Engineering THAILAND

STEM modules

A set of resources for gifted and talented students following STEM supplementary courses.

Stuart Bevins, Tony Daniels, George Forster,
Emily Perry, Gareth Price, Mark Windale.

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The STEM modules

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School traffic management	7 - 10
Rice grain dryer	9 - 12
Smart packaging	11/12
Tsunami Town	7/8
Oil spill	10/11
Pack popper	7 - 10
Measuring volume	9/10
Whitening, pleasant-tasting toothpaste	7/8
Drone detectives	11/12
Mars breakdown	7/8
Cleaning up pollution	9 - 12
Flood protection	9/10

School safety

The context

Congestion often occurs around schools when students are arriving or departing. Parents' cars, school buses and public transport all add to the confusion. There is also potential danger from impatient drivers who may try to force their way through the blockage. If the whole process were more efficient, accidents would be reduced, people would get to school and work on time and traffic would run more smoothly.

The student challenge

The students will play the role of planners and traffic control engineers. They have been commissioned to design a system for a drop-off and pick-up point within the school grounds, thus removing parked cars from the highway. The scheme amounts to a very short term car park where parents can park, in a specially designed area, to off-load their children and their books etc. The site will be unsupervised but will be controlled by barriers and/or traffic lights to ensure that cars leave and re-join the road safely. It must include a system to encourage parents to stop for just enough time to deal with the children. The team must come up with a plan and working models to support their design.

Information and criteria for design are:

- The school has 2,500 students.
- It is a combined primary and secondary school.
- Around 50% of them arrive by private transport.
- Around 25% travel on school buses, 15% on public transport and the remainder on foot.
- School start time is 09.00 and end time 15.00 for pupils aged 5 – 10 and 16.00 for pupils 11 – 16 years. Some students stay on to after school clubs until 17.30.
- Normal peak traffic time is between 08.30 and 09.30.
- The scheme should mean that vehicles linked to the school are never parked on the road, i.e. the drop-off area should accommodate all vehicles transporting pupils
- The scheme should provide for the through-flow of vehicles and the most efficient use of space whilst vehicles are stationary. Waiting times should be reduced to a minimum. How will this be enforced?
- The scheme should include space for vehicles to leave the highway and a system for ensuring that they re-join the road safely, including sensors, barriers and lights where necessary

The Output

The project will produce a presentation and specification for a traffic control system for a school. Students should be able to present their plans with reasons for all of their design decisions with models available to support their plans as required….

Students will be expected to:

- produce a plan for a drop-off and pick-up point within a school grounds to meet the above criteria.
- investigate other similar systems to gain ideas of possible solutions.
- work as a team member with a particular role to experience the benefits of team working.
- discuss a number of potential solutions and to choose one to model.
- bring together ideas to produce a final report which evaluates a number of options and recommends one with supporting justifications.
- develop and make a presentation of the team's conclusions.

Running the project

The stages and roles below offer guidance for running the project.

Stage	Student acticvity	Teacher guidance	Week
Problem identification	Students work together as a group to discuss the information given, and to develop a description of the specific problem to be solved. They should formulate a number of questions, the answers to which will guide them towards one particular solution. Traffic flow and waiting time limits will be important here. By the end of this session all members of the groups should agree on the problem and what the outcome should be, although a complete description will not be possible at this stage.	The task here is to define the problem in a way that is capable of solution in the time (six weeks) given. The definition will give clarity to the information required and the roles of the group. This may be the first time this group has worked together and the teacher should place emphasis on ensuring that they have clearly defined roles, including a leader.	0.5

Background research	Having described the problem and its solution students will need to provide background information to enable them to complete it. For example it may be useful to know the typical flow rate of vehicles along a major street in a city. Once a credible figure has been obtained it can be used in the model to fix at least one variable. Students will want to to work out how many students on average ride in a single car or bus in order to calculate the number of vehicles to deal with. The groups should allocate various information areas to different group members to make the process more efficient.	Teachers should help students get started by discussing what kind of information they may need. This could take the form of working through a theoretical solution. However the approach should not be didactic, questions should be used to stimulate students to understand why they need certain information. **SAFETY:** Teachers need to consider the safety aspects of students collecting live data on traffic flow from busy roads or intersections.	0.5 – 1.5
Specification	The specification is what the scheme should deliver. It should describe outcomes and not suggest solutions – that is for the developer. It should include statements like “The scheme should ensure that x students can be dropped off safely per 5 minutes.” Or “A through-flow of *y* cars per minute is necessary”.	The main role of the teacher here is to make sure that the demands of the specification are practical and not impossible to reach. Again, an approach that helps the students write their own specification is best.	1.5 – 2
Alternative solutions	All problems have several possible solutions and it is important to consider them all. Students should seek to be creative as unexpected solutions may save money or time. For example, it might be more efficient to make several smaller dryers that can be used by several local farmers at the same time. That would depend upon whether the increased yield gained by speedy drying boosts income sufficiently to cover the increased costs and still leave a profit. Potential solutions can be theoretically tested by the use of SWOT analysis. At the end of the session students should have a firm idea of their proposed design.	Student solutions must be credible and practical, but teachers should encourage originality and innovation. Sometimes discussing an impractical solution can reveal more information that will help solve the problem. Teachers should try not to prompt the students. The students should originate their own ideas. Teachers should try not to point out specific problems with an idea – that is for the students to find out.	3

Develop and prototype	Students should decide upon one idea to take forward. They should develop the idea in detail, which may involve making more detailed drawings or working descriptions. They should at least begin to build their model during this week.	Students will work enthusiastically at this point because their ideas are reaching fruition. They will have to think about a testing regime. They will probably need less intervention now.	4
Test and redevelop	A testing regime should have been devised so that the model can be tested effectively.	This is the place to ask "What if?" questions, especially if some aspects cannot be physically tested.	5
Report the results	The team has reached its conclusion and should be ready to recommend its solution. The form of presentation should be decided. In this case the presentation will probably be a report recommending a single solution. The report should contain the problem and how this solution addresses it, why this solution is best and what alternatives were considered.	The student group could present to a simulated school governing board. They should use their model to demonstrate how the system works, its advantages and disadvantages. A written report should accompany the presentation.	6

Assessment

In view of the general guidelines for assessing G&T students, it is recommended that this module is assessed in three ways:

1. A group assessment.
2. An individual written document.
3. A personal reflective statement

1. The group assessment

The general assessment is an assessment of the overall group performance, with criteria and marks as follows:

Element	Assessment criteria	Comments on interpretation	Marks
Producing a definition	• Shows clear understanding of the issues that will impact upon and shape the problem • Can articulate the problem in a concise form that is capable of practical solution	This section tests the higher levels of Bloom's taxonomy. To score highly the group must work together constructively to produce a precise and concise definition.	25

Creativity, originality and choice of preferred solution	• Shows originality in identifying a range of proposed solutions • Demonstrates a logical approach to SWAT analysis of proposed solutions	G&T students display different areas of advanced ability. Creativity, "thinking outside the box" and not being inhibited by current solutions is a common feature of G&T behaviour.	25
Organisation, efficiency and thoroughness of preparation, including research	• The group demonstrates efficient organisation with tasks well directed • Shows a clear approach to the research, seeking the information required, without wasting time on irrelevancies	G&T students often perform well in these areas and evaluating research is an important skill.	25
Quality of presentation, including planning and clarity of explanations	• Shows that the presentation is well organised and progresses logically, each point following logically from the one before • Explanations use simple language	Clear explanations may not come easily to G&T students whose thought processes may be complex. Since communication is highly important in all careers and walks of life, high quality communication is important for G&T students.	25

2. The individual written response

Students should create a written document of no more than 500 words which evaluates their chosen solution from the perspective of the potential users including those who pass the school at peak times. What are their views and does the proposed scheme offer any benefit?

Factors to consider in marking include, how well can the student

- put themselves in the position of the user (empathising),
- communicate their thoughts, and
- describe compromises to make the scheme will suit all?

3. The personal reflective statement

Students should consider individually the questions below:

- How could you change and rewrite the problem to bring out more social issues and how do you think this would change your own report?
- In the light of what you have learnt from undertaking this project what advice would you give to those developing new or changing existing vehicular access to schools.

Drying rice for storage

The context

Thailand is the world's greatest exporter of rice and is the sixth largest producer overall. Thailand has plans to increase the land available for rice production, with a goal of adding 500,000 hectares to its existing 9.2 million hectares of rice-growing areas. The main strain of rice produced is Jasmine, a high quality rice. Although it has a lower yield than other types of rice, it can fetch more than double the price of other grains.

12 – 37% of rice is lost in harvest, processing and storage. Some of this waste can be reduced by better drying to improve storage life. When harvested, rice has a moisture content of 20-25%. It needs to be dried to less than 14% for milling and 9% for storage.

The process of drying rice is expensive and the wetter the rice the more fuel has to be used. Dryers can be large, complex and very expensive pieces of machinery, making access impossible for smaller farms in remote districts.

If a simpler, cheaper grain dryer could be designed for rural communities it would increase the storage potential of the rice. Less rice would be wasted to scavengers (rats and mice), microbial degradation (rotting) and pests. More and higher quality rice would go to market and fetch better prices.

The student challenge

Students will play the role of a team of engineers, agricultural specialists and rice farmers that has been asked to design a low cost dryer which produces rice dried-down sufficiently for milling and storage. The dryer must be mobile enough to take to rural communities, operate using available fuels, be innovative and sustainable. A working prototype model of the dryer should be made and demonstrated.

The design of the dryer must incorporate the following features:

- Is effective in use.
- Be capable of operating out of doors, or in a low cost building.
- Have low running and maintenance costs.
- Must be economical to run, so that the rice grains produced can be competitively priced in commercial markets.
- Should be accompanied by various methods of measuring moisture content of the grain, including portable electrical devices. This should include devices for use in the field, at harvest and during the drying process. The latter might be built-in, but could be detachable.
- The dryer should be mobile to allow use close to the harvest site on different terrain.

- Be as eco-friendly as possible (e.g. use of solar power to heat drying air, which should not be too hot).

The Output

The project will involve research and teamwork and lead to a working prototype of a rice dryer. Students will also have to present this and the reasons for their decisions through a presentation of some description.

Students will be expected to:

- produce a plan and to build a working (as far as possible) prototype dryer including the features described above'
- apply the principles of effective grain drying to rice drying in Thailand through the design developed.
- research the requirement for rice drying in Thailand in order to make the proposed solutions relevant.
- list the advantages of appropriate technology solutions in order to apply them to this design
- identify the difficulties of the use of technology in remote areas and to balance its costs and benefits
- work as a member of a team with each member having different roles in order to demonstrate the efficiency of team work
- develop a way that the recommended solution can be presented

Running the project

The stages and roles below offer guidance for running the project.

Stage	Student activity	Teacher guidance	Week
Problem identification	Students work together as a group to discuss the information given, and to develop a description of the specific problems associated with rice drying in remote areas. They should formulate questions that need to be answered to complete the module, for example: • Where will the dryer be needed? • How much grain will need to be processed? • Will it be batch or continuous process? • What will be the heating element? • How will air be moved through the grain? By the end of this session all members should agree on the problems and have some design ideas for their dryer, although a complete description will not be possible at this stage.	The task here is to define the problem in a way that is capable of solution in the time (six weeks) given. Identification of the specific questions will clarify what information is needed to place constraints upon the design. Teachers should ensure that the questions are valid and useful. Irrelevant question will waste time in such a short module. This may be the first time this group has worked together and the teacher should place emphasis on ensuring that they have clearly defined roles, including a leader.	0.5

Background research	Having described the problem and possible alternative solutions students will need to provide background information to enable them to complete it. For example it may be useful to know the variety of terrain where rice is grown so that the design is mobile enough to access all growing areas. Students will want to know the basis on which existing grain dryers work so that they can look at ways of simplifying their design. Once the materials used for standard dryers are known more eco friendly materials can be explored including looking at a variety of locally available materials. The group should allocate various information areas to different group members to make the process more efficient.	Teachers should help students get started by discussing what kind of information they may need. This could take the form of working through a theoretical solution. However the approach should not be didactic, questions should be used to stimulate students to understand why they need certain information.	0.5 – 1.5
Specification	The design specification is what the scheme should deliver. It should describe outcomes and not suggest solutions. The group will go on to prototype a solution. It should include statements like “The dryer should be capable of drying x amount of rice in y minutes.”	The main role of the teacher here is to make sure that the demands of the specification are practical and not impossible to reach. Again, an approach that helps the students write their own specification is best.	1.5 – 2
Alternative solutions	All problems have several possible solutions and it is important to consider them all. Students should seek to be creative as unexpected solutions may save money or time. For example, it might be more efficient to make several smaller dryers that can be used by several local farmers at the same time. That would depend upon whether the increased yield gained by speedy drying boosts income sufficiently to cover the increased costs and still leave a profit. Potential solutions can be theoretically tested by the use of SWOT analysis. At the end of the session students should have a firm idea of their proposed design.	Student solutions must be credible and practical, but teachers should encourage originality and innovation. Sometimes discussing an impractical solution can reveal more information that will help solve the problem. Teachers should try not to prompt the students. The students should originate their own ideas. Teachers should try not to point out specific problems with an idea – that is for the students to find out.	3
Develop and prototype	Students should decide upon one idea to take forward. They should develop the idea in detail, which may involve making more detailed drawings or working descriptions. They should at least begin to build their model during this week.	Students will work enthusiastically at this point because their ideas are reaching fruition. They will have to think about a testing regime. They will probably need less intervention now.	4

Test and redevelop	A testing regime should have been devised so that the model can be tested effectively (including on challenging terrain).	This is the place to ask “What if?” questions, especially if some aspects cannot be physically tested.	5
Report the results	The team has reached its conclusion and should be ready to recommend its design. The form of presentation should be decided. In this case the presentation will probably be a demonstration, using the prototype model to dry some grain (or using some simulated test grain) and demonstrate its ability to work in small spaces and difficult terrain. The report should contain the problem and how this solution addresses it, why this solution is best and what alternatives were considered.	The student group could present to a group representing owners of small rice growing farms They should use their model to demonstrate how the system works, its advantages and disadvantages. A written report should accompany the presentation.	6

Assessment

In view of the general guidelines for assessing G&T students, it is recommended that this module is assessed in three ways:

1. A group assessment.
2. An individual written document.
3. A personal reflective statement

1. The group assessment

The general assessment is an assessment of the overall group performance, with criteria and marks as follows:

Element	Assessment criteria	Comments on interpretation	Marks
Producing a definition	• Shows clear understanding of the issues that will impact upon and shape the problem • Can articulate the problem in a concise form that is capable of practical solution	This section tests the higher levels of Bloom’s taxonomy. To score highly the group must work together constructively to produce a precise and concise definition.	25
Creativity, originality and choice of preferred solution	• Shows originality in identifying a range of proposed solutions • Demonstrates a logical approach to SWAT analysis of proposed solutions	G&T students display different areas of advanced ability. Creativity, “thinking outside the box” and not being inhibited by current solutions is a common feature of G&T behaviour.	25

Organisation, efficiency and thoroughness of preparation, including research	• The group demonstrates efficient organisation with tasks well directed • Shows a clear approach to the research, seeking the information required, without wasting time on irrelevancies	G&T students often perform well in these areas and evaluating research is an important skill.	25
Quality of presentation, including planning and clarity of explanations	• Shows that the presentation is well organised and progresses logically, each point following logically from the one before • Explanations use simple language	Clear explanations may not come easily to G&T students whose thought processes may be complex. Since communication is highly important in all careers and walks of life, high quality communication is important for G&T students.	25

2. The individual written response

Each student should create a written document of no more than 500 words which evaluates their chosen solution from the perspective of the of farmers who will use the grain dryer. What are their views and does the new dryer offer any benefit over traditional methods?

Factors to consider in marking include, how well can the student

- put themselves in the position of the user (empathising),
- communicate their thoughts, and
- describe compromises to make the scheme will suit all?

3. The personal reflective statement

Students should consider individually the question:

- In the light of what you have learnt whilst undertaking this project what advice would you give to those developing new technologies for use in rural areas?

Smart packaging

The context

Packaging plays an important role in the processing and marketing of perishable items such as fruit or medicines. For example, appropriate packing materials can reduce mechanical damage, the use of sealed-in atmospheres can control ripening while sterilisation and radiation treatment can slow microbial decomposition. Built-in temperature indicators can show when storage temperatures have been too high. However, these can be expensive and technically difficult solutions. This module is about using innovative approaches to develop simpler ways of making perishable items last longer and retain their good appearance.

The cut surfaces of many fruit and vegetables such as bananas, avocados, apples, pears, bananas and potatoes turn brown when exposed to air. The discolouration is due to the cut cells releasing an enzyme called polyphenol oxidase. It catalyzes a reaction between phenolic compounds from the cells and oxygen from the air which forms new compounds called o-quinones. In turn these react with amino acids or proteins to form the brown compounds. The brown colours appear at different rates depending upon the amount of enzyme present, the ripeness of the fruit and its variety.

There are several ways of slowing the browning, for example washing the cut surfaces, treating them with syrup, fruit juice or salt. Whilst syrup excludes oxygen the others reduce the surface pH and slow down the oxidation reaction.

Microbial degradation of fruit and vegetables involves bacteria and fungi using the fruit as a substrate (food) from which to gain energy. The process is much faster if the fruit's surface has been damaged. The process can be slowed, for example, by reducing the temperature or washing, especially with non-toxic wetting agents or non-toxic antimicrobials to remove or kill the microbes.

The student challenge

In this module students play the role of food scientists. They will develop and test packaging to reduce or prevent browning and to prolong storage life. They might investigate three or four different methods, but each method should be thoroughly studied, e.g. using a dilution series to determine the best concentration of solution to use to wash freshly cut fruit.
They will need to set up a standard testing system so that treatments can be compared with the normal process. Having identified the best conditions to prolong quality, the students should investigate packaging solutions e.g. plastic bags, tight wrapping in film, cellophane packs etc.

The Output

The project will involve research and teamwork and lead to an understanding of the role of packaging in reducing food wastage. Students should also devise a testing system for packaging types and use this to grade various types of packaging systems of their own devising. They should be able to communicate their methods and findings through a written report.

Students will be expected to:

- produce a system, including the pack, to preserve high quality in cut fruit and vegetables.
- produce a system, including the pack, to reduce microbial degeneration of fruit and vegetables.
- make prototypes of the packs.
- carry out tests to evaluate the packs.
- produce a report to recommend a system accompanied by the prototypes.

Running the project

The stages and roles below offer guidance for running the project.

Stage	Student acticvity	Teacher guidance	Week
Problem identification	Taking the role of food scientists students should formulate the questions that need to be answered in order to produce the end result. This will indicate the research required.	Defining the required outcome in this way will clarify the steps needed to achieve the result. The teacher may need to encourage students to take different roles in the investigation. However, the teacher's role is to challenge ideas and to guide students to make their own decisions.	0.5
Background research	In this module there is quite a bit of basic science information to be gathered to understand the underpinning principles. Students will need to gather enough information to be able to select the methods they are going to use and test.	Teachers can bring an experienced eye to the problem. Whilst they should stimulate students to come up with their own ideas they should challenge the ideas and guide students towards systems that are likely to be practical under the module conditions i.e. time allocations etc.	0.5 – 1.5
Specification	The specification is a description, of what the end product should be. It cannot give very precise details at this stage because the development process has to take place.	The main role of the teacher here is to make sure that the demands of the specification are practical and not impossible to reach. Again, an approach that helps the students write their own specification is best.	1.5 – 2

Alternative solutions	There may be several ways to meet the specification, for example different substances could be used to prevent oxidation. A number of options should be selected for exploration. Students might like to consider what are the most practical possibilities.	Student solutions must be credible and practical, but teachers should encourage originality. Sometimes discussing and impractical solution can reveal more information that will help solve the problem. Teachers should try not to prompt the students. The students should originate their own ideas. Teaches should try not to point out specific problems involved in an idea – that is for the students to find out.	3
Develop and prototype	In this case a number of options should be explored by experiment.	Teachers should explain the scientific method and ensure that students include enough controls and that fair tests are conducted.	4
Test and redevelop	A leading candidate for the system should be revealed by the experiments. Students should modify it according the results.	This is the stage where modifications can take place. Students should largely work alone at this stage.	5
Report the results	The team should be ready to make a recommendation about the final packaging solution. They should make a presentation supported by the prototypes. The report should present evidence to justify their final selection.	The presentation could be in the form of a scientific paper or a recommendation to a fruit and vegetable marketing chain.	6

Assessment

In view of the general guidelines for assessing G&T students, it is recommended that this module is assessed in three ways:

1. A general assessment of the report or presentation for each group.
2. A written document from each student
3. A personal self-reflection statement

1. The group assessment

The general assessment is an assessment of the overall group performance, with criteria and marks as follows:

Element	Assessment criteria	Comments	Marks
Producing a definition	• Level and speed of understanding the main problem • Level and speed of identifying and understanding the surrounding issues that impact upon the problem • Analysing how these elements interact • Sophistication and depth of discussion • Synthesising these into a concise definition	This section tests the higher levels of Bloom's taxonomy. To score highly the group must work together constructively to produce a precise and concise definition.	25
Creativity, originality and choice of preferred solution	• Creativity and originality of solutions • Analysis of the strengths and weaknesses of the candidates solutions • Clarity with which the preferred solution is chosen, including credibility of the preferred solution	G&T students display different areas of advanced ability. Creativity, "thinking outside the box" and not being inhibited by current solutions is a common feature of G&T behaviour.	25
Organisation, efficiency and thoroughness of preparation, including research	• How well was the group managed and how well did they work together? • Were tasks distributed evenly? • Was the research relevant and well targeted? • Were the results relevant?	G&T students often perform well in these areas an evaluating research is an important skill.	25
Quality of presentation, including planning and clarity of explanations	• The presentation should be well organised with an introduction, content with results and analysis leading to a clear conclusion. • Explanations should use simple language • Presentations should be well paced and well timed.	Clear explanations may not come easily to G&T students whose thought processes may be complex. Since communication is highly important in all careers and walks of life, high quality communication is important for G&T students.	25

2.The individual written response

Students should create a written document of no more than 500 words which evaluates their chosen solution. They should consider how well their product meets the original specification and how well it would work in everyday life as opposed to lab conditions. They must consider if there are any dangers in its used its economic viability - is the cost of preservation higher than the saleable price of the fruits?

Factors to consider in marking include, how well can the student

- put themselves in the position of the user (empathising),
- communicate their thoughts, and
- describe compromises to make the scheme will suit all?

3. The personal reflective statement

Students should consider individually these questions.

- Do you think the original module requirement was important? If so, why is it important to lengthen shelf life?
- Where do you think are the weaknesses in the experimental techniques and how would you conduct the experiment if you were to repeat it?
- In the light of what you have learnt whilst undertaking this project can you suggest any other applications for this or similar devices?

Preparing for a tsunami

The context

In 2004 a deadly tsunami hit the Andaman Islands and the west coast of Thailand at Phuket. 5,400 people were killed and 3,100 were reported as missing. Waves up to 10m high were recorded at Khao Lak. Resultant flooding reached the 3rd floor level. This tsunami was caused by an earthquake in the Indian Ocean and was the result of the Indian and Burma tectonic plates colliding.

After the 2004 tsunami, some redevelopment has involved ideas such as constructing tall structures that enable people to be rescued by helicopter. Most rebuilt tourist hotels and other buildings remain in the same locations close to the shoreline and have not benefited from tsunami-defensive features. However, mangroves have been planted in several coastal areas as a buffer zone between the sea and human dwellings.

There are many ways of reducing the worst effects of a tsunami, including avoiding development in tsunami areas. Other strategies include building on high ground behind protective barriers or building on piers or raised structures. Other methods rely on ditches, forests and beams that slow down water movement and filter out debris. Debris moving at high speed with the flowing water and can be a major source of injury or death.

The student challenge

Clearly, tsunami cannot be prevented so the emphasis is on preventing loss of life when one occurs. Students will act in teams including town planners, architects and civil engineers to plan a town able to cope with catastrophic floods due to massive tidal waves.

The town does not have to be in the immediate impact zone but it must have easy access to the coast, possibly for a tourist resort. The plan should look at all aspects of the rebuild, including the availability of resources, location of services such as roadways, water purification plants and electricity supply lines. It should consider use of the surrounding area, siting and design of civil buildings and housing and communications.

The team must come up with a physical model of the town's layout to demonstrate communications between vital installations such as hospital and airport, schools and residential areas.

Information and criteria for plan are:

- The town should be designed for 10,000 residents.
- It should include flood control mechanisms such as barriers, early warning systems and rescue procedures.

- Buildings should be both flood proof and have rapid escape routes.
- Infrastructure should be designed to continue to function during flooding
- Sewers and water systems should be flood resistant.
- Building structures and materials should be able to resist ingress of water
- The site should be one with minimal flood risk but be accessible to the flood risk area.
- Developments should be as eco-friendly as possible and reduce pollution from energy usage and waste production.

The Output

The project will involve research and teamwork and lead to a plan and possibly a model of the flood-resistant town. Students will also need to present their proposals effectively to their peers.

Students will be expected to:

- list the requirements needed for a town that serves 10,000 residents
- estimate the threat and potential damage to communities by catastrophic tidal waves or tsunamis in order to plan to mitigate future events
- develop, describe and model some features of buildings and the town that demonstrate ways of protecting against or mitigating the effects of tsunamis
- produce a plan for such a town and to demonstrate its features and features of its building through models
- gain experience of planning and executing a complex project in order to be able to apply the same principles to different problems
- gain experience of working in a team and so understand the different roles of team members and the potential contributions they can make
- develop a way that the recommended solution can be presented

Running the project

The stages and roles below offer guidance for running the project.

Stage	Student acticvity	Teacher guidance	Week
Problem identification	Students work together as a group to clarify their approach and the specific questions that they will answer. By the end of the session that should have a list of questions that will enable them to plan and build the tsunami resistant town.	The task here is to define the problem in a way that is capable of solution in the time (six weeks) given. This will give clarity to the information required and the roles of the group. This may be the first time this group has worked together and the teacher should place emphasis on ensuring that they have clearly defined roles, including a leader.	0.5

Background research	Having described the problem and originated a number of possible solutions, students will need to provide background information to enable them to complete it. For example they will need to understand all aspects involved in siting and planning a small town, what risk flooding poses and the most up to date flood defences, warning and rescue strategies. It might be helpful to investigate areas of the world most affected by tidal waves and the type of terrain most at risk of damage from them e.g. communities sited on flat land adjacent to a beach. This will help when deciding on a site for the town for example it might be built where the land starts to rise above the tidal flood plane. Buildings can be raised above flood inundation levels on piers or hardened podiums with vertical escape routes e.g. flat roofs for helicopter rescue Slowing techniques to slow the flow of the water involve creating friction that reduces the destructive power of waves. Specially designed forests, ditches, slopes, and beams can slow and strain debris from waves. To work effectively, these techniques are dependent on correctly estimating the inundation that could occur.	Teachers should help students get started by discussing what kind of information they may need. This could take the form of working through a theoretical solution. However the approach should not be didactic, questions should be used to stimulate students to understand why they need certain information.	0.5 – 1.5
Specification	The specification is what the scheme should deliver. It should describe requirements and not provide solutions. Students will take this specification (brief) and use it to develop the proposed solution. It should include statements like “The buildings should be raised of the ground to be clear of the maximum water level”	The main role of the teacher here is to make sure that the demands of the specification are practical and not impossible to reach. Again, an approach that helps the students write their own specification is best.	1.5 – 2

Alternative solutions	All problems have several possible solutions and it is important to consider them all. This is the week for innovation. Students should be creative. Novel solutions may save money or time. For example, it might be cheaper and safer to encourage the local population to move to a mountainous area where there are employment possibilities.	Student solutions must be credible and practical, but encourage originality. Sometimes discussing an impractical solution can reveal more information that will help solve the problem. Teachers should try not to prompt the students. The students should originate their own ideas. Teaches should try not to point out specific problems – that is for the students to find out. Students should consider surrounding issues like employment opportunities and possibly develop new ones.	3
Build the model	Students should decide upon one plan to take forward. They should develop the idea in detail, which may involve making more detailed drawings or working descriptions. They should at least begin to plan and build their model town during this week.	Students will work enthusiastically at this point because their ideas are reaching fruition. They will have to think about how to illustrate all the features they have chosen for the town in the form of a model.	4
Report the results	The team has built its model town in its hinterland and it should incorporate all the features they have planned. The presentation should involve detailed descriptions of all these features and justify why they have been selected. A written report should be completed outlining all the aspects covered in the presentation.	The model could be described and presented to the Government who commissioned the planning of the town together with a written report.	6

Assessment

In view of the general guidelines for assessing G&T students, it is recommended that this module is assessed in three ways:

1. A general assessment of the report or presentation for each group.
2. A written document from each student
3. A personal self-reflection statement

1. The group assessment

The general assessment is an assessment of the overall group performance, with criteria and marks as follows:

Element	Assessment criteria	Comments on interpretation	Marks
Producing a definition	• Shows clear understanding of the issues that will impact upon and shape the problem • Can articulate the problem in a concise form that is capable of practical solution	This section tests the higher levels of Bloom's taxonomy. To score highly the group must work together constructively to produce a precise and concise definition.	25
Creativity, originality and choice of preferred solution	• Shows originality in identifying a range of proposed solutions • Demonstrates a logical approach to SWAT analysis of proposed solutions	G&T students display different areas of advanced ability. Creativity, "thinking outside the box" and not being inhibited by current solutions is a common feature of G&T behaviour.	25
Organisation, efficiency and thoroughness of preparation, including research	• The group demonstrates efficient organisation with tasks well directed • Shows a clear approach to the research, seeking the information required, without wasting time on irrelevancies	G&T students often perform well in these areas an evaluating research is an important skill.	25
Quality of presentation, including planning and clarity of explanations	• Shows that the presentation is well organised and progresses logically, each point following logically from the one before • Explanations use simple language	Clear explanations may not come easily to G&T students whose thought processes may be complex. Since communication is highly important in all careers and walks of life, high quality communication is important for G&T students.	25

2. The individual written response

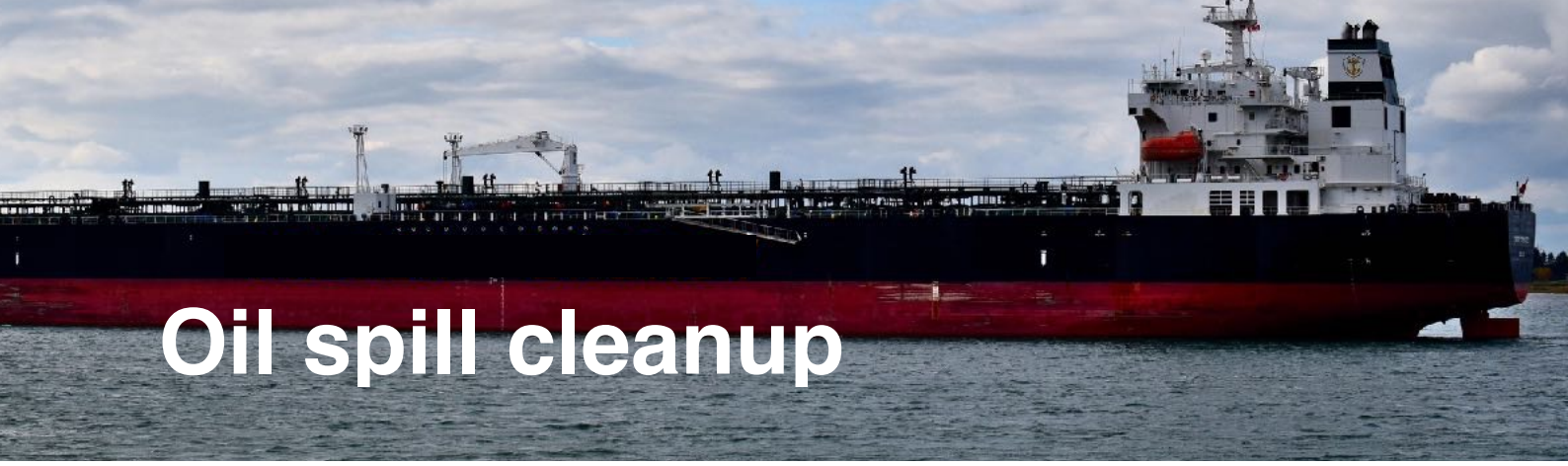
Students should create a written document of no more than 500 words which evaluates their chosen solution from the perspective of the both the commissioners (Government) and users. Does the plan satisfy the criteria given by the commissioners? What features will the local population be happy with and which might they struggle to accept?

Factors to consider in marking include, how well can the student

- put themselves in the position of the user (empathising),
- communicate their thoughts, and
- describe compromises to make the scheme will suit all?

3. The personal reflective statement

Students should consider individually the question, In the light of what you have learnt from undertaking this project what advice would you give to those planning towns in tsunami risk areas?



Oil spill cleanup

The context

An oil spill can cause significant pollution. Heavy, tar-like crude oil can contaminate beaches for years. Oil kills wildlife. It reduces the insulating and buoyancy properties of bird's feathers and animal fur and so flight is impossible for birds and other animals cannot stay afloat. They become susceptible to cold and usually die. A large number of affected animals make any clean-up operation difficult and, even if it were possible, toxic chemicals are required to remove the sticky contamination.

Thailand's largest oil spill was the Rayong/Ko Samet spill on 27th July 2013 when more than 100,000 kg of oil was lost. Other spills around the world come from many sources including ship wrecks or leaks from underwater well heads.

Oil spills also have disastrous economic, social and environmental consequences. Housing, transport, tourism and local industries can be seriously affected. They can become the focus of media attention and have caused political instability.

When a serious oil spill takes place, emergency operations focus first on containment and preventing further loss. The following clean-up can be long and laborious and involve removing an enormous mass of debris, sand, soil and rocks. The addition of foam can help emulsify and disperse oil slicks and sometimes heavier oil fractions are sunk to break up and decompose naturally on the sea bed.

Despite international agreements on clean-up spills legal battles for compensation continue. As oil becomes scarce more advanced technology is required to explore areas where extraction is increasingly difficult and so it is likely that spills will continue as long as people want oil.

The student challenge

A serious oil spill has occurred as the result of an oil tanker being ship wrecked near the southern islands and coast of Thailand, areas particularly attractive to tourists. The oil is heavy crude oil, thick and tar-like. The students play the role of the disaster management team.

In this module they must:

- Develop an emergency plan for immediate containment.
- Develop an intermediate plan for clean-up and dispersal to allow return to some commercial activities as soon as possible.
- Develop a longer term plan that addresses a full return to normal life and commercial development.

The plans should look at the factors such as the type of oil involved, the site and prevailing local weather i.e. winds and local temperatures. They should consider all the ways of dealing with the spill such as containment, dispersal, adding biological agents and natural breakdown. It will then be necessary to look at ways of dealing with and minimising the environmental damage to animals, birds, plants and the environment in general, in the longer term, including its effects on commerce such as tourism.

Information and criteria for the plan are:

- Oil has started to come ashore on some of the outlying islands and is threatening popular tourist beaches.
- This is a large spill – 2,500Tonnes (2,500,000kg) of oil has already been spilled.
- The winds are on-shore with high tides are predicted in the next 24 hours.
- The area is famous for its natural beauty, wild birds and rare species.
- The methods to be used for oil dispersal should cause minimal damage to the environment.
- The rescue and treatment of wildlife should be planned in detail.
- Other agencies and their roles should be included.
- Plans should include clean up and restoration of beaches. Since tourism is essential to the Thai economy, accounting for more than 10% of its GDP, tourism must be given a high priority.
- In addition to the immediate emergency plan, the final presentation must make recommendations about the longer term future and any sustainable preventative measures.

The Output

The project will involve research and teamwork and lead to a written plan to deal with a major oil spill and its implications. Students will also have to present this and the reasons for their decisions through a presentation of some description.

Students will be expected to:

- produce an emergency plan for the first seven days following an oil spill, off the coast of Thailand, containing containment and immediate treatment
- produce a report recommending intermediate action (for a period of a year) following an oil spill off the coast of Thailand, containing dispersal and destruction options
- produce a report for the longer term to deal with the after effects of an oil spill off the coast of Thailand, containing plans for a return to normal and further commercial development
- ensure the reports to take account of the danger to local wildlife and plan to minimise this danger.
- take account of the danger to local communities from, for example fire, and plan to minimise this danger.
- plan for compensation from the ship owners, estimate the amount of compensation and how it would be spent.

Running the project

The stages and roles below offer guidance for running the project.

Stage	Student acticvity	Teacher guidance	Week
Problem identification	Students work together as a group to clarify their approach based on the locality, size and nature of the spill. By the end of the session they should have an outline of the containment and clean up strategies they will use to deal with this disaster. They should concentrate on the immediate emergency at this stage.	The task here is to define the problem in a way that is capable of solution in the time (six weeks) given. The definition will give clarity to the information required and the roles of the group. This may be the first time this group has worked together and the teacher should place emphasis on ensuring that they have clearly defined roles, including a leader.	0.5
Background research	Having described the problem and originated a number of possible solutions, students will need to provide background information to enable them to complete it. For example, they will need to understand all the known methods of containing and dealing with an oil spillage in this type of geographic area with large areas of coastline. Means of cleaning contaminated beaches and soil, and treating affected wildlife should be researched. Which methods would be most efficient and least harmful to the environment? How will the containment and clean up be carried out? Will large numbers of people have to be employed to reach the shores of all the islands so that they are clear before the next tourist season.	Teachers should help students get started by discussing what kind of information they may need. This could take the form of working through a theoretical solution. However the approach should not be didactic, questions should be used to stimulate students to understand why they need certain information.	0.5 – 1.5

Specification	The specification is what the scheme should deliver. It should describe requirements and not provide solutions. Students will take this specification (brief) and use it to develop the proposed solution. It should include statements like “Teams of experienced wild life rescuers should be recruited”.	The main role of the teacher here is to make sure that the demands of the specification are practical and not impossible to reach. Again, an approach that helps the students write their own specification is best.	1.5 – 2
Alternative solutions	All problems have several possible solutions and it is important to consider them all. This is the week for innovation. Students should be creative. Novel solutions may save money or time. For example, it might be cheaper and quicker to select a small number of popular beaches and islands and carry out a complete clean up on them rather than only partially clearing all the beaches. Careful managing of press reports might save the area from becoming unattractive to tourists.	Student solutions must be credible and practical, but encourage originality. Sometimes discussing an impractical solution can reveal more information that will help solve the problem. Teachers should try not to prompt the students. The students should originate their own ideas. Teaches should try not to point out specific problems – that is for the students to find out. Students should consider surrounding issues like long term effects on wildlife and possibly develop new ones.	3
Report the management strategy	Students should decide upon the strategies they will be using in their plan. This will include the timing of all the interventions. They should develop the ideas in detail, which may involve making more detailed maps or working descriptions. They should explain their strategies in a detailed report.	Students will work enthusiastically at this point because their ideas are reaching fruition. They will have to think about how to present their disaster management plan	4
Report the results	The team will present their plan to local officials from all the communities in the affected areas, environmental experts, representatives from the press and the ship owners. The presentation will be supported by their written plan	The presentation should be detailed and professional and include all the team. Different team members could target sectors of the audience e.g. the environmental experts, press etc.	6

Assessment

In view of the general guidelines for assessing G&T students, it is recommended that this module is assessed in three ways:

1. A general assessment of the report or presentation for each group.
2. A written document from each student
3. A personal self-reflection statement

1. The group assessment

The general assessment is an assessment of the overall group performance, with criteria and marks as follows:

Element	Assessment criteria	Comments on interpretation	Marks
Producing a definition	• Shows clear understanding of the issues that will impact upon and shape the problem • Can articulate the problem in a concise form that is capable of practical solution	This section tests the higher levels of Bloom's taxonomy. To score highly the group must work together constructively to produce a precise and concise definition.	25
Creativity, originality and choice of preferred solution	• Shows originality in identifying a range of proposed solutions • Demonstrates a logical approach to SWOT analysis of proposed solutions	G&T students display different areas of advanced ability. Creativity, "thinking outside the box" and not being inhibited by current solutions is a common feature of G&T behaviour.	25
Organisation, efficiency and thoroughness of preparation, including research	• The group demonstrates efficient organisation with tasks well directed • Shows a clear approach to the research, seeking the information required, without wasting time on irrelevancies	G&T students often perform well in these areas an evaluating research is an important skill.	25
Quality of presentation, including planning and clarity of explanations	• Shows that the presentation is well organised and progresses logically, each point following logically from the one before • Explanations use simple language	Clear explanations may not come easily to G&T students whose thought processes may be complex. Since communication is highly important in all careers and walks of life, high quality communication is important for G&T students.	25

2. The individual written response

Students should create a written document of no more than 500 words. In it they should write a letter to the ship owners asking for compensation to be paid to the local area for the damage caused by the disaster. They should make future predictions of how this disaster will affect the local communities and wildlife in the long term and describe any considerations for example financing wildlife treatment centres that will have to be implemented?

Factors to consider in marking include how well can the student

- put themselves in the position of the user (empathising),
- communicate their thoughts, and
- describe compromises to make the scheme will suit all?

3. The personal reflective statement

Students should consider individually the question:

- In the light of what you have learnt from undertaking this project can you suggest any areas of research that might increase the efficiency of the clean up and/or reduce damage from oil pollution in the future?

The context

Modern tablets or pills are often dispensed in packaging called blister packs. The pills are held in a small pocket, the blister, made from plastic film. The pill is held in place by a flat backing of plasticised aluminium foil. The blister may be transparent. The pill is extracted by pressing the blister to force the pill to break through the foil.

The advantages of dispensing pills in this way are:

- Integrity of the medicine - dust often forms on surfaces of drugs rubbing against one another in a bottle
- Blister packs isolate the medicine from atmospheric conditions preventing deterioration from humidity changes and unwanted oxidisation
- Easy to transport small quantities of drugs without damaging them
- Easy to store specific numbers of pills
- Decreases dispensing time
- Easier to manage dosage. Days can be printed on the packs to indicate when the pill should be taken which makes monitoring whether a pill has been used much simpler
- Blister packs are difficult for young children to open and make it less likely that many pills will be removed at once

However, blister packs can cause problems. Older or disabled people may have difficulty in breaking the foil to remove the pills from their blisters. Pills may pop out uncontrollably and be lost. A knife might be used to open the pack, which might pose the chance of cuts, injury or tearing the pack. In 2004 over 6,000 Americans went to hospital with injuries resulting from opening difficult packaging! Such disadvantages may reduce efficiency and eliminate any advantages of blister packs

The student challenge

Students will have to consider different sizes and shapes of tablets, pills, capsules and soft gel capsules. The pills may be loose or tightly fitting in the blister packs. Some capsules have soft gel outer coats and need to be handled gently. The force required to operate the device will have to be suitable for older people.

Students will act as design engineers who will design, build and test a device that will enable the elderly and disabled to remove pills and capsules easily from blister packs.

A working prototype model of the device should be made and demonstrated. The prototype should be tested with a small number of people who have difficulty opening blister packs.

The design and presentation of the device must consider the following issues:

- Function in a domestic setting.
- Not allow contamination of the contents.
- Easily cleaned.
- Be safe to use.
- Durable and capable of multiple use or, alternatively, be disposable.
- Made from environmentally-friendly materials.
- Capable of economically viable commercial production.
- Be easily stored in a domestic setting.
- Fulfil the challenge i.e. allow easy removal of pills and capsules from a variety of blister packs by people who have previously had difficulty with this action.
- A presentation and demonstration of the device will take the form of a pitch to potential sponsors and manufacturers

The Output

The project will involve research and teamwork and lead to a report on the use of blister packs and the development of a blister pack suitable for people who find the traditional packs difficult to use. Students will also have to present this and the reasons for their decisions through a presentation of some description.

Students will be expected to:

- research a variety of blister packs in order to define the range of operating parameters for the device e.g. size.
- research the advantages of their use in dispensing drugs to determine whether some alternative approach would be more appropriate.
- investigate and understand what makes these packs challenging to open in order to determine what difficulties need to be overcome to inform the design process.
- check whether there are similar devices available and suggest how they might be improved.
- design and make a prototype device and demonstrate its use.
- work as a member of a team.
- recruit suitable people and test the prototype.
- present the development to potential sponsors.

Running the project

The stages and roles below offer guidance for running the project.

Stage	Student acticvity	Teacher guidance	Week
Problem identification	Students work together as a group to discuss the information given, and to understand the nature of the difficulties subjects experience opening blister packs. By the end of this session all members of the group should agree on the problems and have some embryonic design ideas for their device, although a complete description will not be possible at this stage.	The task here is to define the problem in a way that is capable of solution in the time (six weeks) given. Identification of the specific questions will clarify what information is needed to place constraints upon the design. Teachers should ensure that the questions are valid and useful. Irrelevant question will waste time in such a short module. This may be the first time this group has worked together and the teacher should place emphasis on ensuring that they have clearly defined roles, including a leader. Encourage students to be open minded and innovative in their approach.	0.5
Background research	Having described the problem and possible alternative solutions students will need to provide background information to enable them to complete it. For example they will have investigate a number of packs to determine the varieties commonly used. They should question and observe a number of people trying to open a variety of packs and try to thoroughly understand their difficulties.	Teachers should help students get started by discussing what kind of information they may need. This could take the form of working through a theoretical solution. However the approach should not be didactic, questions should be used to stimulate students to understand why they need certain information.	0.5 – 1.5
Specification	The design specification is what the scheme should deliver. It should describe outcomes and not suggest solutions. The group will go on to prototype a solution. It should include statements like “The handle of the device should be made from xxxxx”	The main role of the teacher here is to make sure that the demands of the specification are practical and not impossible to reach. Again, an approach that helps the students write their own specification is best.	1.5 – 2

Alternative solutions	All problems have several possible solutions and it is important to consider them all. This is the week for innovation. Students should be creative; unexpected solutions may save money or time. Several design ideas should be tested on the subjects, not all will find any one device as helpful as others. It may be that one device is helpful with certain type of blister packs but not for other packs. Perhaps two devices that help most people need to be taken forward for prototyping? Potential solutions can be theoretically tested by the use of SWOT analysis. A number of different solutions should be suggested and tried on the subjects and a final design chosen.	Student solutions must be credible and practical, but teachers should encourage originality and innovation. Sometimes discussing an impractical solution can reveal more information that will help solve the problem. Teachers should try not to prompt the students. The students should originate their own ideas. Teachers should try not to point out specific problems with an idea – that is for the students to find out.	3
Develop and prototype	Having decided upon one idea to take forward. They should develop the idea in detail, which may involve making more detailed drawings or working descriptions. They should at least begin to build their prototype during this week.	Students will work enthusiastically at this point because their ideas are reaching fruition. They will have to think about a testing regime. They will probably need less intervention now.	4
Test and redevelop	A testing regime should have been devised so that the model can be tested on a range of people and blister packs.	This is the place to ask “What if?” questions, especially if some aspects cannot be physically tested.	5
Report the results	The team has reached its conclusion and should be ready to recommend its design. The form of presentation should be decided. In this case the presentation will probably involve explanations and a demonstration, using the prototype model. Video clips or photos of the testing of various ideas and demonstration of the prototype with elderly and / or disable people may be used. These tests and demonstrations should be in domestic settings.	The student group could present to a simulated board of a potential sponsor. They should use their model to demonstrate how the system works, its advantages and disadvantages. A written report should accompany the presentation.	6

Assessment

In view of the general guidelines for assessing G&T students, it is recommended that this module is assessed in three ways:

1. A general assessment of the report or presentation for each group.
2. A written document from each student
3. A personal self-reflection statement

1. The group assessment

The general assessment is an assessment of the overall group performance, with criteria and marks as follows:

Element	Assessment criteria	Comments on interpretation	Marks
Producing a definition	• Shows clear understanding of the issues that will impact upon and shape the problem • Can articulate the problem in a concise form that is capable of practical solution	This section tests the higher levels of Bloom's taxonomy. To score highly the group must work together constructively to produce a precise and concise definition.	25
Creativity, originality and choice of preferred solution	• Shows originality in identifying a range of proposed solutions • Demonstrates a logical approach to SWOT analysis of proposed solutions	G&T students display different areas of advanced ability. Creativity, "thinking outside the box" and not being inhibited by current solutions is a common feature of G&T behaviour.	25
Organisation, efficiency and thoroughness of preparation, including research	• The group demonstrates efficient organisation with tasks well directed • Shows a clear approach to the research, seeking the information required, without wasting time on irrelevancies	G&T students often perform well in these areas an evaluating research is an important skill.	25
Quality of presentation, including planning and clarity of explanations	• Shows that the presentation is well organised and progresses logically, each point following logically from the one before • Explanations use simple language	Clear explanations may not come easily to G&T students whose thought processes may be complex. Since communication is highly important in all careers and walks of life, high quality communication is important for G&T students.	25

2. The individual written response

Students should create a written document of no more than 500 words which evaluates their chosen solution from the perspective of the potential users. They should also suggest improvements to the device based on these comments.

Factors to consider in marking include, how well can the student

- put themselves in the position of the user (empathising),
- communicate their thoughts, and
- describe compromises to make the scheme will suit all?

3. The personal reflective statement

Students should consider individually the question, In the light of what you have learnt whilst undertaking this project can you suggest any other applications for this or similar devices?

Dispensing small volumes of liquid

The context

Some liquids such as medicines, need to be dispensed repeatedly in relatively accurate volumes. Mechanisms to do this directly from the storage container can reduce contamination, but existing models generally measure the same fixed quantity on each occasion. The task here is to design a simple adjustable device so that the operator can choose different quantities rapidly. Students should evaluate different designs perhaps including plungers or simple tipping devices. A working prototype should be built.

There are many different, sometimes patented, methods of delivering set amounts of liquid drugs, involving pipettes, pipettes with pumps, pipettes that deliver repeated amounts, syringe plungers, burettes etc. Some are integrated into the bottle top or they may be separate individual containers. Many involve very sophisticated technologies, delivering very small accurate amounts. However, there are many situations where different amounts may be needed for each patient, for example where the amount is related to the patient's weight or age. Very few devices are available to deliver variable but precisely set amounts.

The student challenge

Students are design engineers who will design, build and test a device that will deliver variable amounts of liquid medicines. The device should be suitable for use in hospitals, clinics and in patient's own homes, or even in field clinics.

The design and presentation of the device must incorporate the following features:

- Function in clinical and non-clinical settings
- Deliver accurate volumes of liquid
- Be easily cleaned or disposable
- Be safe for both health workers and patients to use
- Durable and capable of use by multiple people
- Be made from environmentally friendly materials
- Be capable of economically viable manufacture
- Be easily stored in a domestic setting
- Maintain sterility of the liquid it contains, even after opening
- The presentation at the end of the module should involve a demonstration of the device

The Output

The project will involve research and teamwork and lead to a working prototype of a dispenser for small volumes of liquids that is easy to use and delivers volumes within appropriate limits. Students will also have to present this and the reasons for their decisions through a presentation of some description.

Students will be expected to:

- research a variety of simple delivery systems, which have been designed to deliver fixed quantities of liquid, in order to assess whether a new design is needed and to adapt or adopt the best principles.
- investigate whether existing systems can be adapted or made simpler.
- identify circumstances where specific variable amounts of drugs are required.
- make a device, incorporating the required characteristics above and demonstrate its use.
- work as a member of a team with each member having different roles in order to demonstrate the efficiency of team work.
- test the final design.
- develop a way that the recommended solution can be presented.

Running the project

The stages and roles below offer guidance for running the project.

Stage	Student acticvity	Teacher guidance	Week
Problem identification	Students work together as a group to discuss the information given, and to understand the need to deliver medicines in set but variable amounts. By the end of this session all members of the group should agree on the problem and have some embryonic design ideas for their device, although a complete description will not be possible at this stage.	The task here is to define the problem in a way that is capable of solution in the time (six weeks) given. Identification of the specific questions will clarify what information is needed to place constraints upon the design. Teachers should ensure that the questions are valid and useful. An irrelevant question will waste time in such a short module. This may be the first time this group has worked together and the teacher should place emphasis on ensuring that they have clearly defined roles, including a leader.	0.5

Background research	Having described the problem and possible alternative solutions, students will need to provide background information to enable them to complete it. For example, they will have investigate a number of simple delivery systems for medicines. They research the circumstances where set, variable amounts of medicines are needed.	Teachers should help students get started by discussing what kind of information they may need. This could take the form of working through a theoretical solution. However the approach should not be didactic, questions should be used to stimulate students to understand why they need certain information.	0.5 – 1.5
Specification	The design specification is what the scheme should deliver. It should describe outcomes and not suggest solutions. The group will go on to prototype a solution. It should include statements like "The bottle should tip to 45 degrees to allow delivery of xx amount of liquid."	The main role of the teacher here is to make sure that the demands of the specification are practical and not impossible to reach. Again, an approach that helps the students write their own specification is best.	1.5 – 2
Alternative solutions	All problems have several possible solutions and it is important to consider them all. This is the week for innovation. Students should be creative, unexpected solutions may save money or time. Several design ideas should be tested.	Student solutions must be credible and practical, but teachers should encourage originality and innovation. Sometimes discussing an impractical solution can reveal more information that will help solve the problem. Teachers should try not to prompt the students. The students should originate their own ideas. Teachers should try not to point out specific problems with an idea – that is for the students to find out.	3
Develop and prototype	Having decided upon one idea to take forward. They should develop the idea in detail, which may involve making more detailed drawings or working descriptions. They should at least begin to build their prototype during this week.	Students will work enthusiastically at this point because their ideas are reaching fruition. They will have to think about a testing regime. They will probably need less intervention now.	4
Test and redevelop	A testing regime should have been devised so that the model can be tested.	This is the place to ask "What if?" questions, especially if some aspects cannot be physically tested.	5

Report the results	The team has reached its conclusion and should be ready to recommend its design. The form of presentation should be decided. In this case the presentation will probably involve explanations and a demonstration, using the prototype model.	The student group could present to a simulated health device supply company which may develop the device commercially. They should use their model to demonstrate how the system works, its advantages and disadvantages. A written report should accompany the presentation.	6

Assessment

In view of the general guidelines for assessing G&T students, it is recommended that this module is assessed in three ways:

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Creativity, originality and choice of preferred solution	• Shows originality in identifying a range of proposed solutions • Demonstrates a logical approach to SWAT analysis of proposed solutions	G&T students display different areas of advanced ability. Creativity, "thinking outside the box" and not being inhibited by current solutions is a common feature of G&T behaviour.	25
Organisation, efficiency and thoroughness of preparation, including research	• The group demonstrates efficient organisation with tasks well directed • Shows a clear approach to the research, seeking the information required, without wasting time on irrelevancies	G&T students often perform well in these areas and evaluating research is an important skill.	25

Quality of presentation, including planning and clarity of explanations	• Shows that the presentation is well organised and progresses logically, each point following logically from the one before • Explanations use simple language	Clear explanations may not come easily to G&T students whose thought processes may be complex. Since communication is highly important in all careers and walks of life, high quality communication is important for G&T students.	25

2. the individual written response
Students should create a written document of no more than 500 words which evaluates their chosen solution from the perspective of the potential users. They should also suggest improvements to the device based on these comments.

Factors to consider in marking include, how well can the student
- put themselves in the position of the user (empathising),
- communicate their thoughts, and
- describe compromises to make the scheme will suit all?

3. The personal reflective statement
Students should consider individually the question, In the light of what you have learnt whilst undertaking this project can you suggest any other applications for this or similar devices?

The context

Many people want whiter teeth, but there are very few people who have naturally brilliant white enamel. Just as our hair and skin colour vary, so do our teeth. Teeth can also become discoloured as we age and may be stained by drinks like tea and coffee. Smoking also stains teeth.

Unless teeth are cleaned regularly, bacteria build up living on food and drink remains, particularly at the junction between teeth and gums. This plaque also discolours teeth and can become hardened into tartar. Some people may have staining under the surface, which can be caused by certain antibiotics or by tiny cracks in the enamel which take up stains.

Many whiting toothpastes contain abrasives such as silica (finely ground sand or glass) that clean teeth by wearing away surface stains. Some toothpastes contain a mild bleach like sodium carbonate. Dentists may use stronger preparations. Whitening toothpaste can never actually change the colour of teeth but, if used over a number of weeks, teeth appear whiter because they are super clean! In some countries a chemical called blue covarine is added to toothpaste, it sticks to the teeth and creates an optical illusion which makes teeth appear less yellow.

The remedies described above may lighten the shade of teeth but the only way to get white teeth is to have them capped in white enamel.

The student challenge

The module task is to make a pleasant tasting, whitening toothpaste and test it for acceptability by the general public (represented by other students). Suitable safe whitening compounds will need to be identified. To do this students may need to devise a test using an enamel substitute rather than testing their prototypes on people. The toothpaste should have the following characteristics:

- Be effective and safe to use.
- Be pleasant to taste, various sweeteners such as saccharine, aspartame, stevia and sucralose can be tested for acceptability. You should test for the best sweetener. You may find other suitable and pleasant flavourings.
- The final report should contain the results of the tests to recommend one formulation as suitable for market and include samples of the toothpaste you have developed.

The Output

The project will involve research and teamwork and lead to a sample of toothpaste which has been tested for taste, commercial acceptability and effectiveness. Students wills have to produce documentation describing their methods and findings and giving details of their toothpaste formulation.

Students will be expected to:

- produce a formula for a pleasant tasting, safe, whitening toothpaste.
- make a sample of the toothpaste.
- test the toothpaste over time and design a chart to assess the whitening progress.
- develop several different flavours for the paste and test these to identify the most popular flavour.
- produce a report to recommend your new toothpaste.

Running the project

The stages and roles below offer guidance for running the project.

Stage	Student acticvity	Teacher guidance	Week
Problem identification	Students should formulate the questions that need to be answered in order to produce the end result. This will indicate the research required and testing strategies that have to be developed.	Defining the required outcome in this way will clarify the steps needed to achieve the result. The teacher may need to encourage students to take different roles in the investigation. However, the teacher's role is to challenge ideas and to guide students to make their own decisions.	0.5
Background research	In this module there is quite a bit of basic science information to be gathered to understand the underpinning principles. Students will need to gather enough information to be able to select the whitening methods and flavours they are going to use. Product testing should be researched and tasting sessions organised	Teachers can bring an experienced eye to the problem. Whilst they should stimulate students to come up with their own ideas they should challenge the ideas and guide students towards systems that are likely to be practical under the module conditions i.e. time allocations etc. Teachers should pay particular attention to the use of safe chemicals.	0.5 – 1.5
Specification	The specification is a description, of what the end product should be. It cannot give very precise details at this stage because the development process has to take place.	The main role of the teacher here is to make sure that the demands of the specification are practical and not impossible to reach. Again, an approach that helps the students write their own specification is best.	1.5 – 2

Alternative solutions	There may be several ways to meet the specification, for example different flavours such as chocolate or lemon could be trialled. A number of options should be selected for exploration. Students might like to consider what are the most practical possibilities.	Student solutions must be credible and practical, but teachers should encourage originality. Sometimes discussing an impractical solution can reveal more information that will help solve the problem. Teachers should try not to prompt the students. The students should originate their own ideas. Teachers should try not to point out specific problems involved in an idea – that is for the students to find out.	3
Develop and prototype	In this case a number of formulae should be explored by experiment and tested on volunteers.	Teachers should explain the scientific method and ensure that students include enough controls and that fair tests are conducted. **SAFETY**: Students should not be allowed to test any pastes on humans before having their formulations checked and agreed by the teacher.	4
Test and redevelop	A leading formula should be revealed by the experiments. Students should modify it according to the results.	This is the stage where modifications can take place. Students should largely work alone at this stage.	5
Report the results	The team should be ready to present and justify their formula and allow the panel to sample the toothpaste for its taste. They should make a presentation showing evidence of the success of the formula supported by test results.	The presentation could be in the form of a verbal presentation describing the product, tests carried out and results with a tasting session for the toothpaste.	6

Assessment

In view of the general guidelines for assessing G&T students, it is recommended that this module is assessed in three ways:

1. A general assessment of the report or presentation for each group.
2. A written document from each student
3. A personal self-reflection statement

1. The group assessment

The general assessment is an assessment of the overall group performance, with criteria and marks as follows:

Element	Assessment criteria	Comments on interpretation	Marks

Producing a definition	• Shows clear understanding of the issues that will impact upon and shape the problem • Can articulate the problem in a concise form that is capable of practical solution	This section tests the higher levels of Bloom's taxonomy. To score highly the group must work together constructively to produce a precise and concise definition.	25
Creativity, originality and choice of preferred solution	• Shows originality in identifying a range of proposed solutions • Demonstrates a logical approach to SWAT analysis of proposed solutions	G&T students display different areas of advanced ability. Creativity, "thinking outside the box" and not being inhibited by current solutions is a common feature of G&T behaviour.	25
Organisation, efficiency and thoroughness of preparation, including research	• The group demonstrates efficient organisation with tasks well directed • Shows a clear approach to the research, seeking the information required, without wasting time on irrelevancies	G&T students often perform well in these areas and evaluating research is an important skill.	25
Quality of presentation, including planning and clarity of explanations	• Shows that the presentation is well organised and progresses logically, each point following logically from the one before • Explanations use simple language	Clear explanations may not come easily to G&T students whose thought processes may be complex. Since communication is highly important in all careers and walks of life, high quality communication is important for G&T students.	25

2. The individual written response

Students should create a written document of no more than 500 words which evaluates their chosen solution from the perspective of the potential users. They should consider issues such as How well does your product meet the original specification, does it really whiten teeth? Does it taste nice? Are there any dangers in its use? Do you believe it is a commercially viable product?

Factors to consider in marking include how well can the student

- put themselves in the position of the user (empathising),
- communicate their thoughts, and
- describe compromises to make the scheme will suit all?

3. The personal reflective statement

Students should consider individually the question:

- How important is it for people to whiten their teeth? Is this something scientists and technologists should encourage? Why? Why not?
- Where do you think are the weaknesses in the experimental techniques and how would you conduct the tests if you were to repeat them?

The good drone

The context

Most people think of drones, unmanned aerial vehicles, in terms of military use. However, they have many uses from mapping, aerial photography and surveying to search and rescue. One day drones may even deliver parcels to you!
Water is arguably the most precious resource world wide but large quantities are lost through leakage, particularly in desert regions where it has to be transported over vast distances and it is difficult to maintain pipe lines.

Leaking underground pipes produce areas of soil with higher water levels than the surrounding areas. It should be possible for drones to detect these damper areas by colour. Drones are already used to detect areas of diseased crops and research is currently underway into their use in detecting leaks in remote situations.

The student challenge

Students play the role of research scientists investigating the use of drones to detect leaks in water pipes in remote, inhospitable areas. Their task is to develop a simple system that uses easily available, relatively cheap technology to detect water leaks using colour data sent back to base where the data can be analysed and action taken. This would make the detection of such leaks cheap and easy for communities where sophisticated technology is not available.

Although the students will not be able to make or use real drones in their experiments, this module is designed to demonstrate how a colour scale can be developed through simulations. Students can use simple equipment such as digital cameras, smart phones and domestic photo handling software to develop a colour scale related to the percentage of soil moisture content. They will have to take into account differences in their recording equipment, soil types and errors. They should also propose a strategy for transferring their conclusions to a drone, suggesting how they would deal with drone height above the ground and compensation for different intensities and quality of incoming sunlight etc.

The specific requirements are:

- The colour scale should be related to water content of soil.
- Simulated areas should be used to calibrate the recording instrument.
- The equipment should be as simple and cheap as possible.
- Simple photo handling software should be used to measure the variables chosen e.g. colour or brightness.
- Other factors that could affect the results should be identified eg different soil types, angle from which the colour is estimated, sun light brightness should be identified and their influence investigated.

- A report should be produced explaining the system and its advantages, the report can be made as a presentation.

The Output

The project will involve research and teamwork and lead to a system capable of measuring water content of soil samples by colour analysis. Students will also have to present their method and the reasons for their decisions through a presentation of some description.

Students will be expected to:

- produce a system to detect changes water content of soil that can be fitted on a drone to remotely detect water leaks from pipes.
- develop a colour scale related to percentage of soil water or other means of detecting the amount of water in soil such as temperature
- use simple, readily available technology to develop the system
- show how the system could be used with drones
- work as a member of a team with each member having different roles
- present the results of development

Running the project

The stages and roles below offer guidance for running the project.

Stage	Student acticvity	Teacher guidance	Week
Problem identification	Taking the role of research scientists, students should formulate the questions that need to be answered in order to produce the end result. This will indicate the research required, such as signs of water in soil and how these can be sensed and recorded. These will then have to be tested and a scale devised.	Defining the required outcome in this way will clarify the steps needed to achieve the result. The teacher may need to encourage students to take different roles in the investigation. However, the teacher's role is to challenge ideas and to guide students to make their own decisions.	0.5
Background research	In this module there is quite a bit of basic science information to be gathered to understand the underpinning principles. Students will need to gather enough information to be able to select the methods they are going to use and test.	Teachers can bring an experienced eye to the problem. Whilst they should stimulate students to come up with their own ideas they should challenge the ideas and guide students towards systems that are likely to be practical under the module conditions i.e. time allocations etc.	0.5 – 1.5

Specification	The specification is a description, of what the end product should be. It cannot give very precise details at this stage because the development process has to take place.	The main role of the teacher here is to make sure that the demands of the specification are practical and not impossible to reach. Again, an approach that helps the students write their own specification is best.	1.5 – 2
Alternative solutions	There may be several ways to meet the specification, for example photography or heat sensors. A number of options should be selected for exploration. Students might like to consider what are the most practical possibilities.	Student solutions must be credible and practical, but teachers should encourage originality. Sometimes discussing and impractical solution can reveal more information that will help solve the problem. Teachers should try not to prompt the students. The students should originate their own ideas. Teachers should try not to point out specific problems involved in an idea – that is for the students to find out.	3
Develop and prototype	In this case a number of options should be explored and tested.	Teachers should explain the scientific method and ensure that students include enough controls and that fair tests are conducted.	4
Test and redevelop	A leading candidate for the system should be revealed by the experiments. Students should modify it according the results.	This is the stage where modifications can take place.	5

Report the results	The team should be ready to make a recommendation about the final solution. They should make a presentation supported by a demonstration. The report should present evidence to justify their final solution. It may not be possible to present an actual drone but capabilities should be suggested. The means of detecting the increased water levels resulting from a leak should be demonstrated along with an explanation/ demonstration of how the data can be collected and used to pin point the leak.	The presentation could be in the form of a verbal presentation justifying their choice of solution to the challenge.	6

Assessment

In view of the general guidelines for assessing G&T students, it is recommended that this module is assessed in three ways:

1. A general assessment of the report or presentation for each group.
2. A written document from each student
3. A personal self-reflection statement

1. The group assessment

The general assessment is an assessment of the overall group performance, with criteria and marks as follows:

Element	Assessment criteria	Comments	Marks
Producing a definition	• Level and speed of understanding the main problem • Level and speed of identifying and understanding the surrounding issues that impact upon the problem • Analysing how these elements interact • Sophistication and depth of discussion • Synthesising these into a concise definition	This section tests the higher levels of Bloom's taxonomy. To score highly the group must work together constructively to produce a precise and concise definition.	25

Creativity, originality and choice of preferred solution	• Creativity and originality of solutions • Analysis of the strengths and weaknesses of the candidates solutions • Clarity with which the preferred solution is chosen, including credibility of the preferred solution	G&T students display different areas of advanced ability. Creativity, “thinking outside the box” and not being inhibited by current solutions is a common feature of G&T behaviour.	25
Organisation, efficiency and thoroughness of preparation, including research	• How well was the group managed and how well did they work together? • Were tasks distributed evenly? • Was the research relevant and well targeted? • Were the results relevant?	G&T students often perform well in these areas an evaluating research is an important skill.	25
Quality of presentation, including planning and clarity of explanations	• The presentation should be well organised with an introduction, content with results and analysis leading to a clear conclusion. • Explanations should use simple language • Presentations should be well paced and well timed	Clear explanations may not come easily to G&T students whose thought processes may be complex. Since communication is highly important in all careers and walks of life, high quality communication is important for G&T students.	25

2. The individual written response

Students should create a written document of no more than 500 words which considers the suggestion that the drone used to detect water leaks could be captured and use by terrorists. Does this justify its use? Why? Why not? Suggest how to prevent the use of stolen drones by terrorists

Factors to consider in marking include, how well can the student

- put themselves in the position of the user (empathising),
- communicate their thoughts, and
- describe compromises to make the scheme will suit all?

3. The personal reflective statement

Students should consider individually the question:

- Can you suggest any improvements to the system you have developed and could it be adapted for other similar uses?

Mars rescue!

The context

After Earth, Mars is the most habitable planet in the Solar System. Although life as we know it could not exist currently on Mars, it may once have supported primitive bacteria and there is some evidence that liquid water flowed on the surface in the past. There is little wonder that there is such an interest in Mars exploration.

Today, Mars is a very inhospitable place, with temperatures varying between -125^{o}C to +70^{o}C. The Martian atmospheric pressure is about 1% of that on Earth at sea level. It comprises about 95% carbon dioxide and does little to protect the surface from cosmic radiation. Large dust storms, maybe covering an area as large as Africa, occur every few months and grow big enough to encircle the planet approximately every five and half years. However, although winds travel at up to 70 km per hr, because the atmospheric pressure is so low, they carry little force and would do minimal damage to equipment. Most of the Martian atmosphere has been lost to space, leaving an dry dusty surface containing iron oxide, which gives Mars its red colour. There is a little water left which forms ice caps at the poles and evaporates to give thin clouds when the surface is warm enough.

Since the 1960's there have been have been 43 Mars missions but barely half have been completely successful. The most recent missions have been more successful and since the millennium only one has failed. Nevertheless, the challenges faced when planning a mission to Mars are formidable.

The student challenge

A future manned mission to Mars has to overshoot its landing site because an unusually severe sand storm arrives. They land at a site which is further away from the base camp than planned. The mission carries a vehicle (Mars Rover 10, known as MR10) designed to take the crew from its landing point to base camp, but their overshooting means that they do not have enough fuel. So they must be rescued by a Mars Rover (MR1) from base camp. MR1 has enough fuel to reach MR10, but breaks down on its way. A wheel collapses and there is no spare. Although it cannot reach the base, MR10 can reach the broken-down rover.

The student team has to design a wheel or trailer so that MR1 can get back to base. The arriving astronauts can travel on MR10 to MR1and transfer to it for the journey back to base. Information and features to be incorporated:

- The wheel has to fit MR1
- The wheel has to have some kind of internal suspension to ride the relatively small rocks encountered on the Martian surface

- The wheel has to be tracked to give sufficient friction with the surface
- The wheel should be light and durable i.e. recommend a material for construction
- Students can assume there is enough fuel (all kinds) and oxygen for the journeys

The Output

The project will involve research and teamwork and lead to a design for a replacement wheel for the MR1 or a trailer to carry the damaged rover. Students will also have to present this and the reasons for their decisions through a presentation of some description.

Students will be expected to:

- discover more about conditions on Mars.
- investigate existing Mars Rovers in order to use the principles in this design
- design a means to get the MR1 back to base, taking into account the conditions on Mars, limitations on manpower and materials likely to be available.
- make a device (model) to allow crew members to be transported to base camp.
- work as a member of a team with each member having different roles in order to demonstrate the efficiency of team work.
- develop a way that the recommended solution can be presented.

Running the project

The stages and roles below offer guidance for running the project.

Stage	Student activity	Teacher guidance	Week
Problem identification	Students work together as a group to discuss the information given, and to understand the nature of the difficulties the conditions on Mars impose on the problem. By the end of this session all members of the group should agree on the problems and have some embryonic design ideas for their solution, although a complete description will not be possible at this stage.	The task here is to define the problem in a way that is capable of solution in the time (six weeks) given. Identification of the specific questions will clarify what information is needed to place constraints upon the design. Teachers should ensure that the questions are valid and useful. Irrelevant questions will waste time in such a short module. This may be the first time this group has worked together and the teacher should place emphasis on ensuring that they have clearly defined roles, including a leader.	0.5

Background research	Having described the problem and possible alternative solutions students will need to provide background information to enable them to complete it. For example they will have to investigate limitations on the workforce on Mars i.e. how many people are on Mars at any one time, how long and hard are they able to work in the prevailing conditions. What are their skills etc.	Teachers should help students get started by discussing what kind of information they may need. This could take the form of working through a theoretical solution. However the approach should not be didactic, questions should be used to stimulate students to understand why they need certain information.	0.5 – 1.5
Specification	The design specification is what the scheme should deliver. It should describe outcomes and not suggest solutions. The group will go on to prototype a solution. It should include statements like "The new wheel should be made of xxx"	The main role of the teacher here is to make sure that the demands of the specification are practical and not impossible to reach. Again, an approach that helps the students write their own specification is best.	1.5 – 2
Alternative solutions	All problems have several possible solutions and it is important to consider them all. This is the week for innovation. Students should be creative, unexpected solutions may save money or time. The design idea should be tested on simulated Mars conditions where practical. Potential solutions can be theoretically tested by the use of SWOT analysis. A number of different solutions should be tried and a final design chosen	Student solutions must be credible and practical, but teachers should encourage originality and innovation. Sometimes discussing an impractical solution can reveal more information that will help solve the problem. Teachers should try not to prompt the students. The students should originate their own ideas. Teachers should try not to point out specific problems with an idea – that is for the students to find out.	3
Develop and prototype	Having decided upon one design to take forward it should be developed in detail, which may involve making more detailed drawings or working descriptions. They should at least begin to build their prototype during this week.	Students will work enthusiastically at this point because their ideas are reaching fruition. They will have to think about a testing regime. They will probably need less intervention now.	4

Test and redevelop	A testing regime should have been devised so that the model can be tested in simulated Mars conditions.	This is the place to ask “What if?” questions, especially if some aspects cannot be physically tested.	5
Report the results	The team has reached its conclusion and should be ready to recommend its design. The form of presentation should be decided. In this case the presentation will probably involve explanations and a demonstration, using the prototype model. Video clips or photos of the testing of various ideas may be used.	The student group could present to NASA Mars Safety Board board. They should use their model to demonstrate how the solution works, its advantages and disadvantages. A written report should accompany the presentation.	6

Assessment

In view of the general guidelines for assessing G&T students, it is recommended that this module is assessed in three ways:

1. A general assessment of the report or presentation for each group.
2. A written document from each student
3. A personal self-reflection statement

1. The group assessment

The general assessment is an assessment of the overall group performance, with criteria and marks as follows:

Element	Assessment criteria	Comments on interpretation	Marks
Producing a definition	• Shows clear understanding of the issues that will impact upon and shape the problem • Can articulate the problem in a concise form that is capable of practical solution	This section tests the higher levels of Bloom’s taxonomy. To score highly the group must work together constructively to produce a precise and concise definition.	25
Creativity, originality and choice of preferred solution	• Shows originality in identifying a range of proposed solutions • Demonstrates a logical approach to SWOT analysis of proposed solutions	G&T students display different areas of advanced ability. Creativity, “thinking outside the box” and not being inhibited by current solutions is a common feature of G&T behaviour.	25
Organisation, efficiency and thoroughness of preparation, including research	• The group demonstrates efficient organisation with tasks well directed • Shows a clear approach to the research, seeking the information required, without wasting time on irrelevancies	G&T students often perform well in these areas and evaluating research is an important skill.	25

Quality of presentation, including planning and clarity of explanations	• Shows that the presentation is well organised and progresses logically, each point following logically from the one before • Explanations use simple language	Clear explanations may not come easily to G&T students whose thought processes may be complex. Since communication is highly important in all careers and walks of life, high quality communication is important for G&T students.	25

2. The individual written response

Students should create a written document of no more than 500 words which evaluates their chosen solution from the perspective of the astronauts. They should consider the conditions they will have to undertake the rescue in. What will be the astronauts views and emotions and can students suggest improvements to the device?

Factors to consider in marking include, how well can the student

- put themselves in the position of the user (empathising),
- communicate their thoughts, and
- describe compromises to make the scheme will suit all?

3. the personal reflective statement

Students should consider individually the question:

- In the light of what you have learnt whilst undertaking this project what would be your priorities for improvements and what arguments would you use to convince others to incorporate them in a new design?

Cleaning polluted water

The context

Water pollution is caused by toxic chemicals, bio-contamination and pathogens. Industries produce many forms of pollution, for example carbon dioxide, carbon monoxide, nitrogen oxides and sulphur dioxide that cause climate change. Waste chemicals are discharged as by-products of industrial processes. Even compounds containing toxic substances such as arsenic, which is used in metal electro-plating, can be often washed into rivers or left in pools near the factory.

Creating such toxic pollution is also wasteful. Many of the pollutants can be recycled and re-used relatively cheaply. For example, some plants that will grow in high concentrations of heavy metal pollutants can be harvested and the heavy metals recovered.

Drinking water pollution is a major global problem, it has been suggested that it is the leading cause of death and disease, accounting for the deaths of more than 14,000 people per day, worldwide. An estimated 580 people in India alone die every day from illness related to water pollution and about 90% of water in Chinese cities is polluted. But it is not just developing countries that have an acute water pollution problem, the developed world also struggles to keep water clean. A recent report from the United States found major pollution in many water sources.

In Thailand both surface and ground water are used for human water supply and both are increasingly polluted by human sewage, industrial and agricultural run-off waste. It has been estimated that one third of surface water is poor quality. The increasing pollution is caused by a rising population, poor water and agricultural practices and water shortage in some regions, despite floods in others.

The student challenge

Many old mine workings or industrial waste tips produce polluted water. Mines may be flooded and the water spilling from the mines contains many toxic compounds. Waste tips may leak pollutants into rain water which collects in toxic pools around them and may even leak into human water supplies.

The students' task is to find a way of containing toxins and to clean the water releasing water pure enough to enter water courses that lead to reservoirs for potable water. They will have to research the likely components in the waste and find economic ways of dealing with it. Solutions might include settling pools, reed beds and containment. In some situations plants can be used to absorb pollutants or toxins from the solution. They can then be harvested and disposed of safely. Copper can be retrieved and recycled in this way.

Information and criteria for the clean up are:

- Water in the area surrounding an old mine has become polluted, it is affecting the local ground water and is lying in toxic pools on the site.
- The clean up must use an environmentally sensitive system
- If possible the system, in addition to the production of clean water, should have another advantage to the local community such as the retrieval of saleable heavy metals

The Output

The project will involve research and teamwork and lead to a method of monitoring and cleaning polluted water. Students will also have to present this and the reasons for their decisions through a presentation of some description.

Students will be expected to:

- develop a specification for water entering water courses serving reservoirs
- list the most likely contaminants, their toxic and other polluting effects.
- discover the most successful methods of cleaning contaminated water and how they work.
- develop tests for contaminants to identify suitable sites and to check that pollutants have been removed after treatment
- describe an effective decontamination method and demonstrate its use.
- work as a member of a team with each member having different roles in order to demonstrate the efficiency of team work.
- develop a way that the recommended solution can be presented.

Running the project

The stages and roles below offer guidance for running the project.

Stage	Student activity	Teacher guidance	Week
Problem identification	Students work together as a group to discuss the information given, and to understand the nature of water contamination and the difficulties involved in cleaning the water. By the end of this session all members of the group should agree on the problems and have some embryonic design ideas for their solution, although a complete description will not be possible at this stage.	The task here is to define the problem in a way that is capable of solution in the time (six weeks) given. Identification of the specific questions will clarify what information is needed and place constraints upon the design. Teachers should ensure that the questions are valid and useful. This may be the first time this group has worked together and the teacher should place emphasis on ensuring that they have clearly defined roles, including a leader.	0.5

Background research	Having described the problem and possible alternative solutions students will need to provide background information to enable them to complete it. For example they will have to define contaminated water and identify the most likely contaminants in water surrounding old mine workings. What are the most effective means of cleaning up?	Teachers should help students get started by discussing what kind of information they may need. This could take the form of working through a theoretical solution. However the approach should not be didactic, questions should be used to stimulate students to understand why they need certain information.	0.5 – 1.5
Specification	The design specification is what the scheme should deliver. It should describe outcomes and not suggest solutions. The group will go on to prototype a solution. It should include statements like "The reed beds should be planted within xxx of the site"	The main role of the teacher here is to make sure that the demands of the specification are practical and not impossible to reach. Again, an approach that helps the students write their own specification is best.	1.5 – 2
Alternative solutions	All problems have several possible solutions and it is important to consider them all. This is the week for innovation. Students should be creative, unexpected solutions may save money or time. The potential solutions should be tested on pre contaminated water to test its effect. A number of different solutions should be tried and a final system or systems chosen. Different contaminants may need different solutions to achieve removal.	Student solutions must be credible and practical, but teachers should encourage originality and innovation. Sometimes discussing an impractical solution can reveal more information that will help solve the problem. Teachers should try not to prompt the students. The students should originate their own ideas. Teachers should try not to point out specific problems with an idea – that is for the students to find out.	3
Develop and prototype	Having decided upon the clean up system to take forward it should be developed in detail. They should at least begin to build the model of the decontamination system during this week.	Students will work enthusiastically at this point because their ideas are reaching fruition. They will have to think about a testing regime. They will probably need less intervention now.	4
Test and redevelop	The final clean up system should be tested on contaminated water.	This is the place to ask "What if?" questions, especially if some aspects cannot be physically tested.	5

Report the results	The team has reached its conclusion and should be ready to recommend its system. The form of presentation should be decided. In this case the presentation will probably involve explanations and a demonstration using contaminated water with the model of the system.	The student group should use their model to demonstrate how the solution works, its advantages and disadvantages to members of the local community. A written report should accompany the presentation.	6

Assessment

In view of the general guidelines for assessing G&T students, it is recommended that this module is assessed in three ways:

1. A general assessment of the report or presentation for each group.
2. A written document from each student
3. A personal self-reflection statement

1. The group assessment

The general assessment is an assessment of the overall group performance, with criteria and marks as follows:

Element	Assessment criteria	Comments on interpretation	Marks
Producing a definition	• Shows clear understanding of the issues that will impact upon and shape the problem • Can articulate the problem in a concise form that is capable of practical solution	This section tests the higher levels of Bloom's taxonomy. To score highly the group must work together constructively to produce a precise and concise definition.	25
Creativity, originality and choice of preferred solution	• Shows originality in identifying a range of proposed solutions • Demonstrates a logical approach to SWOT analysis of proposed solutions	G&T students display different areas of advanced ability. Creativity, "thinking outside the box" and not being inhibited by current solutions is a common feature of G&T behaviour.	25
Organisation, efficiency and thoroughness of preparation, including research	• The group demonstrates efficient organisation with tasks well directed • Shows a clear approach to the research, seeking the information required, without wasting time on irrelevancies	G&T students often perform well in these areas and evaluating research is an important skill.	25

Quality of presentation, including planning and clarity of explanations	• Shows that the presentation is well organised and progresses logically, each point following logically from the one before • Explanations use simple language	Clear explanations may not come easily to G&T students whose thought processes may be complex. Since communication is highly important in all careers and walks of life, high quality communication is important for G&T students.	25

2. The individual written response

Students should create a written document of no more than 500 words which evaluates their chosen solution from the perspective of the local population who will use the water in their homes. What will their views be and how can you convince them that the water is safe to drink (drinking it yourself will not demonstrate long term effects!)?

Factors to consider in marking include, how well can the student

- put themselves in the position of the user (empathising),
- communicate their thoughts, and
- describe compromises to make the scheme will suit all?

3. The personal reflective statement

Students should consider individually the question, In the light of what you have learnt whilst undertaking this project can you suggest any other, better ways of cleaning up contaminated water?

Flood proof house

The context

Some areas of Thailand are susceptible to flash flooding from rivers breaking their banks due to water rapidly washing downhill. The high volume of water is a result of high rainfall, deforestation and tropical storms. Despite building containment basins, flood drainage channels and flood defences, floods still occur, especially in rural areas because the volume of water exceeds the capacity of drainage channels. Sometimes dams have to be opened due to an exceptionally high water volume washing downriver.

Flood proofing existing dwellings and introducing flood proof designs for new buildings has become a high priority in communities at high risk of flooding. Such houses usually have the main living areas at first floor level. The kitchen, where most electrical appliances are found is on the second floor. Architects sometimes group houses together with first-floor walk-ways between them. The ground floor is constructed of engineering brick which is more resistant to water than other building materials.

The student challenge

The challenge is to design a house for an area where there is a high risk of flooding. The site for the house is by a river and there is no alternative site, due to close surrounding buildings and the need to provide accommodation near to an industrial park. The students, acting as a town planning team, must decide whether to protect the site from incoming water, divert it or to build the house in such a way as to be flood proof. They must build a model house to demonstrate its features.

Information and criteria for plan are:

- The house should be suitable for six residents, such as a family of six, grandparents, parents and two children, with four bedrooms
- The plan should describe its relationship to adjacent houses, common access, common waste disposal, car parking etc.
- Specific building materials should be described and their function explained
- Include design features such as flood proof window screens
- Services should be flood proof e.g. valves on waste pipes to stop back flow of sewage.
- Escape routes should be included
- The design should be as eco-friendly as possible.

The Output

The project will involve research and teamwork and lead to a working prototype of a rice dryer. Students will also have to present this and the reasons for their decisions through a presentation of some description.

Students will be expected to:

- list the requirements needed of a house design for a family of this size in a flood risk area
- investigate current designs for flood proof housing in order to use some features in the house design
- describe the design features most suitable for a flood risk area in Thailand
- identify and use as appropriate in the design flood resistant materials
- produce a model house that clearly demonstrates the flood protection features
- gain experience of working in a team and so understand the different roles of team members and the potential contributions they can make
- develop a way that the recommended solution can be presented

Running the project

The stages and roles below offer guidance for running the project.

Stage	Student activity	Teacher guidance	Week
Problem identification	Students work together as a group to clarify their approach and the specific questions that they will answer. By the end of the session that should have a list of questions that will enable them to plan and build a flood proof house.	The task here is to define the problem in a way that is capable of solution in the time (six weeks) given. The definition will give clarity to the information required and the roles of the group. This may be the first time this group has worked together and the teacher should place emphasis on ensuring that they have clearly defined roles, including a leader.	0.5
Background research	Having described the problem and originated a number of possible solutions, students will need to provide background information to enable them to complete it. For example they will need to understand all aspects involved in flood proofing a dwelling house. Buildings can be raised above flood inundation levels on piers or hardened podiums with both horizontal and vertical escape routes e.g. high level walk ways and flat roofs for helicopter rescue.	Teachers should help students get started by discussing what kind of information they may need. This could take the form of working through a theoretical solution. However the approach should not be didactic, questions should be used to stimulate students to understand why they need certain information.	0.5 – 1.5

Specification	The specification is what the scheme should deliver. It should describe requirements and not provide solutions. Students will take this specification (brief) and use it to develop the proposed solution. It should include statements like “The first floor should be xxx meters above the ground floor”	The main role of the teacher here is to make sure that the demands of the specification are practical and not impossible to reach. Again, an approach that helps the students write their own specification is best.	1.5 – 2
Alternative solutions	All problems have several possible solutions and it is important to consider them all. This is the week for innovation. Students should be creative. Novel solutions may save money or time. For example, building into banks/hillsides to make access and escape easier.	Student solutions must be credible and practical, but encourage originality. Sometimes discussing an impractical solution can reveal more information that will help solve the problem. Teachers should try not to prompt the students. The students should originate their own ideas. Teachers should try not to point out specific problems – that is for the students to find out. Students should consider surrounding issues like employment opportunities and possibly develop new ones.	3
Build the model	Students should decide upon one design to take forward. They should develop the idea in detail, which may involve making more detailed drawings or working descriptions. They should at least begin to plan and build their model house during this week.	Students will work enthusiastically at this point because their ideas are reaching fruition. They will have to think about how to illustrate all the features they have chosen for the town in the form of a model.	4
Report the results	The team has built its model house and it should incorporate all the features they have planned. The presentation should involve detailed descriptions of all the flood proofing features and why they have been selected using the model to illustrate them. A written report should be completed outlining all the aspects covered in the presentation.	The model could be described and presented to the local planning authority who will be able to recommend the design to those wanting to build flood proof houses in the area.	6

Assessment

In view of the general guidelines for assessing G&T students, it is recommended that this module is assessed in three ways:

1. A general assessment of the report or presentation for each group.
2. A written document from each student
3. A personal self-reflection statement

1. The group assessment
The general assessment is an assessment of the overall group performance, with criteria and marks as follows:

Element	Assessment criteria	Comments on interpretation	Marks
Producing a definition	• Shows clear understanding of the issues that will impact upon and shape the problem • Can articulate the problem in a concise form that is capable of practical solution	This section tests the higher levels of Bloom's taxonomy. To score highly the group must work together constructively to produce a precise and concise definition.	25
Creativity, originality and choice of preferred solution	• Shows originality in identifying a range of proposed solutions • Demonstrates a logical approach to SWOT analysis of proposed solutions	G&T students display different areas of advanced ability. Creativity, "thinking outside the box" and not being inhibited by current solutions is a common feature of G&T behaviour.	25
Organisation, efficiency and thoroughness of preparation, including research	• The group demonstrates efficient organisation with tasks well directed • Shows a clear approach to the research, seeking the information required, without wasting time on irrelevancies	G&T students often perform well in these areas and evaluating research is an important skill.	25
Quality of presentation, including planning and clarity of explanations	• Shows that the presentation is well organised and progresses logically, each point following logically from the one before • Explanations use simple language	Clear explanations may not come easily to G&T students whose thought processes may be complex. Since communication is highly important in all careers and walks of life, high quality communication is important for G&T students.	25

2. The individual written response
Students should create a written document of no more than 500 words which evaluates their chosen solution from the perspective of the planning authority and potential house builders and owners. Does the plan satisfy the criteria given? What features will make it appealing to potential developers and residents and which might they struggle to accept?

Factors to consider in marking include, how well can the student
- put themselves in the position of the user (empathising),
- communicate their thoughts, and
- describe compromises to make the scheme will suit all?

3. The personal reflective statement

Students should consider individually the question:

- In the light of what you have learnt from undertaking this project what advice would you give architects designing flood proof houses?