Design and Technology

Singapore-Cambridge General Certificate of Education Ordinary Level (2020)

(Syllabus 7051)

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The Common Last Topics highlighted in yellow will not be examined in 2020 O-Level national examination.

Singapore Examinations and Assessment Board

CAMBRIDGE International Examinations

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INTRODUCTION

This syllabus is designed to lead to an examination for that part of the school curriculum identified as Design and Technology (D&T). It offers an examination for pupils who have followed a course of study that emphasises designing involving research, reasoned application of knowledge and skills in the areas of design and technology.

The main sections in the syllabus document are:

- Aims
- Assessment Objectives
- Subject Content
- The Examination

AIMS

The following aims of the syllabus describe the educational intent of D&T for the GCE examination. The aims are the major guiding influence in the syllabus implementation. They are not listed in order of priority. The aims of the D&T syllabus are to enable pupils to:

- foster positive values and develop dispositions for enterprise, creativity and innovation through research and exploration, idea conceptualisation and development, communication, working with materials and tools in response to needs identified
- harness their innate curiosity and ability to create through design-and-make activities
- develop the quality of tenacity through continuous refinement of their ideas towards a viable solution within a given timeframe
- exercise judgements of an aesthetic, technical and economic nature
- develop an awareness of design in social, cultural and environmental areas
- acquire knowledge and skills beyond that as stipulated in the syllabus through the contexts of the design-and-make activities.

In achieving the aims, pupils also develop safe working habits.

ASSESSMENT OBJECTIVES

The three assessment objectives in D&T are:

A Knowledge with understanding

B Design problem solving

C Realisation

The assessment objectives are designed to reflect the syllabus aims and to act as the reference against which the assessment will be made. The description of each assessment objective giving a list of activities a candidate should be able to carry out follows.

Candidates should be able to:

A KNOWLEDGE WITH UNDERSTANDING

1. demonstrate the ability to apply appropriate knowledge in materials, processes and technological areas

2. extend from their own knowledge and experience towards creating an innovative design solution

B DESIGN PROBLEM SOLVING

3. plan and manage a design project using available resources leading to its completion within a given timeframe

4. identify clearly a situation for which a design solution is required

5. research, gather, record and synthesise relevant information from various sources

6. define and analyse a need, and develop ideas by considering relevant human, functional, aesthetic, technological, economic, cultural and environmental factors, through the use of appropriate thinking skills

7. generate ideas using appropriate methods

8. Refine ideas through ongoing testing and evaluation prior to realisation

9. apply appropriate communication methods

C REALISATION

10. organise the work procedures involved in the realisation of a design solution

11. realise a design solution in appropriate material(s) using suitable techniques.

ASSESSMENT GRID

The assessment objectives are weighted to give an indication of their relative importance. They are not intended to provide a precise statement of the number of marks allocated to particular assessment objectives.

Paper	Assessment Objectives			Total
	A Knowledge with Understanding	B Design Problem Solving	C Realisation	
1 (Written Examination)	10%	20%	–	30%
2 (Design Project)	20%	30%	20%	70%
Overall	30%	50%	20%	100%

SUBJECT CONTENT

To meet the requirements of this examination, all candidates should have a good understanding of the Design Method before embarking on the Design Project. They will also need to acquire design techniques and strategies, and have a sound working knowledge of the plastics, metal and wood, and the three technological areas, namely Structures, Mechanisms and Electronics. It is expected that the Design Project will require further research and specialisation. With this in mind, the syllabus aims to encourage the inclusion of other materials and technologies where appropriate. Teachers should involve pupils in dialogue whenever possible.

The subject content is organised into three sections, namely:

Section 1 Design

Section 2 Technological Areas

Section 3 Materials and Practical Processes

The order of the topics that follows is not to be taken as the order to be taught. Teaching of the topics should take an integrative approach to support design activities to help candidates appreciate the application of the relevant knowledge and skills at the various design stages.

Only Sections 1 and 2 will be examined in the Paper 1 Written Examination.

SECTION 1 DESIGN

This area of study is concerned with candidates:

- acquiring and applying thinking skills and tools
- developing the ability to visualise, explore, develop, present and communicate their ideas
- making design decisions through purposeful design tasks. Such tasks should be strategically planned by integrating related topics with the aim of developing good design conceptualisation and development skills among the candidates.

1. Design Method

Designing is concerned with creating change and is undertaken in many different ways. Design, as a unique way of thinking and acting, involves planning with meaningful intention and purpose. Broadly and simply defined, designing comprises rational thought processes undertaken in a somewhat logical sequence and all this is nested within a holistic fabric of critical and creative thinking processes that also involves intuitive responses. For this examination, design is concerned with situations which are primarily centred on meaningfully identified needs, problems, desires and/or wants calling for solutions that can be realised through manufactured artefacts. The solutions may be arrived at through diverse methods but each will include the statement of a brief, ideation, development and realisation that require conscious efforts in research, investigation and on-going evaluation of information and data collected and decisions made. A convenient model to help pupils engage in design activity is shown in Fig. 1.

Figure 1 Design Model

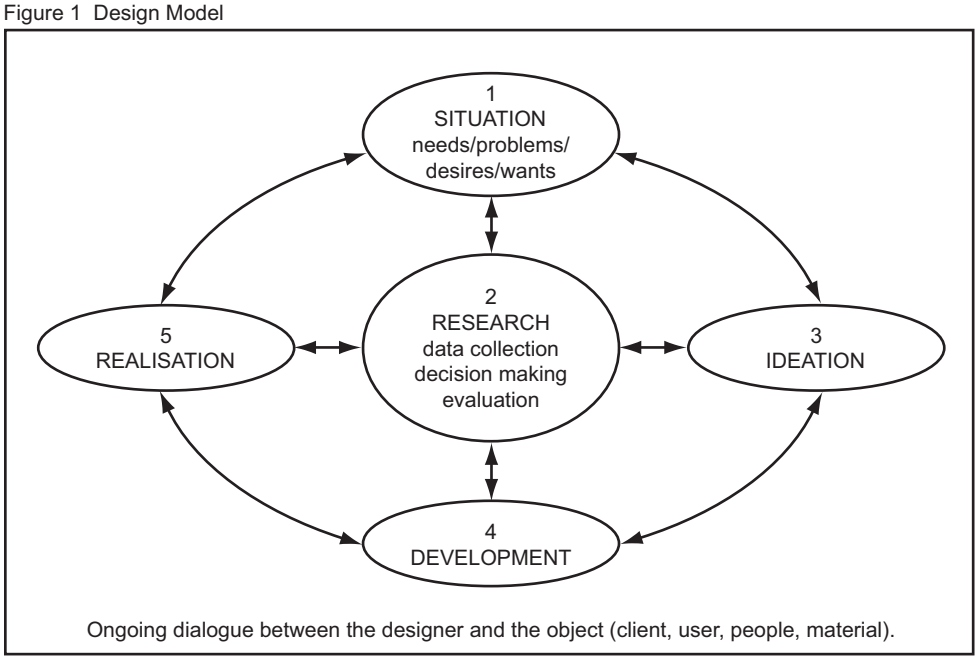

Fig. 1

Note: The numbering of the design stages is meant as a guide.

The arrows show that designing is not always a linear process and that it is dynamic in nature requiring frequent and careful looping back to other stages of the design model in a holistic manner.
The designer is engaged in multiple actions of switching back and forth between a thinking-questioning-evaluating mode and a doing-acting mode. For example when formulating the design brief and specifications resulting from research work, further research and investigative work may be needed to confirm, clarify or focus decision-making, etc. When developing the chosen solution one may be faced with difficulty in trying to meet the identified needs. There is a need therefore to revisit, e.g. the ideation stage to reconsider solution for development or to re-look at the situation identified.

An important design action that must take place in the process of designing is the ongoing dialogue between the designer and the object (client, user, people and material). This is an integral part of designing and is crucial to the successful execution of any design outcome.

Essential to designing is the ability to use appropriate 2D and 3D graphical techniques in design communication. There is also often a need to model in other ways so as to visualise a possible solution or part solution. Quick model making can be used to help in the process of decision making during the design or development stage.

Upon thorough and thoughtful development of the final design proposal with respect to the identified needs, the last stage is the realisation of the artefact. This stage calls for logical planning of the practical making processes. During realisation, evaluation and refinement of the final design proposal should not be ruled out, with the aim of achieving an optimal design solution.

Topics/Contents	Candidates should be able to:
2. Project Management	
• Project Scheduling	• plan for a project taking into consideration the stages of work and resources required • monitor and where necessary make adjustments to the plan to ensure the completion of the project within a given timeframe.
3. Research	
• Information Search Skills • Information Analysis – compare and contrast; classify; categorise	• gather data from a range of sources, e.g. reference books, internet and enquiry through research and observation, interview, survey, etc. • summarise and present findings for decision making.
4. Need Definition	
• Needs Analysis – PIES (physical, intellectual, emotional, social needs); mood board; user analysis; product analysis • Writing Design Brief • Prioritising and Substantiating Design Requirements	• define identified design opportunities • state design brief • write design specifications.
5. Idea Generation and Development	
• Brainstorming • SCAMPER • Shape Borrowing • Attribute Listing • Morphological Analysis	• gather and use information on products, materials, manufacturing methods and technologies related to the identified design needs and opportunities • generate and record ideas as possible solutions to the identified needs/opportunities using a range of techniques • use models or mock ups as a means to test and evaluate the feasibility of design solutions, where applicable • develop the proposed design solution thoughtfully and thoroughly in the areas of functionality, aesthetic, ergonomics, materials and production methodology • recognise the need for continuous evaluation of the design thinking and decision making in order to refine the design solutions • synthesise information to arrive at a feasible and desirable solution.
6. Realisation Plan	
• Orthographic Projection Drawings • Flow Chart • Production Schedule	• show plans that would allow for the realisation of the final proposed solution within the given time frame through: – working drawings accompanied with materials list according to drawing standards and conventions – a flow chart informing the sequence of realisation – a work schedule for monitoring progress.
7. Evaluation	
• Appraisal against Needs, Design Brief and Specification • Survey, Interview • Decision Making – PMI (plus, minus, interesting) – SWOT analysis (strengths, weaknesses, opportunities, threats) • Experimentation • Design Modelling	• evaluate existing products to identify design opportunities • refine the proposed design solution with the identified design opportunities and the specifications as framework • make necessary changes during the realisation stage leading to a viable final product • assess the impact of the product on the intended users and unforeseen effects.

Topics/Contents	Candidates should be able to:
8. Design & Technology in Society	
• Design Evolution • Responsibility of Designers and Technologist • Impact of Technology on the Individual and the Society • Design Sustainability	• appreciate design evolution through a recognition of how designers respond to changing pressures and influences as time progresses • understand the responsibility and place of the designer and technologist in society and industry • understand the effects of the rapid developments in technology on the individual and the society • learn about issues in design related to social, cultural, environmental and economic factors.
9. Design Communication	
• Design Elements: line, shape, form, colour, texture • Design Principle: balance, proportion, contrast, emphasis • Freehand Sketching • Presentation Skills • Working Drawings • Modelling	• appreciate the use of design elements and principles to communicate design ideas and design aesthetics • understand the relevance of design elements and principles to good presentation skills • use quick freehand sketching techniques to explore and develop ideas • make models for testing and design decision making • show ideas and describe methods of construction by using pictorial drawing, exploded and sectional views where applicable • produce measured orthographic drawings through the use of conventional drafting method and/or Computer Aided Drafting (CAD).
10. Ergonomics and Anthropometry	
• Ergonomics • Anthropometry	• apply relevant ergonomics factors and anthropometric data when designing.

SECTION 2 TECHNOLOGICAL AREAS

This area of study allows candidates to acquire basic knowledge and understanding related to Structures, Mechanisms and Electronics for designing and making controlled systems. It is intended that hands-on activities be used to develop a broad understanding of the three technological areas. Candidates should apply the knowledge in one or more technological areas appropriate to the context of their Projects. Whenever possible, candidates should also be given the opportunity to keep abreast of developments in these areas. The three technological areas can be summarised as follows:

Structures – supporting systems designed for minimal movement

Mechanisms – movement systems designed to transfer and control physical movement and forces from one point/direction to another

Electronics – control systems designed to sense, process and control via electrical signals.

Topics/Contents	Candidates should be able to:
11. Structures • Loads and Forces • Types of Structures • Equilibrium and Rigidity of Structures	• understand what a structure is and the need for manufactured structures • classify natural and man-made structures as in plants, trees, honeycombs, webs, animal skeletons vs that of bridges, cranes, pylons, roofs, domestic furniture • explain the terms loads, forces (tension, compression, bending, shear and torsion), struts, ties, beams, cantilever beam and describe their relation to structures • apply the concept of equilibrium as a result of applied load and reaction • use different methods of reinforcing such as gussets, ribs, braces, laminating, honeycomb and triangulation.
12. Mechanisms • Transmission of Motion • Conversion of Motion • Control of Motion	• understand and sketch simple examples of levers and linkages in use • explain the function of a simple pulley system, the relationship between speed of rotation of pulley, diameter of pulley and velocity ratio of a pulley system • explain simple gear ratios, transmission speeds and their effects on transmission of motion • give examples of types of motion: rotary, linear, oscillating, reciprocating • describe the use of crank, cam, follower, rack and pinion, bevel gearing, worm and wheel gearing, the screw in converting linear motion to rotary motion and vice versa • understand and explain the concept of cable control, pneumatic control, hydraulic control • analyse and describe mechanisms in terms of input, process, output and feedback; recognise the difference between open and closed loop systems.

Topics/Contents	Candidates should be able to:
13. Electronics • Basic Electricity • Common Electronic Components And Their Uses • Circuits for timer, sensing for light, moisture and temperature	• give examples of conductors and insulators • define electric current and state its sources (dry cells, batteries, photovoltaic cells) • understand and apply the units used to measure current, voltage, resistance and capacitance including multiple and sub-multiple units • state the relationship between current, voltage and resistance (Ohm's law) • recognise that the resistance of a circuit can be varied by arranging resistors in series or in parallel • understand the use of common components in electronics: filament bulbs, switches (toggle, rocker, slide, reed, tilt, push-button, membrane panel), resistors, potential dividers, variable resistors, light-dependent resistors, light-emitting diode, capacitor, transistors, thyristor, relays and solenoids, electric motors, stepper motors, integrated circuits (e.g. CD4017 and 555 timer) • read simple electronic circuit diagrams and assemble simple electronic circuits with the use of electrical soldering iron • use and modify timer circuits; sensing circuits for light, moisture and temperature for different applications.

SECTION 3 MATERIALS AND PRACTICAL PROCESSES

This area of study is concerned with developing candidates' ability to:

- select appropriate processes for setting/marking out, shaping, joining and assembly, and finishing with respect to the materials used
- demonstrate the correct use of hand tools, equipment and machine and
- show a concern for economy in the use of materials, components, time, energy and other resources.

Candidates should experience working with metals, plastics, wood and basic modelling materials to enable them to realise their final design proposals. The scope should cover basic practical processes involving hand tools, equipment and machines. Throughout the programme, candidates must show a proper regard for safe workshop practice pertaining to conduct, use of materials, tools, equipment, machine and others.

Topics/Contents	Candidates should be able to:
14. Resistant Materials • Types of Common Wood, Metals and Plastics and Their Uses • Forms of Materials Available • Selecting Materials	• understand materials classification and properties with respect to their uses • show knowledge of available material forms, types, sizes • understand the selection basis of materials for use • show awareness of issues related to sustainability with respect to materials usage.
15. Smart Materials • Shape-Memory Alloys and Plastics • Piezoelectric Materials • Fibre-Optic Sensors	• show awareness of smart materials and their applications.

Topics/Contents	Candidates should be able to:
16. Marking Out • Marking Out on Metals, Plastics and Wood	• measure and/or mark out work so that future operations can be carried out successfully, accurately and speedily using the appropriate tools.
17. Shaping • Wasting Hand Processes • Wasting Machine Processes • Deformation	• select and carry out appropriate methods to give the desired shape, form or contour • use moulds, formers and dies or adhesives to assist in forming the desired shapes, form or contour • have knowledge of some mass production processes.
18. Joining and Assembly • Mechanical Fasteners • Jointing • Adhesives • Knock-down Fittings • Jigs and Formers	• use various methods of fabricating and fitting to join parts of a job to form the desired structure, or give the required movement, to enable it to perform its task satisfactorily, both permanently and temporarily with the aid of holding devices, formers or jigs.
19. Finishing • Abrasives • Types of Finishes • Finishing Techniques	• appreciate the functional and aesthetic role of finishing in designing • select appropriate surface finish for interior and exterior use • select appropriate special finishes that will prevent corrosion or stains, or withstand heat or liquids • prepare and apply surface treatment necessary for the material to perform its designed role most satisfactorily.

THE EXAMINATION

PAPER 1 2-hour Written Examination [30% of the total marks for the subject.]

This will be a formal timed examination in which candidates will be required to show their knowledge and understanding of the topics in Sections 1 and 2, namely Design and Technological Areas. Candidates will be expected to call upon the experience of designing via the design process-in-action. They will be expected to answer all questions. Candidates are free to make use of colour and other media for the communication of ideas in their answers. This timed paper will be despatched to the examining authority for marking.

Part A *[40% of the total marks of the paper – 40 out of 100 marks]*
Five questions requiring short answers will be set based mainly on design process and design contents.

Part B *[60% of the total marks of the paper – 60 out of 100 marks]*
Three questions will be set based mainly on the three technological areas, namely, Structures, Mechanisms and Electronics.

Candidates can choose not to be examined in ONE of the three highlighted Technological areas above. Hence candidates are to answer all questions in Part A and TWO out of three questions from Part B.

PAPER 2 Design Project [70% of the total marks for the subject.]

Schools will be informed of the theme for the Design Project set by the examining authority in January of the examination year. Candidates are required to personally identify a design opportunity based on the given theme.

The Design Project is to be completed by candidates for submission to the centre by a date set by the examining authority. It is to be marked internally using given criteria. See pages 12–16 for the project requirements, assessment guide and criteria. Centres with more than one assessor will have to carry out internal moderation to ensure accuracy and consistency in marking. Assessment for the Design Project should be made on the assessment form which will be provided by the examining authority. There will be external moderation by Moderators.

All centres will be required to send a selection of marked work to the examining authority for the purpose of external moderation. Instructions for the despatch of the selected Design Projects from centres and the completed assessment forms will be sent to centres in due course.

The Design Project comprises two interrelated components:
Part A The Design Journal
Part B Final Presentation.

Part A *The Design Journal*

The Design Journal is a complete documentation of all design activities related to the Design Project theme carried out by the candidates. It is to reflect the candidates' personal response to the design process of planning, research and exploration, formulation of brief and specifications, design proposals and on-going evaluation. This may take the form of research materials, notes, doodles, sketches, calculations, decision making, etc. Candidates are strongly discouraged from re-working their Journal for submission. Models and mock-ups may also be included as part of the Design Journal, where appropriate.

Format: A3-size sheets that are securely fastened/A3-size sketch pads and models/mock-ups, as appropriate.

Part B *Final Presentation: Presentation Boards and Artefact*

The Final Presentation is to show the quality of the final design proposal: details, viability, innovativeness and desirability.

The candidate will be expected to demonstrate his/her:

(a) graphic design skills to communicate succinctly the final design proposal through the presentation boards; and

(b) workmanship and sensitive use of materials and appropriate constructional methods through the realisation of the final design proposal.

Format for Presentation Boards: Maximum three A2-size boards, single-side

NOTE: Candidates are required to use in their design at least one of the three resistant materials and technological areas within the syllabus. The use of other materials and technological areas may be included where appropriate. Oral presentation is not a requirement.

ASSESSMENT OF PAPER 2 (DESIGN PROJECT)

The criteria upon which the marking scheme will be built include:

the extent and quality of research; the ability to plan, execute and monitor the progress of the Design Project; the ability to record critical information, identify situations, investigate needs; idea conceptualisation and development showing creative and analytical thought in response to the need being addressed; quality of the design proposal; overall practical skills management in the realisation of the artefact.

		Marks
Part A	**The Design Journal**	
Planning and Monitoring		10
Research		20
Idea Conceptualisation and Development		30
	Total (Part A)	**60**
Part B	**Final Presentation: Presentation Boards and Artefact**	
Need Definition, Design Brief and Specification		10
Presentation Drawing		15
Working Drawing		15
Artefact		30
Quality of Proposed Design Solution		10
	Total (Part B)	**80**
	TOTAL (Paper 2)	**140**

TEACHERS' GUIDE TO ASSESSMENT

The assessment is to reflect:

- the candidate's engagement in arriving at a design proposal in response to the need confronted
- the quality of the design proposal and
- the overall management of practical skills in the realisation of the artefact.

NOTE: Teachers are not precluded from acting as advisers to their candidates.

The following guidance is intended to assist teachers in the assessment of the Design Project.

PART A – The Design Journal

The candidate will be expected to show evidence of use of relevant information, conceptualisation and development of the design proposal through investigation, doodles, sketches, models or mock-ups, decision making and ongoing evaluation leading to the final design proposal.

	Candidates should:
Planning and Monitoring	• produce a plan for the execution of the Design Project that makes the best use of time and various resources, taking into consideration testing, ongoing evaluation and changes necessary to develop and refine the design proposal leading to the realisation of the artefact. The plan might be in the form of a flow diagram and a time-schedule showing details at the various stages of design work adequate for monitoring to complete the Design Project within the given timeframe.
Research	• seek out information from various resources, discriminating in selection and use of information at various stages of design work to make informed decisions. Testing and evaluation through models and/or mock-ups, where appropriate, could form part of the investigative research.
Idea Conceptualisation and Development	• record the investigation made and show an ability to conceptualise and develop a design proposal thoroughly and thoughtfully. Evidence may be in the form of developmental sketches with appropriate annotations to capture the flow of ideas, and models or mock-ups where appropriate.

PART B – Final Presentation

The candidate will be expected to communicate the intent of the final design proposal, its function, details, and its effectiveness and desirability with respect to the need identified.

	Candidates should:
Need Definition, Design Brief and Specification	• state clearly the design need, design brief and specification resulting from investigative research in response to the given theme.
Presentation Drawing	• illustrate the contextual use of the final design proposal using appropriate graphical techniques.
Working Drawing	• produce working drawings using the proper convention and standards.
Artefact	• demonstrate an ability to manipulate materials sensitively and apply technologies with accuracy of workmanship and quality of finish.
Quality of Proposed Solution	• show that he/she has responded to the aesthetic and technical requirements of the design brief and specification and has demonstrated originality and inventiveness in the design solution.

CRITERIA FOR THE ASSESSMENT OF PAPER 2 THE DESIGN PROJECT [Total 140 marks]

Criteria	Max Mk	Level 1	Level 2	Level 3	Level 4
Part A – The Design Journal [60 marks]					
Planning and Monitoring	10	1–2 Need ongoing guidance to plan and ensure progress in work. Plan shows broad stages and is superficial.	3–5 Considerable guidance needed to plan and monitor progress in work. Plan shows broad stages with some details.	6–8 Some guidance needed to prepare a plan showing timed main stages and details that allows for monitoring of work progress.	9–10 Self-initiated plan that shows detailed realistic timed stages with time allocation for ongoing evaluation work and monitoring of work in progress.
Research	20	1–5 No or little use of information gathered for decision making.	6–10 Some research with relevant information used for decision making.	11–15 Adequate research on main aspects of design project for decision making.	16–20 Thorough research, discriminating in selection of information and its use to support decision making.
Idea Conceptualisation and Development	30	1–7 Little evidence of development of concept. *[Concept based on existing idea. No change in idea.]*	8–15 Aspects of concept explored with some evidence of refinement. *[Decisions made. Process not evident]*	16–23 Concept developed in some aspects key to the need identified through doodles, annotated sketches and mock ups via on-going evaluation.	24–30 Good concept thoroughly and thoughtfully developed in functionality, aesthetics, ergonomics, materials, production methods, etc. through doodles, annotated sketches and mock ups via on-going evaluation.
Part B – Final Presentation: Presentation Boards and Artefact [80 marks]					
Need Definition, Design Brief and Specification	10	1–2 Unclear or general information on need, design brief and specifications.	3–5 A statement of need identified, design brief and some relevant factors established in response to the theme.	6–8 Clear definition of need identified, design brief and important factors established in response to the theme.	9–10 Clear definition of critical need identified, design brief and important factors established in response to the theme.
Presentation Drawing	15	1–3 Lacking on both quality and detail.	4–7 Competent graphic presentation but lacking detail.	8–11 Competent graphic presentation with sufficient detail on design solution.	12–15 Competent graphic presentation with all detail showing contextual use of design solution.
Working Drawing	15	1–3 Working drawing with materials list showing no or little details.	4–7 Working drawing with materials list showing main requirements.	8–11 Detailed working drawing with materials list.	12–15 Detailed working drawing with materials list. Drawing standards adhered to.
Artefact	30	1–7 Limited skill control with major inaccuracy and blemishes.	8–15 Average skill control with minor inaccuracy and blemishes.	16–23 Good skill control with good accuracy and some blemishes.	24–30 Excellent skill control with good accuracy and little blemishes.
Quality of Proposed Design Solution	10	1–2 Similar to existing idea with little attempt to value add.	3–5 A plausible solution.	6–8 An effective solution.	9–10 A desirable solution that simplifies or introduces new way of doing things and is likely to sustain user interest.