where they explain what they did, how they worked and what the result was. The teacher motivates the audience to put forward questions:

- Did you find any difficulties in applying the Engineering Design Process? What difficulties did you face?
- Did you change your original design? What affect did this/these change(s) have upon the final design?
- How would you change your design if you had to host more bird nests and consequently to protect more water birds?
- Do the suggested materials work properly and safely? What materials you might substitute?
- What changes did you make to your design in order to improve buoyancy?
- What changes did you make to your design in order to improve stability?
- If you had more time what you would add, change, or do differently?

If you can't explain it simply, you don't understand it well enough. (Albert Einstein).

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Construction Instructions

Fastenings

The making process is quite easy as it does not require specialized skills. The only "technique" needed is to understand the function of zip ties (tie raps). Zip ties are really powerful fasteners and the only way to untie them is to cut them.

1. Pupils can use zip ties in order to tie the pipes together (Fig. 1). In that way they can assemble the frame of the floating nest (Fig. 2). It is better to use two zip ties in the shape of an **X** (Fig. 1) instead of one.]

Figure 1: Zip ties used to tie the PVC pipes together. In the figure you can see that the zip ties are crossed. In that way you can make sure that the bond will be strong enough.

Figure 2: In this picture we can see how we can keep on fastening pipes together in order to construct the frame of the platform.

In figure 3 we show the steps one can follow in order to connect 8 pvc pipes together and construct the frame of the floating nest. We point out that the following structure is just a proposition. The teacher should urge student teams to imagine design and construct their own ideas. The design shown in figure 3 is just an example of how pipes can be tied together using zip ties.

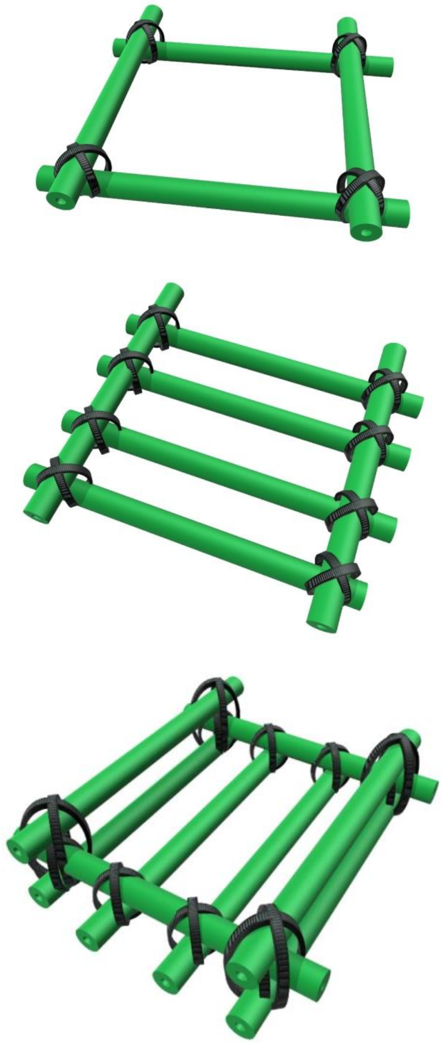

Figure 3: In this picture we can see how the pipes can be tied together in order to construct the frame of a platform. Note that this design is only a suggestion. Pupils should be encouraged to imagine and design their own ideas. This picture serves only as an example of how we can fasten the pipes together.

2. There are of course some cases in which the zip ties are not long enough to tie something we want. In such cases the only thing we can do is to join two or more zip ties together (Fig. 4).

Figure 4: Two joined zip ties. In this way we can join together more than two zip ties in order to maximize the length.

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3. The next step is to attach the wooden floor to the raft as shown in Fig. 5. For the floor you will need 3-4 plywood sheets. The wooden sheets can be attached to the frame as shown in figure 5.

Figure 5. Wooden sheets attached to the nest's frame.

4. In order to tie the wooden sheets on the pipes, one has to drill holes in the sheets. Through these holes one can use zip ties or rope to tie the wooden sheets to the frame (see Fig. 6)

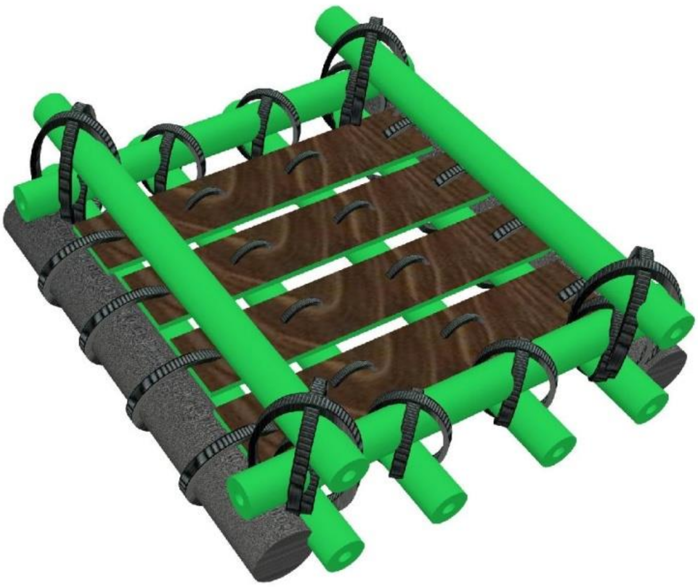

Figure 6. Wooden sheets tied to the nest's frame.

5. The joined zip ties can be used to fasten the floaters on the frame of the platform (Fig. 7). Of course for the same reason, pupils can use fishing line, rope, or duct tape concerning each time the advantages and disadvantages of the material they use. For example, there is a possibility after intense use in water; the duct tape will no longer stick to the floaters or the pipes. Note that firstly the pupils should drill holes on the plywood boards through which the zip ties will pass.

Through the holes of the wooden boards the pupils can insert a zip tie (or joined zip ties) and then fasten the plywood and floaters on the pipes of the frame (Fig. 7).

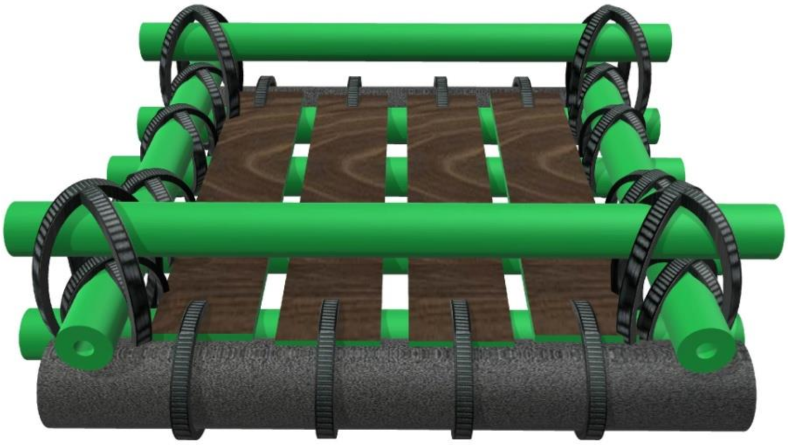

Figure 7: An example of how the floaters can be fastened on the frame using joined zip ties. While fastening the floaters you can fasten as well the wooden floor to the pvc frame.

6. Concerning the issue of floaters we propose three different solutions. Instead of using the floaters made of foam (which are shown in Figs. 7 and 8) the teacher can provide student teams with 4 plastic bottles or 20 styrofoam cups. Students can use Styrofoam cups in order to construct floaters of different sizes and volumes. The purpose of providing different types of floaters is to urge students test their properties and decide which type or material is better for their construction. In order to construct a floater from cups see figure 8.

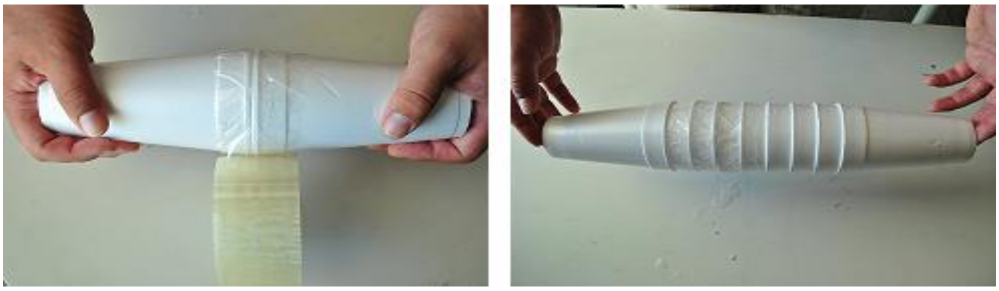

Figure 8. Constructing floaters using Styrofoam cups.

In figure 9 we present the final design of the floating nest. We remind that this design is only a suggestion. The teacher should encourage student teams to imagine, construct and test their own designs. We note that there are no specific designs which are wrong or right. A design is considered successful as long as it meets the criteria set in Activity 1.

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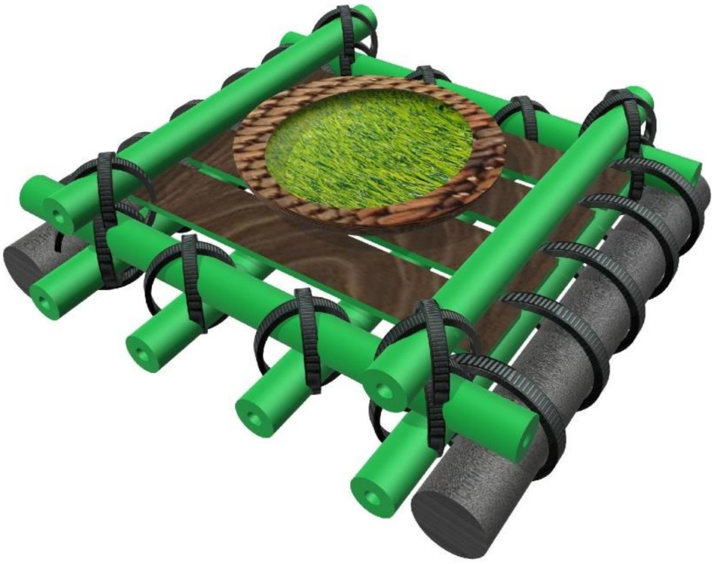

Figure 9. The final design of the floating nest.

Cutting

For cutting the PVC pipes (in case you can’t have them precut) you will need a pipe cutter (Fig. 8).

Figure 8. PVC Pipe Cutter

Figure 9. How to cut a PVC pipe

- Mark the pipe at the point where it needs to be cut. Use a permanent marker.
- Open the pipe cutter jaws by pulling apart the handles. Place the pipe in the cutter jaws and push the cutter's handles together so that the pipe is held in the jaws with the cutter blade directly over the mark on the pipe.
- Push the cutter's handles fully together. This will push the blade completely through the pipe, cutting it into two pieces (Fig. 11).

List of Materials

Material	**Total amount per group**
Bucket	1

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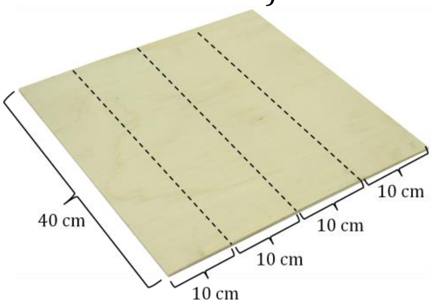
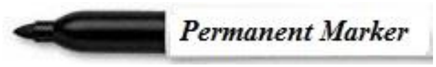
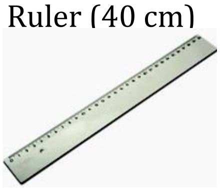
Dynamometer 10N (or 1 Kg) 	1
Pump for balloons 	1
Balloons (medium or large size) 	5
Paper napkins 	10
Baking Soda 	1 tea spoon
Small fishing weights 	15
Large Fishing Weights 	4
Plastic container (e.g. toothpick box) 	1

Swimming noodles (cut into pieces of 40 cm in length) 	4 per team
Styrofoam Cups (330-350 ml) 	20 per team
Plastic pipes (50 cm each) 	8
Plywood-board (40 x 40 cm) (cut into 4 pieces 40 cm x 10 cm each) 	4
Duct tape 	1
Fishing line (or thin rope) 	1
Scissors 	2

Zip Ties (aka Tie Wraps) 	100
Pencils 	2
Permanent marker 	2
Ruler (40 cm) 	2
Plastic tank 0.5 – 1 m^3 (for testing the floating platform) 	1 (for all groups)
Screwdrivers 	2
PVC Pipe cutter (if needed) 	1

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Science Careers and Your Future[1]

There are numerous scientific, engineering technological elements which are involved in the development of actual floating rafts, platforms and in general marine environment structures.

Ocean Engineering extends from building dams and reservoirs in a micro level to planning, designing and executing structures, equipments and constructions that benefit not just humans but also the existence of marine life-forms at its zenith.

Ocean engineers apply various engineering sciences, including mechanical engineering, electrical engineering, electronic engineering, and computer science, to the development, design, operation and maintenance of watercraft propulsion and on-board systems and oceanographic technology. It includes but is not limited to power and propulsion plants, machinery, piping, automation and control systems for marine vehicles of any kind, such as surface ships and submarines.

An Ocean Engineer has to be well-versed not just with his required educational background but also along with the extra-curricular skills that will help him to do his job well and achieve goodwill for his ideas. Practicality combined with the knowledge imparted from books, in today's times, is a very important factor that an Ocean Engineer has to keep in mind while helping to put the world ahead in terms of its marine constructional development.

Ocean engineering is a field that has a lot of scope for development and progress. And with the right skill-set like good communication skills, ability to work well as a team member and adeptness in the usage of a computer and its various applications and programs, an Ocean Engineer can be expected to reach the top of the reclusive yet unique profession.

It is, however, also important to understand that an Ocean Engineer along with the above mentioned attributes is required to be aware and responsible about the core and staple object of his construction and designing – the water forms and the creatures and the flora and fauna that inhabit it.

For Events (tips on setting up and running the challenge in an event setting)

If this challenge takes place in science festival or science museum as a:

i) **Mini-Workshop (90 minutes)**

As this is a workshop taking place in a festival or in a museum time is relatively limited.

- Skip the Preparatory Activity Strong Paper Table. Discuss with the participants the concepts of engineering and technology. Focus on the

[1] http://www.marineinsight.com/careers-2/what-does-an-ocean-engineers-do/

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Engineering Design Process only as it consists of the core of the whole project.

- From Activity 1 state the problem and focus on the constraints and the criteria that must be met. Have them pose questions concerning the problem.
- Urge the participants to suggest the physical principles that underlie the problem. Skip the experiments proposed in Activity 3 that concern the scientific principles that underlie the engineering problem. Discuss the scientific principles that will be used.
- Review the other activities in terms of content and time, focusing especially on how to respond to questions that might come up.
- To avoid spending time teaching each person how to make the raft, make samples that illustrate the process.
- Prepare many copies of the instructions as well as enough materials for 4-5 parallel sessions. Establish a testing zone outside from building areas for the testing/ presenting the final designs.
- Skip Activity 6-Present Final Solution

ii) **Pop-up event (30-45 minutes)**

Pop-ups are about creating an atmosphere that people would love to participate in. Focus on the uniqueness of the experience that people will have if they participate.

- Have a video of a custom made floating nest cleaner in order to draw their attention.
- Ask them if they think that they are able to build a floating nest, using every day materials, in just 30 minutes.
- Have a banner explaining in few words the Engineering Design Process. Focus on the steps that the participants have to follow and skip the Preparatory Activity Strong Paper Table.
- Focus on the construction part. Prepare many copies of the instructions as well as enough materials for 4-5 parallel sessions. To avoid spending time teaching each person how to make the floating raft, make samples that illustrate the process. In general, get extra materials! It's better to have too many materials.
- Activities 0-3 can be excluded. Review the other activities in terms of content and time, focusing especially on how to respond to questions that might come up.
- Establish a testing zone, with large tables and water supply.
- Estimate how many participants will be at your event. Then add 20%. This figure will help to accommodate a larger-than-expected crowd.
- Skip Activity 6-Present Final Solution.

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References

[1]. Henry Samueli School of Engineering and Applied Science, (2017). What engineers do. UCLA engineering. Available at: http://engineering.ucla.edu/descriptions-of-majors-offered/

[2]. College Factual. (2017). Engineering Overview. Available at: http://www.collegefactual.com/majors/engineering/, http://www.umich.edu/~ptclab/

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