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A LEVEL

Delivery Guide

DESIGN AND TECHNOLOGY

H404, H405, H406
For first teaching in 2017

Topic Area 4:
Design thinking and communication – Design Engineering

Version 1

Contents

TOPIC AREA 4: DESIGN THINKING AND COMMUNICATION – DESIGN ENGINEERING

Introduction

A LEVEL

DESIGN AND TECHNOLOGY

A guide to approaching the teaching of the content related to Topic Area 4: Design thinking and communication – Design Engineering

Delivery guides are designed to represent a body of knowledge about teaching a particular topic and contain:

- **Content:** A clear outline of the content covered by the delivery guide;
- **Thinking Conceptually:** Expert guidance on the key concepts involved, common difficulties learners may have, approaches to teaching that can help learners understand these concepts and how this topic links conceptually to other areas of the subject;
- **Thinking Contextually:** A range of suggested teaching activities using a variety of themes so that different activities can be selected which best suit particular classes, learning styles or teaching approaches.

If you have any feedback on this Delivery Guide or suggestions for other resources you would like OCR to develop, please email resources.feedback@ocr.org.uk

Link to qualification:

http://www.ocr.org.uk/qualifications/as-a-level-gce-design-and-technology-h004-h006-h404-h406-from-2017/

DISCLAIMER

This resource was designed using the most up to date information from the specification at the time it was published. Specifications are updated over time, which means there may be contradictions between the resource and the specification, therefore please use the information on the latest specification at all times. If you do notice a discrepancy please contact us on the following email address: resources.feedback@ocr.org.uk

Sub Topic 1: Techniques for communicating ideas

Exam content

4.1 How do designer engineers use annotated 2D and 3D sketching and digital tools to graphically communicate ideas?

a. Demonstrate an understanding of how to use annotated sketching and digital tools to graphically communicate ideas and sketch modelling to explore possible improvements, in terms of physical requirements, such as:

- function, usability, construction, movement, stability, composition, strength
- aesthetic qualities
- manufacturing processes
- suitability of materials and components.

b. Demonstrate an understanding of methods used to represent systems and components to inform third parties, including:

i. constructional diagrams/working drawings

ii. digital visualisations

iii. circuit and system diagrams

iv. flowcharts with associated symbols

v. prototypes and models.

4.2 How do industry professionals use digital design tools to support and communicate the exploration, innovation and development of design ideas?

a. Demonstrate an understanding of how designers develop products using digital tools and online collaboration, such as:

- discussing and exchanging ideas with specialists
- developing designs concurrently with other designers
- explaining and communicating their design decisions to stakeholders.

b. Demonstrate an understanding of how digital design software, including CAD and CAE are used during product development, such as:

- visual presentation, rendering and photo-quality imaging
- product simulation and systems simulation
- scientific analysis of real-world physical factors to determine whether a product will break or work the way it was intended.

NEA content

d. Apply digital and non-digital skills and techniques that are suitable to the stage of development and record real-time progress throughout an iterative design process, such as:

- informal 2D and 3D sketching and modelling to communicate initial ideas
- system and schematic diagrams, annotated sketches, exploded diagrams, models and written notes, to communicate development iterations
- audio and visual recordings to share thinking, explorations and the functionality of ideas
- formal 2D and 3D working drawings to outline specification requirements; 3D illustrations, mathematical modelling and computer-based tools to present final design solutions; schedules and flow charts to deliver planning
- writing reports and/or summaries to record the thinking process
- presentations and real-time evidence to communicate throughout the project.

Thinking conceptually

General approaches:

For learners to establish effective communication skills, they need to have the opportunity to experience a broad range of different styles available, including those of sketching, modelling and diagrams which will need to be applied in all situations. These will range from quick response scenarios, where time is limited, through to the use of specialist symbols and software to ensure clarity of communication with third parties is paramount to the success of a design stage. With each type of communication outcome, the learner will need to have access to the appropriate tools, materials and equipment to allow them to learn and apply these techniques during practice/directed tasks, before they become independent and capable of making decisions about communication on their own during their NEA project. An understanding of materials, processes, techniques and requirements will help learners to annotate different types of design media, though some CAD packages will support learners in achieving effective and strong layout of sketches and CAD images.

Initial activities in the classroom should encourage learners to establish a confident, rapid approach to sketching, where an appreciation of form and movement are important to document. Once learners have established this, they will benefit from more technical instruction towards sketching with more time available, and where details of function, usability, construction, stability, composition and strength can be conveyed with more detailed using, for example; reference sketches, information sketches or prescriptive sketches.

Where manufacturing techniques are to be communicated, learners will only be able to access this task if they are confident in this information technique prior to the task. Materials however, can be conveyed using rendering techniques, or by moving to CAD.

When learners need to communicate more technical data such as schematics, circuit diagrams, or similar, they will need sufficient knowledge of what and why these types of drawings are created for. The use of CAD is beneficial here, but not essential. A confidence in applying 2D and 3D software such as Autodesk Fusion 360 or Techsoft 2D design or Circuit Wizard to name three, will allow learners to speed up the generation of technical documentation. All the benefits of CAD, including time and ability to edit, means learners will develop a set of transferable skills that can be applied to other aspects of the specification and NEA.

Where physical modelling and prototyping are options, it will be important for learners to recognise that models are aesthetic and prototypes functional. This will allow learners to focus on the priorities for each. Rapid modelling will require materials that can be worked quickly with little equipment, such as modelling foams or structural assembly kits. Where more time is required, this will likely be in the area of prototyping, especially where electronic systems will require repeated testing to prove a concept as functional.

In order to work at the level required for this specification, it is important to look at where and how to build learners skills and experience. Online tutorial and training providers offer free courses to support learners in specialising their CAD skills towards focused areas of study. These contexts and skills are not likely to be covered by the course teacher(s) during lesson time. Platforms such as Udemy (www.udemy.com) offer a broad range of courses that are free and promote specific areas of design engineering, such as prosthetics or user centred design. Many software platforms provided on this and other sites, are extremely useful and can allow learners to simulate environments and physical performance of virtual products using real material parameters.

Wherever possible, learners will need to take advantage of the digital recording of all evidence; ranging from scanned-in sketches to digital sketches, photographic evidence or models and screenshots of CAD models as they develop. More sophisticated CAD software will provide the opportunity for exporting reports which can be used, as appendices, to an NEA assignment and support deeper learning into virtual model simulation.

Where required, learners will need to practice the nature of describing and writing report-based accounts of project progression, and may want to practice recording thoughts through video or audio recording, especially in the iteration phase, to support an NEA project submission with less reflective written evidence and more real-time live information

Common misconceptions or difficulties learners may have:

Many learners will find it challenging to produce 'perfect' sketches for their NEA work. This should be communicated to all learners as a misconception, and that communication in all forms is simply a method of conveying information. Learners should not aim to perfect sketching techniques. Learners should select which method of communication is appropriate for which type of information they need to convey. Learners will rarely need to communicate an idea with a perfect two-point perspective sketch, and may well be better suited to use rough sketching, physical models and section drawings or perhaps employ CAD. Methods of communication should be seen as tools to support the design process, and support how the learner interacts with the stakeholders at all stages of the project.

Conceptual links to other areas of the specification – useful ways to approach this topic to set learners up for topics later in the course:

The use of communication techniques, in all their forms, will reach broadly across the entire specification. This will range from identifying requirements (Specification reference: Section 1), where communication of information might be sketched, as a diagram or using CAD, through to viability of design solutions (Specification reference: Section 8), where tests might be sketched or may include sketched responses from stakeholders or where simulation is the test method using CAD. Learners should be fully engaged with a variety of communication techniques, the importance of forming a method of recording and documenting progress and the application of this learning across all areas of the specification.

Using a resource such as ID Cards, developed by Loughborough University School of Design, provides the teacher with a range of different types of sketching and modelling tools, a design engineering learner may need to employ at any given time during a design project.

The sketch styles include:

- idea sketching for quick ideas
- study sketching for appearance and proportion
- referential sketching for observation work
- memory sketching for mapping ideas
- coded sketching for systems thinking
- information sketching for quick detailed ideas with annotation
- sketch rendering for materials information
- prescriptive sketching for technical functions including mechanisms and manufacturing.

For models they include:

- sketch models for rapid form
- design development to relay component information and mock-ups
- functional models for working prototypes of electronics
- operation models for ergonomic factors
- appearance models for realism
- assembly models for evaluation of component relationships
- models to evaluate fit- and sub-assembly
- service models for demonstration or maintenance.

.Learners may also want to employ:

- scenario/story boards for descriptions of interactions and context
- layout renderings for orthographic precision in rendering
- presentation renderings for appearance presentations
- diagrams for pure communication of schematics and principles
- perspective drawings for non-colour communication of designs
- general arrangement drawings for assembly of parts
- detailed drawing for cross-sectional views
- technical illustrations for exploded realistic views.

A structured approach to using each or just the appropriate approaches from this list would allow learners to practice developing skills (either by hand or using CAD) to convey information to a third party (which could be a peer).

Learners would benefit from being given specific products and systems that already exist and being required to (re)create drawings and models for these, in some cases, almost reverse engineering them. Learners will also benefit if there are exemplar outcomes to compare to.

Once learners are able to apply the most fundamental styles/methods of communicating design ideas, they should be able to progress onto scenario-based applications, where a product or context(s) is provided to the learners, and they simply need to choose the appropriate communication techniques and apply these to produce assessable outcomes for a teacher or peer to critique.

For example: *'Provide the learner with a context in which a designer would like to know the arrangement of parts inside a mechanical toy before it can be produced. Learners will need to reverse engineer the position of each component by product disassembly, and by drawing the location as either cross-sectional views or an exploded general arrangement drawing, or similar.'*

Once learners have established the importance of different communication techniques in different situations, they can commence a practice design challenge in which the instruction is to communicate with stakeholders at each stage of the project, appropriately. This may require simple sketches and CAD modelling to show a potential customer, through to the technical schematics of a circuit that will be produced by a specialist surface mounting PCB manufacturer. The open design task as a practice will help learners use these skills in preparation for the NEA, where there is no specific requirement to produce certain types of communication documents, but to produce sufficient evidence to demonstrate communication of the progress of the project to all the relevant parties at each stage.

In order for learners to understand the importance of collaboration in design, a task requiring learners to pitch and present ideas to peers or other parties would support learners in identifying; what is required to exchange ideas, especially to those with expertise. Learners could work in pairs to act out (role play) being stakeholders, or work together as designers on the same project, sharing ideas and working concurrently. Learners may wish, at the discretion of the teacher and time allocation to the task, to learn and employ desktop publishing techniques to manipulate and improve images that are sketched or developed in 3D CAD software packages. They may wish to create more effective media such as superimposed images in context, to help the stakeholders understand and interpret the solution.

Title	Organisation/ Company	Web link	Summary description	Additional description detail	Relevant chapter (i.e. Content, Thinking Conceptually, Thinking Contextually)	Mapping to specification level
ID Cards App	IDSA Loughborough University	App store	This App provides short summarised guidance on the range of different sketching, modelling and diagram types used and employed by design engineers. Each example has a picture and description to support learners in establishing how they might employ it.	Learners can use the App to provide suggestions or direct guidance on what they can use in relation to communication of design development and iteration.	Thinking contextually, content.	4.1 a, b, d
Udemy Autodesk Fusion 360 courses	Udemy/ Autodesk	www.udemy.com	This website provides nine tutorial based courses that are all free, and allow learners and teachers the opportunity to learn Autodesk Fusion 360 with specific projects to work through, with each resulting in a qualification certificate.	Learners can specialise in a range of courses including user-centred design, prosthetics, packaging, bottles, ergonomics form, mechanical systems, and more.	Thinking contextually	4.2 a, b

Learner Activity

Select and use ID Cards to identify which to use and when

Introduction

Using the ID Cards App, you are going to work through a series of scenarios provided by your teacher, where you need to identify which types of communication are appropriate, and you might employ as a design engineer. For each scenario, you need to state which you would use and why. If there are multiple answers, you should explain why each is applicable.

The activity

Using the range of scenarios below, identify which communication you would use:

1. You are creating a mind map during a brainstorming session with other designers.
2. You need to show the location and method of opening of a battery compartment on a hand held device.
3. You want to show a customer the colour options of an idea.
4. You are sketching your first range of ideas for a project.
5. You are creating a step by step walk through of a contextual situation.
6. You are giving a presentation pitch to investors of your conceptual idea.
7. You want to show a fellow design engineer how a system works.
8. You need to communicate the assembly of your product from multiple separate parts.
9. You are creating a hand held model.
10. You want to prove that an Arduino system works.
11. You are going to model a solution and use it during a demonstration.
12. You are going to show how to clean and repair an conceptual product.
13. You are going to get customers to handle the solution.
14. You need help from a mechanical systems expert who needs to see how something will work.
15. You are producing final technical drawings before committing to production.

Extension activities/questions:

For one or more of the scenarios, choose a product (provided by the teacher) and create the outcome that is being described to you. Use an appropriate level of detail for that communication type.

Specification content (Sub Topic 2)

Sub Topic 2: Supporting design thinking and problem solving

Exam content

4.3 How do design engineers use different approaches to design thinking to support the development of design ideas?

a. Awareness of different strategies, techniques and approaches to explore, create and evaluate design ideas, including:

- Iterative designing
- user-centred design
- circular economy
- systems thinking.

b. The importance of collaboration to gain specialist knowledge from across subject areas when delivering solutions in design and manufacturing industries.

c. Understand how design engineers use system design processes to define and develop systems that satisfy specified requirements of users using the three sub-tasks of:

i. user-interface design

ii. data design

iii. process design.

d. Understand how design teams use different approaches to project management when faced with large projects, such as critical path analysis, scrum and six sigma.

NEA content

a. Demonstrate an ability to identify and formulate appropriate technical and non-technical specifications reflecting their own investigations and considering stakeholder requirements, including:

- non-technical specifications that cover requirements
- technical requirements that outline the specific requirements needed to support the making of a final prototype.

b. Select and use appropriate methods of communication with stakeholders and users, understanding and applying the principles of user-centred design and other relevant design approaches throughout the iterative design process.

c. Understand how to use communication skills throughout a project, utilising a range of media and presentation techniques appropriate to the project which clarify, record and explain their thinking, and enable others to understand their decisions and intentions.

General approaches:

The core concepts of iterative designing, user-centred design, circular economy and systems thinking should underpin the very nature of how design engineering is taught to all learners. They are the most progressive areas of change in this new specification for problem solving and achieving unique solutions. Each area provides opportunities for learners to employ specific epistemology in a manner relevant to modern industrial practice and future progression into the field of design and engineering.

Iteration by its very nature requires a model of constant exploration, creation and evaluation, powered by continual learning. Learners will extract sufficient information from live research to begin responding to a challenge in context, but as their expertise increases with new learning, so the response will evolve and improve. Learners can use any form of communication strategy to document an iterative process in their NEA, but they will want to achieve this as quickly as possible. Iteration can be powered by all manner of new learning, ranging from materials and process information through to stakeholder requirements and feedback loops with them. At an appropriate point, learners will establish a "final" solution, or at least a suitable iteration that appears on evaluation to meet the challenge set in context. It may later evolve further, as almost all products do over time.

User-centred design places the user at the heart of all design thinking, and employs rigorous activities to ensure user needs are being met throughout the design process. It is a design process that starts with the people being design for, and creates solutions tailor-made to their needs. Learners will need to develop a sense of empathy in order to engage with the process, which can often be supported by resources that create similar circumstances for the learner, e.g. restricted movement gloves to replicate dexterity issues for the elderly or in cold weather.

The circular economy reflects thinking that places the sustainable nature of design engineering at the forefront of decision making. Learners will want to engage with this topic using real case studies of successes achieved by the Circular Economy 100 companies. Learners may engage with the concept by designing solutions that fit into a circular economy or perhaps designing to make a solution transition to a circular economy model.

Systems thinking takes the unique approach of focusing on the interactions between different elements of a system in order to make reliable decisions about how a system might work. The learners should be able to grasp the concept by exploring how technical and social influences interrelate and how this results in specific stakeholder behaviours. Once a context is established within which a system will function, the parts which make up the system are critiqued in relation to their relationships (connections and loops) with one another and with the system itself. Learners will be able to determine how systems function, and show how parts contribute to this, in order to understand complex situations and avoid unintended consequences.

Where learners engage with systems design, they will need to understand how user interfaces are designed, how data is managed and designed to be accessed, and how the process of interacting with a system is approached through design. Flowcharts and structured planning documents allow learners to design a sequence of activities that will enable end-users to use a design solution, access data that relates to it, and carry out a desired objective using it.

In relation to the structured design approach, this is the key consideration of critical path analysis. This is where large and complex sequences of activities are taking place and likely to create bottlenecks or other undesired complications. This concept applies very well to the manufacture of multi-part solutions, where factors such as time can affect the priority of certain manufacturing activities in a manufacturing plan. Learners will likely engage with this topic using mathematical models to plan a sequence of tasks in relation to achieving an overall goal. Similarly both scrum and six sigma offer opportunities for production processes to be configured to improve the successful achievement of a desired goal through either making systems agile or by reducing errors within them respectively.

Where learners are able to employ these areas of learning in their NEA, they will be able to appropriately select which design thinking and planning documentation will suit and support their specific area of response. Learners taking a user-centred approach, for example, will have numerous non-technical requirements to meet, while learners with a focus on systems thinking may find more technical requirements. Depending on whether the learner is tackling electronic, mechanical or structural solutions to an NEA context or a combination of these, they will need to ensure that throughout the NEA they are able to recognise the different types of requirements that arise, how they meet them, how they communicate their approach and response to various stakeholders and how evidence suitable for assessment is generated using the most appropriate media.

Common misconceptions or difficulties learners may have:

There are various models of iteration which create a false approach, making what is essentially a linear approach appear circular. It is important that learners understand and apply the principles set out in this course specification in order to work in a true iterative way. The nature of exploration, creation and evaluation powered by continual learning is important and should underpin learners' approaches to all design engineering activities.

Where learners are engaged with user-centred design, sometimes known as human-centred design, it is important that learners do not just observe stakeholder-interactions in the context-based challenge. It is much better if they engage with the activity themselves, in order to understand and empathise with the stakeholders. This helps them to design with a real understanding of stakeholder opinion rather than respond to interactions without personal experience and empathy.

Thinking conceptually

Conceptual links to other areas of the specification – useful ways to approach this topic to set learners up for topics later in the course:

This section relates to the section on identifying requirements, with crossover and duplicate learning in section 1.1a and 1.2a. It will also support and be supported by the learning in section 1.3.

Existing products and practice in section 2.1, 2.2 and 2.3 will support learners in developing deeper thinking in this topic, and help build a full picture of industrial approaches and foci for the future of design engineering.

Implications or wider issues will further support the learning here, especially in relation to the different approaches to problem solving including systems thinking. Later in the specification, learners will employ knowledge from this topic to their learning about materials and manufacturing processes and may also intend reflecting on design viability through their approach to the design process.

User Centred Design

For this activity, all learners in a group will work to a single context. This will allow each individual in the group to be set a different type of user-centred activity to conduct in order to understand at a deeper level the needs of the people being designed for, i.e. the stakeholders. A context could be taken from the sample materials provided on the OCR website for GCSE or AS Level, or be generated by the teacher. For example, if learners were tasked with the challenge of: *'How do we make people healthier?'* learners will be able to tackle this broad concept and conduct very different types of research.

Each learner can then select or be set a user-centred research task, and as requirements are identified, share these with their class peers. The following list provides 8 potential tasks to conduct:

1. Learn from people – define an audience (both common and extreme individuals), plan what you intend to ask all participants, create a safe environment, and conduct an interview in order to gain inspiration. Consider commencing with quick and easy questions and progress into a deeper more personal series of questions, once trust has been established.
2. Learn from experts – identify expert stakeholders in your field and use them to identify the successes and failures that exist. Plan to ask smart questions the help conversation to flow. Consider presenting initial concepts to experts to critique.
3. Immerse yourself in context – plan to take part in experiencing the challenges of the context and observe/record what you see and feel. Reflect on your observations and apply interpretation to them.
4. Analogous Inspiration – list or visualise activities, behaviours and emotions that you want to achieve from your design solution, then identify other solutions that already achieve this.
5. Create a photo diary of a period of time observing the issue to be resolved.
6. Draw the timeline and stakeholder journey associated with the context and critique each stage.
7. Design and provocative a conceptual solution to your problem and present it for discussion with various stakeholders.
8. Find images associated with the context, either existing solutions or similar, and ask stakeholders to comment, rank and prioritise them. Document their justifications for their decisions.

Once all research has been conducted around a single context, learners return to the group and present their findings, and write down key points on sticky notes collated in a single place. Learners then review these findings as a team and offer insightful proposals for intervention, to solve the challenge. Learners may be able to extract insightful meaning to the issues at large, or find trends in issues and requirements being identified. This could subsequently lead to a design task.

Iterative Design

The focus of iterative design is to ensure that regular cyclical reflection takes place around the creation of a designed solution. The purpose of the process is to avoid a linear model of design where solutions are reached either too early or with a narrow opportunity to conduct insightful evaluation that might inform further improvement. With this in mind, learners may benefit from an artificial recreation of this process, whereby they commence designing with limited information and knowledge, and they progress the design forward by evaluating and then gaining further insight through additional information and knowledge provided by the teacher.

A typical activity could be achieved as follows:

1. Learners are provided a set of components to create a "product", e.g. an interactive coin-operated game.
2. Learners prototype their game.
3. Learners provide it to a user for feedback.
4. Learners are provided new information that will improve the mechanical and/or electronic performance of the game.
5. Learners iterate the games design using the new information.
6. Learners again provide it to the user for feedback.
7. Learners gain further information relating to the game solution.
8. Learners iterate further.
9. Learners gain further user feedback.
10. Continue until solutions are "final".

Depending on the learning focus of the design engineering class, the "product" could be any suitable outcome either mechanical, electronic, structural, or a combination.

Designing Systems interactions

Where learners are engaged in designing a system with a single interface, for example, a screen that provides information about how a system or solution is performing, or where it presents data extracted from the system database. Learners can engage with this task using a simplified modelling activity. In this activity, the stages of operation are written onto pieces of paper/sticky notes etc. and ordered into the most appropriate sequence. Learners can create this to sit alongside a mock-up of the screen and controls, in order to role play the activity. Then, using a peer, learners ask them to interact with the system and press buttons, which will be responded to in the sequence planned on paper. As the sequence fails, additional steps are added through additional notes, until the system is flawless in its operation. The ongoing testing and checking of the system allows learners to discuss the operation live with the user, and make simple written adaptations quickly to fault-find and improve the system. The final system can then be turned into a digital flow chart, or programmed into a platform for coding.

Critical path analysis

In this activity, learners are given a series of events that need to take place, some critical and dependent on others, others independent and not dependent on others. In this activity, learners are tasked with creating a path sequence, in which the solution is achieved as quickly as possible.

The aims are:

- establish first which tasks are critical and have the longest path to completion
- which tasks can be delayed without extending the completion time of the project
- which task sequence, based on dependents, is best applied.

For this task, the teacher provides a table of tasks to be completed, between 10-20, each with an earliest start date, a length to completion, the type of task it is (parallel or sequential) and state if it is dependent on another task being completed first. For example: the welding of a steel frame is dependent on:

A. material being cut to length

B. material being filed and prepared appropriately

C. the area being set up to clamp the material in place.

Each of these dependent tasks (A-C) and the original bigger task, can have times allocated to them in a contextual situation.

Learners must plan out the sequence using connected circles, with the time and description on the line between circles, and the circles containing the number of the task starting.

Additional constraints can be added to the task to add complexity, for example, availability of expert knowledge of an individual to complete a task, numbers of individuals needed to complete a task in the timeframe assigned, etc.

Circular Economy thinking

In this activity, learners are challenged with redesigning an existing solution using the Circular Economy approach. This would be first exemplified through case studies of success, business models that work, and then would see the learners challenged to apply these approaches to an as-yet-unchanged model. For example, learners may learn about the development of rented carpet by a Dutch firm, replacing purchased carpet. By moving to a rented model, where tiles are preferred to entire rolls, the company is able to take back damaged rented tiles, replace them to the customer, and re-use all of the materials from the returning tiles to make new tiles, effectively producing zero waste. The learner will want to evaluate and reflect on examples like this and identify the beneficiaries, the stakeholders and how they gain from this change. Learners could create a cost/benefit analysis or a structured analysis for each stakeholder, by looking at the whole system and how it changes for everyone involved.

With these case studies understood through a sharing of their analysis, learners should be able to consider existing solutions, systems and products, and propose changes to a more circular economy model. This might begin with accessible everyday products like a toothbrush, and move into more specific engineering sectors such as the automotive industry and a look at cars, motorbikes and vans. By developing learner knowledge through independent research into the solution they are redesigning, they will also enhance their ability to propose meaningful changes to the solution they are looking at.

Title	Organisation/ Company	Web link	Summary description	Additional description detail	Relevant chapter (i.e. Content, Thinking Conceptually, Thinking Contextually)	Mapping to specification level
Conducting a Critical Path Analysis	Mindtools	https://www.mindtools.com/pages/article/critical-path-analysis.htm	Using the website as a guide, learners can read about how to conduct a critical path analysis (the example is not engineering based), and then apply its approach to an engineering task.	Learners will gain all of the important learning but will do so out of context, and need to apply it (potentially with help) to an engineering scenario such as a production approach for a engineered solution.	Content Thinking contextually	4.3 d
Human-centred design kit	Ideo	http://www.designkit.org/human-centered-design	Using this central hub, learners can engage with all aspects of Human (user)-centred design, and how to conduct meaningful research with human needs at the centre.	Resources include videos about why we conduct user-centred design, case studies, method tools and an outline approach used in industry.	Content Thinking contextually Thinking conceptually	4.3 a
What is Six Sigma?	N/A	https://www.youtube.com/watch?v=kSi-KpM-kAE0	This short video provides an overview of what Six Sigma is and how it works. The video outlines in a short description the methodologies and fundamental aims of Six Sigma for learners to develop an initial awareness of it.		Content	4.3 d

Learner Activity

User-Centred Design into an Open Context

Introduction

In a class group, your task is going to be to establish creative insight into a context where the solution is yet to be established. The context you will be researching into is

____

Select a research tool from the list below, and conduct it with your choice of stakeholder (associated with the context).

Make sure you make the research task focused on the needs of the stakeholder in question, and avoid leading the results of any research activity.

The activity

Select from the range below a User-centred design research tool.

Conduct this research in relation to your class context.

Using the findings, propose requirements you feel have arisen for your stakeholder(s).

User-centred design tools:

1. Learn from people – define an audience (both common and extreme individuals), plan what you intend to ask all participants, create a safe environment, and conduct an interview in order to gain inspiration. Consider commencing with quick and easy questions, and progress into a deeper more personal series of questions once trust has been established.
2. Learn from experts – identify expert stakeholders in your field and use them to identify the successes and failures that exist. Plan to ask smart questions the help conversation to flow. Consider presenting initial concepts to experts to critique.
3. Immerse yourself in context – plan to take part in experiencing the challenges of a context, and observe/record what you see and feel. Reflect on your observations and apply interpretation to them.
4. Analogous Inspiration – list or visualise activities, behaviours and emotions that you want to achieve from your design solution, then identify other solutions that already achieve this.
5. Create a photo diary of a period of time observing the issue to be resolved.
6. Draw the timeline and stakeholder journey associated with the context and critique each stage.
7. Design and provocative conceptual solution to your problem and present it for discussion with various stakeholders.
8. Find images associated with the context, either existing solutions or similar, and ask stakeholders to comment, rank and prioritise them. Document their justifications for their decisions.

Share your requirements and findings with your peers and produce a single document where all requirements are listed and available to analyse as a team.

Using the requirements, identify the key needs of the stakeholders for this context.

Extension activities/questions:

Design a solution to the challenges and opportunities based on your findings and key requirements (agreed as a group).

Sub Topic 3: Planning design solutions

NEA content

e. Use project management tools and production plans as appropriate during the project to ensure all phases are managed efficiently.

Thinking conceptually

General approaches:

Planning; for accuracy and efficiency (3.2a); for production (the marking criteria); or for the management of a large scale project, all rely on learners developing a thorough and comprehensive strategy that ensures all factors are considered and anticipated. These factors will include: safety, technical requirement, time and resource allocation, cost and efficiency savings, as well as the human factor of delivering a modern and holistic approach to producing engineered outcomes.

While learners will likely see planning as an uninteresting activity, be fixated on preparing to succeed; learners must understand the key benefits of planning in preventing costly failure, and acting to ensure the risk of design engineering is minimised.

During the NEA process, learners will need to effectively project manage an independent project where they are the solely accountable individual for its success or failure, to meet the design brief in the time frame provided. Planning, initially with a framework to work within, will help learners to establish key goals, barriers to success, and anticipate failure in order to take alternative approaches that improve the chances of success. Documents associated with planning will, at times, need to consider time and resources, but later in the project will focus on how quality checking and sequential smaller successes will result in a final design solution that can be tested.

Learners may wish to conduct different analysis activities using project management tools in order to first, understand the stakeholders and context, then progress into defining the concept and prototype, before planning for design production including costing and process efficiency, before finalising with risk assessments, industrial approach mapping and explore failure models for analysis of the final outcome(s).

Throughout the NEA, learners will be able to employ tools and planning documents to support how they are able to meet the timetabled deadlines set out by teachers and also to help focus their own efforts towards manageable goals leading up to completion of the project.

Despite being required to take an iterative approach with unplanned circumstances acting on the process, learners will recognise that planning will support their iterative work, and help guide them throughout their NEA project to a potentially successful design solution.

Common misconceptions or difficulties learners may have:

The main misconception in planning is that it opposes the nature of iteration. Learners may predict that a well-planned approach to design development would provide little opportunity for learners to iterate. This should be communicated effectively that it is not the case, given that an ability to plan for exploration, creation and evaluation will inevitably ensure that the process happens in the first place. Learners will need to understand that planning at an early stage in a project does not require them to know the outcome, but simply provide the time slots to ensure ongoing learning, reflection and new creation can take place. There is no set number of iterations or stages of development that must occur or be planned for; but learners can anticipate that a certain number of times a source of evaluation is sought, reflected on, and acted on. This might involve numerous interactions with different stakeholders, progressively growing in familiarity to the desired solution, and growing also in dependence on a successful outcome being achieved. For example, learners might commence with a retailer who supports the gap in the market identification of the solution, but planning later engages with users, manufacturers, distributors and repair services, so that with each new stakeholder, the level of engagement with the iteration increases in knowledge, until the final critique comes from experts in that field of engineering. This model can be planned for, without knowing the desired outcome, the area of focus or the specific requirements being met, but planning for this process will guide the learner.

In similar fashion, learners should not use standardised template planning documents where more bespoke and context specific documents could be employed. An example is in the production of one-off engineered outcomes, where production scale thinking and allocation of resources take less priority to the regular client-centred feedback system employed to ensure that the final design fits to the stakeholders' expectations.

Conceptual links to other areas of the specification – useful ways to approach this topic to set learners up for topics later in the course:

This topic will link to the marking criteria for the NEA, where planning documentation is a requirement for third party communication and the technical specification. Similarly, learners will recognise the application of planning in areas such as 3a of the course specification, where planning is considered in relation of efficiency and accuracy for large scale production processes.

For the first part of the activity, learners are considering their NEA project and have yet to begin the initial work. Learners will want to establish what forms of planning are associated with the NEA, and what they should achieve by when.

All NEA will:

- have a clear beginning and end time
- have a defined budget
- have a significant time commitment
- have a requirement on resources
- not be repeated.

In order to commence the NEA, learners will map out plans for the following key headings:

- The objective of the project.
- Who will approve this project?
- The schedule of the project.
- The budget of the project.
- The resource allocation to the project.
- How the project will be conducted?
- How the project will be evaluated?

Under each of these headings, the learners are challenged to write down key thoughts, ideas, issues and solutions they feel will apply. They may wish to start with questions such as, "How will I establish what I can spend on materials during this project?" under the budget section. Or, "Who will validate the projects direction early on, and its success at the end?" under multiple headings. The more questions learners establish, the more they can discuss these with peers and the teacher, and identify key goals, people and constraints both material and time related, to their NEA project. This approach will help learners to restrain their projects and prevent them from becoming too big in the objectives.

Initially, learners will commence with defining the project, to include decisions such as:

- What are its objectives?
- Who are the stakeholders?
- How do I identify requirements?
- What sequence will I need to follow?
- By which dates are deliverable outcomes expected?

Learners may wish to map these outcomes onto a GANTT chart, listing dates, time to achieve each goal, and assign responsibility and on which other factors certain goals are dependent. Where learners can then plan for the iteration phase of the project, they can include in this chart:

- When to start iterating?
- Plan for points where the progress is monitored.
- Where approaches might be modified?
- What will be the cut off point for no further iteration?
- Who will form part of the discussion about progress and achievement?

Key to successful planning of the iteration phase is the frequent communication and key decision making with stakeholders. This will involve planning to embrace surprises and unexpected responses, and the willingness in the plan to take risks.

During the NEA project, planning documents will be employed to communicate the manufacture of a final product(s) or solution(s). Learners will no longer be iterating and developing design solutions, these will have been finalised, and established as the final design solution that will go forward to a final prototype(s) and be tested in order to validate success, or identify future improvements that might arise. Learners will be comfortable in producing this in tabular format, to include sufficient technical evidence of how a third party might approach the manufacture, including: order (sequence), materials, production processes, quality checks, time allocation, dependents, safety considerations and potential opportunities to outsource or use production models such as JIT.

Wherever plans are produced, before, during or after the project as progressed, learners will need to be able to identify, evaluate and improve efficiencies in their planning. This could range from proposing cost effective and time effective sequencing, the improvement of a technical design to make production easier (less materials and processes, for example), or through efficient sub-contracting or testing using streamlined systems. Learners should look to communicate these ideas as efficiently as they can in their NEA project, using any appropriate media for this task.

Title	Organisation/ Company	Web link	Summary description	Additional description detail	Relevant chapter (i.e. Content, Thinking Conceptually, Thinking Contextually)	Mapping to specification level
Design Management Tools and Techniques	Cambridge University	http://www.ifm.eng.cam.ac.uk/research/dmg/tools-and-techniques/	These resources provide degree-level techniques and web-based tools that can be applied to the management of various stages of an engineering project, ranging from market research to prototyping and production.		Content	NEA 4e
Smartsheet Blog – Gantt Chart	Smartsheet	https://www.smartsheet.com/blog/where-do-you-find-best-gantt-chart-spreadsheet-templates	This free Excel template and tutorial page will help learners create an initial project Gantt chart where key goals, stages of the project and time are set out in a simple to use Excel template.	Learners will be able to apply this tool to development of their own, or simply create a unique document with these headings and sections.	Thinking contextually	NEA 4e

The small print

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