

# 3

## Growing environments



Teacher sheet

Problem-based learning resources

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## Project brief and variations

Students will attempt to develop a low-cost hydroponic growing system that minimises its environmental impact through re-use of waste to create the growing chambers and minimising energy usage by lights, pumps etc. They will also provide simple advice so that people could try to assemble these low-cost kits at home.

**Maintenance, Installation and Repair (MIR)** candidates will review the systems present in a typical large scale growing environment and suggest a monitoring system which will manage operation of the facility (e.g. noting drop in nutrient levels to drive addition of fertiliser solution) and report or predict component failures (e.g. power outage) and emergencies (e.g. fire outbreak). They will draw up the specifications for the system (or part of it) and assemble and test it making modifications to their original designs as required by the testing.

**Manufacturing, Processing and Control (MPC)** candidates will develop growing environment containers and racking systems with an emphasis of reuse of waste materials (e.g. offcuts), available objects (e.g. guttering, plastic containers like milk bottles) and ease of maintenance so that the system produced is serviceable by people with minimal engineering experience or specialist tools. They will explore the properties of the materials used for the growing system identifying key properties required and testing material samples for these. They will explore how the components can be most conveniently assembled without the need for specialist equipment or tools.

**Design and Development (D&D)** candidates will explore the conditions needed for rapid growth of plants (e.g. light levels, temperature, nutrient supply) in a hydroponic system. They will explore ways to optimise these (e.g. the use of LEDs or natural light) and assess environmental costs (set-up and running costs) for a variety of approaches to maximising production. A central feature of the project will be to produce a cheap, environmentally-friendly system which can be

maintained by users with minimum technical skills and no specialist equipment.

The projects are organised around a version of the engineering design process as shown in **Figure 1**. The CODIFY and PRESENT components are focused on clients and their circumstances while the PLAN, PERFORM and REVIEW processes tend to be internal to the engineering team. This process is often shown as a cycle (the output from one cycle providing an input to stimulate another) and, while the project resources are based around a global arc from CODIFY to PRESENT, teaching and learning will inevitably involve some smaller repeated cycles, or cycles with some components omitted for convenience, throughout the 30 hour project.

Exemplar tasks are mentioned to support students who might be finding it difficult to formulate a way forward but these are only examples of what might be possible rather than mandatory requirements. Students should be encouraged to develop their own work plans, within the limits imposed by the specifications and college timetables, to prepare them better for the world of work.

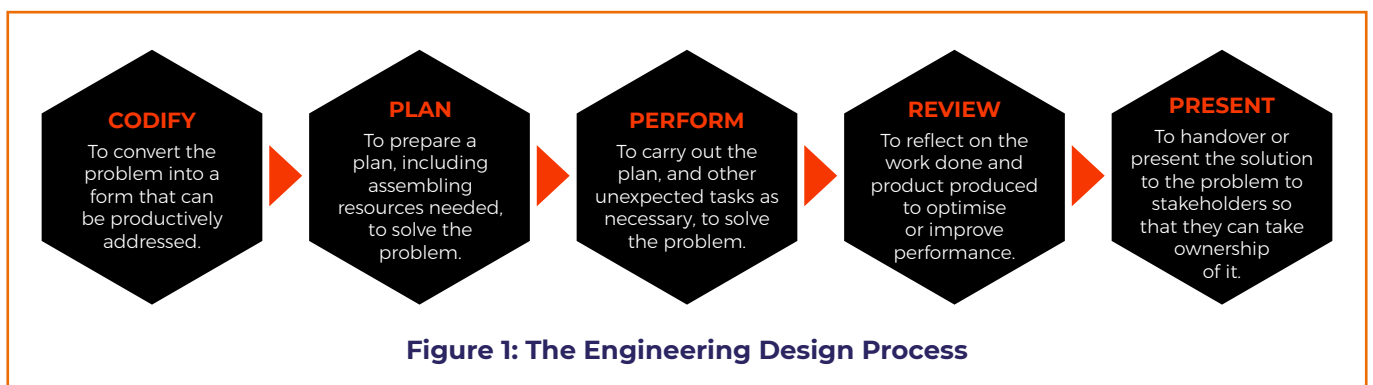
## Project resources

### Student resources

The Students booklet gives details of the proposed context and a series of forms to fill in during the project work. This will help to form a record of their progress. Individual sheets offering support with particular topics or techniques are also available and can be made available at appropriate points in the project.

### Teacher resources

The Teacher resources are provided in a single file and describe the teaching approach used to drive the project. Each context can be interpreted to support particular T-level qualifications (Design and Development (D+D), Maintenance, Installation and Repair (MIR) and Manufacturing, Process and Control (MPC). They equally work well with other technical qualifications. The following parts of the project are common to all three pathways and derive from the context:



**Figure 1: The Engineering Design Process**

- **Project overview:** a simple overview of the content in terms of the relevant core skills from the T-level engineering specifications with a suggested schedule.
- **Learning focus:** the purpose and emphasis of the project in general terms.
- **Success criteria:** illustrative success criteria at three levels for students.
- **Exemplar tasks:** examples of the kinds of tasks suitable to deliver and demonstrate learning linked to the T-Level Core Skills.

The following extra details are supplied for the MPC pathway in the Growing environments project:

- **Teaching sequence:** advice on lesson management including suggestions for formal outputs that can evidence student achievement.
- **Resources:** materials to support particular tasks.

## Project deployment

The full project is a time-consuming endeavour (roughly 30 hours of teaching time). This provides significant learning benefits, particularly in terms of student self-management, by giving time for greater exploration and optimisation. However, this is not always possible. Two options are possible to solve this problem:

1. Provide some of the material needed for the project directly to students, e.g. giving them a pre-built plan rather than asking them to develop their own, supplying experimental data to analyse rather than asking students to plan and carry out an investigation to generate their own. This allows the teacher to explore particular aspects of a project or try out interesting approaches without committing to the whole project.
2. Opting for a slightly modified project with a smaller scope. Again, these will not allow the full skill development of the whole project but can focus on particular aspects of the process where students need extra support. Examples are given in **Table 1** below.

## Learning focus

This project will focus on students' abilities to:

- Audit and use their existing engineering knowledge and understanding to design a viable system for growing food crops efficiently in small spaces or unusual settings.
- Develop their existing engineering knowledge and understanding (e.g. properties of materials and structures, monitoring systems, prioritising work schedules, diagnostic tests) as required to support more sophisticated engineering problem-solving decisions (often containing compromises between different priorities).

**Table 1: Project deployment**

Activity	Phases targeted	Brief description of the activity	Time / hrs
Exploring an engineering issue with an emphasis on sustainability.	<b>CODIFY</b>	Ask students to explore the supply of fresh vegetables in their local area. This can involve exploring the sustainability issues involved in international transport of foods (e.g. salt vegetables from Spain) and the need for heating in UK greenhouses. The output from this work could include a review of potential savings from more local production giving students a chance to explore and manage complex data round carbon cost of the many processes involved in producing, transporting and selling produce.	6
Designing a control system for growing environments	<b>PLAN</b> <b>PERFORM</b>	Ask students to focus on a particular aspect of the management of live crops. This could involve designing an electronic system for monitoring water, nutrient or temperature parameters to ensure rapid collection of reliable and useful data. It would be possible, given more time, to extend this activity to outline suggestions for delivery of key requirements to the growing crop (e.g. choice of actuators, supply systems).	8
Developing packaging of crop	<b>PERFORM</b>	Ask students to design and test a variety of packaging materials to preserve fresh produce for transport to the stores or the consumers' homes. The project could consider the recyclability of the packaging to maintain an emphasis on sustainability for the whole system.	4
Reviewing available packaging solutions	<b>REVIEW</b>	Ask students to review existing packaging systems for fresh produce identifying possible optimisations to increase shelf life, reduce costs and promote sustainability by allowing reuse or recycling of the packaging.	3

- Optimise their growing system to meet explicit design aims drawing on experimental work and engineering knowledge and understanding.
- Work effectively in teams to identify and analyse a problem, create a plan of work to solve the problem and organise the delivery of this with others in a collaborative manner.

## Success criteria


Assessment opportunities across the project will allow all candidates to practise key skills and gather evidence of competence in the general competencies and their increasing background knowledge.

The statements in **Table 2** below are examples of the typical achievements at three levels of sophistication as they move from the left-hand column across to the right-hand side. They can be edited and added to during the process and not all students will be expected to hit all outcomes – they should not be seen as a simple checklist to tick.

## Manufacturing, Process and Control

Manufacturing, Processing and Control (MPC) candidates will develop growing environment containers and racking systems with an emphasis of reuse of waste materials (e.g. offcuts), available

**Table 2: Success criteria**

INCREASING SOPHISTICATION 		
All students will:	Most students will also:	A few pupils will also:
Recognise a clearly-defined problem.	<i>Draw out the key issues in a scenario to codify a problem to be solved.</i>	Consider competing interests in formulating a problem so that multiple strategies to solve it can be suggested.
Use 'common sense' insights to solve a problem.	<i>Consciously and explicitly use their existing engineering knowledge and skills to solve a problem.</i>	Recognise gaps in their existing engineering knowledge and skills and explicitly seek to fill these in order to help with producing a valid solution to a problem.
Produce a rudimentary plan with a clear sequence of tasks	<i>Show tasks, resources and people needed to deliver work with key dates specified.</i>	Agree the plan with relevant parties in consultation and have potential back-up strategies available.
Collect data in an inquiry and modify this raw data as appropriate (e.g. calculating averages, graphing) prior to communicating the data in a report.	<i>Design a valid experimental procedure to generate valid, reliable and useful data.</i>	Modify their experimental procedures to solve problems as they emerge during the activity explaining why their new approaches will produce more useful, valid data.
Justify their strategy decisions by reference to collected data and the original project brief.	<i>Justify their strategy decisions by reference to their existing engineering knowledge and skills, collected data and the original project brief.</i>	Recognise that the first solution to a problem may not be the best and seek to optimise and finesse their initial ideas and products to improve performance.  Make decisions between competing priorities (e.g. cost and performance of components, ease of replacement of components and waste production).
Contribute to a shared report taking personal responsibility for an identifiable component (e.g. digitising calculations with a spreadsheet, producing graphics or specific items of text).	<i>Present a report that is constructed to reflect the needs of the audience.</i>	Manage the delivery of the report answering questions and taking suggestions for future developments as appropriate.
Provide and receive respectful, honest and helpful feedback within their teams.	<i>Modify their behaviour / approach in the light of respectful, honest and helpful feedback.</i>	Support other team members as they seek to modify their behaviour or approaches.

objects (e.g. guttering, plastic containers like milk bottles) and ease of maintenance so that the system produced is serviceable by people with minimal engineering experience or specialist tools. They will explore the properties of the materials used

for the growing system identifying key properties required and testing material samples for these. They will explore how the components can be most conveniently assembled without the need for specialist equipment or tools (**Table 3**).

**Table 3: Manufacturing, Process and Control**

Phase	Core skills from City and Guilds T-level specification (8713: MPC)	Possible tasks	Time / hrs
<b>CODIFY</b>	<p><b>Core Skill A: Analysing and interpreting</b></p> <ul style="list-style-type: none"> <li>Evaluate and confirm the brief with reference to context, objectives and constraints (eg requirements, resources, precedents, technical issues, costs, health and safety, regulations, possibilities)</li> </ul>	<p>Students identify the issues concerned with developing a low-cost alternative to hi-tech urban farming systems that allows individuals with limited resources and no technical skills to build and run a system.</p> <p>Students suggest key features of the proposed system and consider the properties of the materials and components needed.</p>	4
<b>PLAN</b>	<p><b>Core Skill B: Planning and preparation</b></p> <ul style="list-style-type: none"> <li>Propose and plan key activities, stages, methods, processes, techniques, documentation, resources (including types of tools and equipment) and risk assessments.</li> </ul>	<p>Students draw up more detailed specifications for components of the system (including how they will be assembled) and identify possible sources for these components.</p> <p>Students plan inquiries to check nature and properties of materials and objects available to build the system (e.g. plastic pipes, old food containers).</p>	10
<b>PERFORM</b>	<p><b>Core Skill C: Developing responses</b></p> <ul style="list-style-type: none"> <li>Apply engineering and manufacturing processes to achieve specific objectives and to produce quality outcomes, using relevant techniques and technology, within limits of own authority.</li> </ul>	<p>Students carry out inquiries into the properties of suitable materials to manufacture specific components exploring a range of relevant physical properties including ease of use / manufacture and availability.</p> <p>Students explore ways of joining/connecting their individual parts to make a functioning component - both as a prototype and during manufacture.</p> <p>Students identify and describe the key steps in a manufacturing process and consider kit and materials needed to perform this.</p>	10
<b>REVIEW</b>	<p><b>Core Skill D: Evaluating and quality assuring</b></p> <ul style="list-style-type: none"> <li>Carry out investigations, generate proposals and options, identify standard components and systems at relevant stages to gather and evaluate relevant evidence and data, and to confirm the suitability of plans, processes, actions and outcomes (including quality control and quality assurance activities)</li> </ul>	<p>Students review their proposed solution and comment on their work and performance individually and as a team.</p> <p>Students prepare their work output for presentation to client.</p>	4
<b>PRESENT</b>	<p><b>Core Skill E: Communication</b></p> <ul style="list-style-type: none"> <li>Interpreting, using and producing engineering representations and drawings following graphical language and industry conventions.</li> <li>Interpreting and using technical information and media.</li> <li>Communicating with technical and non-technical audiences using technology.</li> </ul>	<p>Students present their plans, data, calculations and risk analysis to the client.</p>	2

## Teaching sequence

### CODIFY (4 hrs)

#### Exemplar tasks

- Students identify the issues concerned with developing a low-cost alternative to hi-tech urban farming systems that allows individuals with limited resources and no technical skills to build and run a system.
- Students suggest key features of the proposed system and consider the properties of the materials and components needed.

#### Teaching strategies

Introduce the project to students either by brainstorming the salads, fresh herbs and other short shelf-life vegetables present in shops or bring in a selection to show the significance and range of the market. Ask students to check the origin of the produce (labels typically identify the source country on vegetables and fruits) and estimate the distance travelled and time taken to get from the farm to the consumer's plate. This activity is to introduce some of the hidden environmental costs behind fresh fruit and vegetables in our shops.

If possible, visit a local farm producing salads. Leafy salads and fresh herbs typically have very short shelf lives. Given the very large proportion of salad vegetables eaten in the UK have travelled from Spain and even beyond a considerable proportion of the post-harvest time can be spent in transit so reducing the time the product can be stored at home before it spoils. Even for leaf salads wrapped in inert gases in plastic containers only around 50% of the food bought is actually eaten – the rest is wasted.

Show video clips of the alternative – hi-tech farming in the UK (e.g. greens for good) and ask students to consider the costs and benefits from expanding the hi-tech urban farm development (e.g. lower food transport costs, efficient use of expensive land in cities, high energy costs of growing rooms, only some crops suitable for growing room systems). Take the opportunity to stress that different people will have different perceptions of the costs and benefits.

Having established an understanding of some of the key issues invite students to explore what they might do 'as engineers'. How can an engineering project help to improve the situation? And which of a selection of different problems should be solved first? And why? This codifying the problem is an essential part of the PBL approach and may seem confusing and disorganised at first but try to avoid delivering neat, pre-built problems for students to solve which will tend to shut down discussion and reduce opportunities for intrinsic motivation.

However, constant drift from one idea to another is not helpful so be prepared to support students by setting tasks that encourage them to refine their thinking.

Typical examples of work that they might consider doing include:

- What do plants need to grow and produce fruit most rapidly? How can engineers build systems that maximise the rate of growth of plants in an environmentally-friendly way?
- What alarms and fault-prevention systems can be built into our growing systems? A few hours of plants being too hot and dry can permanently reduce yield – or kill the crops!
- Which colour light is best for growing plants? And is it best to keep them lit 24 hours a day?
- What waste materials or objects can be used to manufacture environmentally-friendly and cheap growing systems for use at home or on a medium scale?

#### Output and evidence

The output from this stage should be a good understanding of the context, the stakeholders involved and a clear statement of the problem the students have identified. This problem should be challenging but amenable to solution, or clarification, in the time available. This could be evidenced by:

- A presentation showing the issues identified with the supply of fresh leafy vegetables in the UK (e.g. transport costs, environmental impact, wastage) and the stakeholders involved in this situation (e.g. farmers, food processing companies and workers, retail, customers). The presentation should identify a particular problem to solve and describe in outline terms the specification of the product, the rough schedule for completion and how it will contribute to solving the larger problems associated with fresh vegetable supply.
- A document showing the evidence that has informed the understanding of the problem, its source and a measure of its reliability. It should show how insights or conclusions are embedded in rigorous, strong evidence and identify any areas where this evidence is missing or contradictory and might need further exploration.

#### Useful resources

**3: Environmental assessments.** Considering the environmental impacts of a project (e.g. building a new gigafactory to make batteries) or change (e.g. a switch to EV cars) in the immediate and medium-term and for the local area and more widely.

**10: Knowledge audit.** Identifying the knowledge base appropriate to a project and the likely future needs.

**19: Conducting site surveys.** Conducting a site survey for a construction project (e.g. cliff railway, EV charging station, temporary building) or installation (e.g. installing a computer server, refrigeration unit) taking measurements of key features to produce a detailed map with significant measures clearly marked.

**25: Engineering design cycle.** Using the engineering design cycle to stimulate creative solutions to problems.

## PLAN (10 hrs)

### Exemplar tasks

- Students draw up more detailed specifications for components of the system (including how they will be assembled) and identify possible sources for these components.
- Students plan inquiries to check nature and properties of materials and objects available to build the system (e.g. plastic pipes, old food containers).

### Teaching strategies

There is a temptation to simply progress by trial and error and students will assemble bits and pieces randomly or follow obvious strategies (e.g. yogurt pots for growing medium containers etc.) to simply replicate existing systems. Emphasise the need for creative or unexpected designs and ideas and encourage students to draw on any insights from their previous CODIFY work (e.g. 'what is the real problem?' and 'why does the new solution have to look like the old one?').

Much of the planning is likely to involve drawing up of rough designs so encourage students to add sufficient detail and move towards an increasingly sophisticated specification. Typically they might label a component as 'plastic' – encourage them to identify which type of plastic they want and which of its particular properties make it suitable for use in this way? Given the expressed aim of using up waste materials and objects the supply of components should also be considered – used plastic yogurt pots are commonly available but if a design is built around a particular piece of shaped plastic packaging from an expensive washer-dryer or other source that is severely constrained the proposal is flawed!

Students should consider the materials and objects to be used (which might involve planning multiple investigations into their particular properties) and the assembly of these items into functional units. This is a slightly more demanding than a traditional approach which tend to focus on planning for one

task. This is a good opportunity to talk to students about the need to be organised and to identify the key output they are trying to achieve rather than doing lots of different, even creditable, unrelated activities. Only teams with a strategy will succeed in this task.

As part of the planning process, students should identify and agree roles within the team. Take this opportunity to stress the fact that most engineers work in teams and depend on others making their contributions to complete their own work. Ask students to consider how workplaces can be organised to reinforce this team spirit – this provides a useful opportunity to discuss rights and responsibilities in the workplace – everything from punctuality to pay!

Students will need to use a variety of mathematical techniques to calculate key values (e.g. rate of flow of nutrient fluid, forces acting on supports or containers as crops grow (particularly significant for heavy fruits like courgettes, marrows or melons) and extrapolating from these to derive values for the full scale implementation.

### Output and evidence

The output from this stage should be a clear plan that identifies key problems, strategies to solve them and roles and responsibilities of all in the team. This could be evidenced by:

- A strategy document (800 – 1,000 words) outlining the various tests and investigations they will conduct in order to inform their plan for making the growing system. This strategy should address issues like key design goals (technical ones about the system construction and those related to expected system users). The plan should have a clear work plan showing how the various tasks will be completed, who by and what the data they produce will be used for to inform the final design. All of the decisions should be justified by reference to existing engineering knowledge and skills, the particular needs of the context and the characteristics of the proposed solution.

### Useful resources

**2: Risk analysis.** Conducting a risk analysis for a process or project and identify key safety practices and equipment that would be necessary (legally) and advisable (good practice).

**13: Setting SMART objectives.** Reviewing the characteristics and use of objectives to drive development.

**14: Avoiding crises.** Identifying priorities and strategies for work.

**15: Rights and responsibilities.** Identifying key rights and responsibilities in the workplace and how they affect working life.

**22: Responding to a brief.** Developing a strategy to deliver on a brief or win a tender.

## PERFORM (10 hrs)

### Exemplar tasks

- Students carry out inquiries into the properties of suitable materials to manufacture specific components exploring a range of relevant physical properties including ease of use / manufacture and availability.
- Students explore ways of joining/connecting their individual parts to make a functioning component – both as a prototype and during manufacture.
- Students identify and describe the key steps in a manufacturing process and consider kit and materials needed to perform this.

### Teaching strategies

Ask the students to test the properties of the various materials and objects they have identified during the PLAN stage. These materials and objects should be the ones that will be candidates for inclusion in the eventual system and the testing of them should confirm they have the appropriate properties and can be handled easily by the intended system users. Given the emphasis on low-cost and the use of waste objects/materials students should also consider a review of the supply of the requirements.

Students should be managing their own activities as much as possible during this task so the role of the teacher is as a facilitator supplying expert knowledge and skills (e.g. demonstrating specific items of equipment, supporting analysis of data generated) when required and general encouragement. If local employment conditions require very specific skills (e.g. welding, ultrasonic cleaning) it is possible to encourage students to practise these as part of the project. Encourage the students to take responsibility for both the task completion and team cohesion so watch out for one or two members taking over and doing everything while the others are excluded – or complained about!

Inevitably engineering projects throw up problems and difficulties as they progress so encourage students to constantly review their methods to ensure success. At the same time, if a good approach does not work the first time because of unforeseen circumstances (e.g. staff or team absence) or bad luck (e.g. a piece of equipment is faulty) they should repeat the work rather than give up and try something else. In all cases, students

should be able to justify their decisions about changes to their plan when challenged.

Students may need help to reflect informally and continuously on their practical work as opposed to simply waiting for formal assessments or appraisals. Ongoing, continuous reflection is known to maximise learning from a task so help them to do this by asking them to keep a logbook and document their progress (e.g. through simple photos with their phones) and make reference to these documents regularly. All their work will still have to be checked to make sure it has been completed to the required standard (compliance with specification and safety) but encourage a parallel, and continuous, reflection on their performance.

### Output and evidence

The output from this stage should be a complete record of all relevant data, organised by appropriate statistical techniques, and a clear account of how this data was collected and how it will be used to inform the solution of the problem. A clear description of the proposed solution should be provided with any design decisions justified in terms of engineering knowledge and skills, the original problem definition and any supporting data from the practical work. This could be evidenced by:

- A description of the proposed system showing the materials, objects and assembly techniques chosen for its manufacture. The description should be backed up by a number of charts with clear measurements included. The engineering justification for all decisions taken drawing on any experimental work on material properties or construction techniques should also be included.
- A logbook with an account of a particular repair and replacement practical task with notes that show the student has reflected on the process, picked up any potential problems and organised themselves effectively to complete the task to the required standard and within the specified timescale.

### Useful resources

**5: Working with shape and space.** Calculating volume, height, angles of corners, articulations of a 3D shape (e.g. an incubator, temporary building, storage containers) based on measured or published data.

**6: Using mathematical formulae.** Calculating safe working parameters for structural components (e.g. incubator trolley, temporary building roof or struts) based on measurements of properties of materials and published data.

**7: Converting between units.** Converting between different measuring units as appropriate (e.g.

Celsius to Fahrenheit or Kelvin, meters to inches, metres to millimetres or kilometres).

**17: Working in teams.** Developing strategies for successful team working – and suggesting behaviours which can undermine teamwork.

**18: Prioritising projects.** Deciding which parts of a project or work package should be done first.

## REVIEW (4 hrs)

### Exemplar tasks

- Students review their activity and comment on it showing how they used their engineering knowledge and skills, diagnostic tests and direct observation to perform the tasks.
- Students reflect on their team's and their personal performance, identify points of progress and consider options for improvement in the future including identifying training needs.
- Students prepare their work output for presentation to client.

### Teaching strategies

Remind students that there are two aspects to any review of work completed: a check that the task output is up to specification (e.g. is the circuit functional, does the system operate as predicted) and a reflection on the performance of the individuals and team (e.g. did everyone know what they were supposed to do, did the team work well together?). This 'task' and 'team' perspective is important and while the judgements must be clear and supported by evidence the emphasis should be on development and strategies for improvement rather than simply aiming for a 'met/not met' judgement about preset success criteria or a notional mark out of ten.

The review should compare the whole project against the original problem. To what extent have they met their original objectives and what compromises have they had to make? This is best done as a small group activity focussing on the impersonal aspects of the task rather than the performance of individual team members. This 'task' review will also provide material that can be fed into the presentation that forms the final part of the project. Encourage students to consult test data for anything they have made and to carry out compliance and QA processes as required. This aspect of the review should focus on observable, agreed evidence rather than how students felt about their work or how pleased (or otherwise) they were with their performance.

Each student should also be asked to reflect on their personal performance and identify successes, surprises and scope for change. This more personal approach can be quite intimidating for students with low self-esteem or confidence issues and,

equally, can encourage the over-confident to bluster and assume they are doing very well! More formal structures at the start of the course can help to get students used to this type of activity and identify those that may need more support. Eventually all students should be able to reflect on their personal performance, give and receive respectful, helpful feedback and identify ways in which they can improve. Peer review activities are useful but should not be used until you know the class well – probably after they have also done some work on giving and receiving feedback.

### Output and evidence

The output from this stage should be an assessment of the extent to which the problem has been solved or, if that has not been possible, clarified. The assessment should take into account the needs of the various stakeholders in the original context and identify any compromises or negative impacts that will occur if the proposed solution is implemented. As part of the process students should also engage in self-reflection, supported by peer and teacher comments as appropriate, to identify possible areas for development. This could be evidenced by:

- A statement of specific, verifiable project achievements. This statement to be agreed within the team, and potentially by an external adjudicator, and relate to the original context, the problem identified and any other parameters (e.g. schedule, budget) deemed important at the start. The statement should be backed up by objective evidence.
- A personal statement, possibly in a log book, of the lessons learned during the project including technical material (e.g. knowledge of material properties, power calculation skills), team aspects (e.g. working with others, managing conflicts) and personal insights (e.g. 'I work better in the morning', 'I tend to put off work until the last minute and then panic'). This account should include a suggestion of a way to develop an aspect of their work in the future.
- A laboratory or workshop logbook can provide a useful record of work done and support conversations about performance between teacher and students.

### Useful resources

**11: Providing and receiving feedback.** Providing respectful, honest and helpful service to a colleague, subordinate on a product or service.

**12: Reflecting on your performance.** Reflecting on performance – how self-reflection can help development.

**13: Setting SMART objectives.** Reviewing the characteristics and use of objectives to drive development.

## PRESENT (2 hrs)

### Exemplar tasks

- Students present their MIR strategy to the company that is wanting to build the EV charging facility. This strategy should include justifications for any decisions made and identify particular compromises or options.

### Teaching strategies

If the previous Review section was inward-looking for the team and individual this Presentation section is outward-looking and involves presenting the work to others. The work is best done in teams but ensure that all members of the team have a clear role and present an aspect of the project by themselves.

Presentations are typically digital and students often waste more time on transitions, colour choices and digital tricks than the important content of the document. Encourage them to review the original scenario and problem and explain that the presentation must show how this problem has been solved and provide full justification for any decisions made – especially if they are surprising and forced on the work by new data (e.g. power consumption) or changes in circumstances (e.g. a change in budget).

Presentations should have a time limit which must be enforced – a one-minute warning can be helpful but stick to the time agreed. It is also helpful for students to offer a slide count limit as well – one slide per minute is reasonable, three slides per minute is impossible. The surest way to fail with a presentation is to have too many slides to fit into the time slot allocated and start rushing – inevitably, important information is left out!

The presentations can be to the remainder of the class, a senior member of staff, college visitors invited specifically for the task or a combination of all three. Experience of presenting to local employers is particularly valuable – but maybe towards the end of the course when students have had chance to hone their skills.

It is useful to allow questions after a presentation but specify a time limit and be prepared to intervene if questions degenerate into arguments over a specific point between the presenter and questioner.

### Output and evidence

The output from this stage should include a presentation and technical document created for a specific audience. This could be evidenced by:

- A team-based presentation of the project context, stakeholders, key requirements and

achievements lasting for a specified time but less than 10 minutes. This should be backed up by data (e.g. photographs of completed work, diagnostic or compliance test results) but this need not be included in the slide deck. The presentation should reflect the needs of the audience and allow a short time for questions and discussion at the end.

- An illustrated ‘walk through’ of a particular task to showcase a specific candidate’s individual skills. This document should also provide the context in which the task was attempted and any relevant observations or approvals from the supervisor.

### Useful resources

**20: Making a pitch.** Preparing a pitch or proposal for a piece of engineering work (e.g. a growing environment, a production facility).

**21: Delivering a presentation.** Present a pitch (e.g. a growing environment, a production facility) to a body that will make the decision on basis of needs, costs, suitability, sustainability.

## Maintenance, Installation and Repair

Maintenance, Installation and Repair (MIR) candidates will review the systems present in a typical large scale growing environment and suggest a monitoring system which will manage operation of the facility (e.g. noting drop in nutrient levels to drive addition of fertiliser solution) and report or predict component failures (e.g. power outage) and emergencies (e.g. fire outbreak). They will draw up the specifications for the system (or part of it) and assemble and test it making modifications to their original designs as required by the testing (**Table 4**).

## Design and Development

Design and Development (D&D) candidates will explore the conditions needed for rapid growth of plants (e.g. light levels, temperature, nutrient supply) in a hydroponic system. They will explore ways to optimise the factors (e.g. the use of LEDs against natural light) and assess the environmental costs (set-up and running costs) for a variety of approaches to maximising production. A central feature of the project will be to produce a cheap, environmentally-friendly system which can be maintained by users with minimum technical skills and no specialist equipment (**Table 5**).

**Table 4: Maintenance, Installation and Repair**

Phase	Core skills from City and Guilds T-level specification (MIR: 8712)	Exemplar tasks	Time / hrs
<b>CODIFY</b>	<p><b>Core Skill A: Analysing and interpreting</b></p> <ul style="list-style-type: none"> <li>Evaluate and confirm the brief with reference to context, objectives and constraints (eg requirements, resources, precedents, technical issues, costs, health and safety, regulations, possibilities).</li> </ul>	Students explore a hydroponic growing system looking for maintenance needs and identifying key points of failure or points where consumables may need to be added.	4
<b>PLAN</b>	<p><b>Core skill B: Planning and preparation</b></p> <ul style="list-style-type: none"> <li>Propose and plan key activities, stages, methods, processes, techniques, documentation, resources (inc. types of tools and equipment) and risk assessments.</li> </ul>	<p>Students identify likely points of failure drawing on realtime data from existing stations and theoretical considerations based on rate of use, resilience of components etc.</p> <p>Students develop a maintenance strategy to keep the station (or parts of it) functional for the highest percentage of time but within commercial cost limitations.</p> <p>Students identify maintenance requirements, specialist tools or kit and components needed to deliver ongoing maintenance strategy</p>	10
<b>PERFORM</b>	<p><b>Core skill C: Implementing plan</b></p> <ul style="list-style-type: none"> <li>Propose maintenance, installation and repair processes for achieving specific objectives and quality outcomes, using relevant techniques, and technology, within limits of own authority.</li> </ul>	<p>Students carry out some exemplar repairs or replacements of components including situations which require some disassembly of mechanisms.</p> <p>Students collect data on time to complete repair/replacement, ease of task and likely cost in terms of parts, labour and disruption to normal service.</p>	10
<b>REVIEW</b>	<p><b>Core Skill D: Evaluating and QA</b></p> <ul style="list-style-type: none"> <li>Investigate components and systems, to gather and evaluate relevant evidence and data, and to confirm the suitability of processes, actions and outcomes (including quality control and quality assurance activities).</li> </ul>	<p>Students review their performance in the exemplar tasks and review the resilience of their expected maintenance schedule and any potential crises.</p> <p>Students prepare their work output for presentation to client.</p>	4
<b>PRESENT</b>	<p><b>Core Skill E: Communication and presentation</b></p> <ul style="list-style-type: none"> <li>Record, report, communicate and present plans, proposals, processes, issues, risks and outcomes to both technical and non-technical audiences, across a range of suitable formats and media (eg diagrams; physical and digital records, presentations).</li> </ul>	Students present their plans, data, calculations and risk analysis to the client – an EV charging station start-up looking to contract a suitable maintenance partner for their portfolio of new charging stations.	2

**Table 5: Design and Development**

Phase	Core skills from City and Guilds T-level specification (D+D: 8714)	Exemplar tasks	Time / hrs
<b>CODIFY</b>	<p><b>Core Skill A: Planning and preparation</b></p> <ul style="list-style-type: none"> <li>Interpreting and confirming project requirements.</li> <li>Planning and scoping project parameters (e.g. timescales, resources, costs).</li> </ul>	Students explore the costs of fresh leafy vegetables and herbs in the local area and identify some crops that might be suitable for hydroponic growing.	4
<b>PLAN</b>	<p><b>Core Skill A: Planning and preparation</b></p> <ul style="list-style-type: none"> <li>Planning and scoping project parameters (e.g. timescales, resources, costs).</li> <li>Developing project plans.</li> </ul>	<p>Students identify key factors that affect growth of plants and suggest ways these factors might be controlled.</p> <p>Students design inquiries into the effect of specified factors (e.g. light levels and wavelength, ambient temperature) on the productivity of plants looking particularly at increase in saleable product (e.g. fruits, seeds) as opposed to total plant mass.</p>	10
<b>PERFORM</b>	<p><b>Core Skill C: Developing proposals and concepts</b></p> <ul style="list-style-type: none"> <li>Designing proposals to meet set requirements.</li> <li>Developing, modelling and revising concepts.</li> </ul>	<p>Students carry out their inquiries in factors affecting plant growth to identify key variables to manage to maximise production.</p> <p>Students use their experimental data to inform the design of a growing environment identifying features which drive production.</p>	10
<b>REVIEW</b>	<p><b>Core Skill D: Evaluation</b></p> <ul style="list-style-type: none"> <li>Carrying out tests, evaluation and analysis.</li> <li>Evaluating how well project requirements have been met.</li> </ul>	<p>Students review their proposed solution and comment on their work and performance individually and as a team.</p> <p>Students prepare their work output for presentation to client.</p>	4
<b>PRESENT</b>	<p><b>Core Skill B: Communication</b></p> <ul style="list-style-type: none"> <li>Interpreting, using and producing engineering representations and drawings following graphical language and industry conventions.</li> <li>Interpreting and using technical information and media.</li> <li>Communicating with technical and non-technical audiences using technology.</li> </ul>	Students present their plans, data, calculations and design to the client.	2