DESIGN & TECHNOLOGY
SYLLABUS
Lower Secondary

Implementation starting with
2017 Secondary 1

Ministry of Education
SINGAPORE

CONTENTS

1. INTRODUCTION

1.1 Background

This Design & Technology (D&T) Teaching and Learning (T&L) Syllabus is for all courses [Special, Express, Normal (Academic) and Normal (Technical)] at the lower secondary level.

In D&T, pupils learn mainly through design-and-make projects guided by a design process. The design process entails identifying design needs from real-world experiences, generating and developing ideas, and realising the design solution; with research carried out when necessary. Research includes testing ideas through quick mock-ups and evaluating the final design solution with the intended user. In doing so, pupils acquire related knowledge and develop skills that turn ideas into reality and values like mindfulness, empathy and sensitivity in the areas of social, culture and environment.

Since it was first implemented in 1986, the D&T syllabus has been reviewed twice for its relevance and inherent educational richness vis-à-vis the design process as a way of thinking and doing. The review included scanning relevant overseas D&T syllabi; uncovering a common key feature of the design-and-make learning platform to solve real-world ill-defined problems. Feedback was also obtained from pupils, teachers, academics and key stakeholders through communication platforms such as the syllabus review committee, focus group discussions, school visits and D&T Awards pitching sessions.

The 2017 D&T T&L Syllabus emphasises the following:

- thinking through sketching to generate and to develop design solutions
- exploration and experimentation of ideas through mock-ups so as to allow pupils to fail-early in seeking a practical and appropriate design solution for the identified user
- making of the prototype as a cognitive and hands-on endeavour

1.2 Philosophy of D&T Education

Learning in D&T emphasises contribution towards educating pupils as persons (Annex) through the development of cognitive skills and abilities unique in the field of design. It goes beyond pupils merely learning content knowledge and developing problem-solving skills.

Rather, learning in D&T is about pupils developing a way of thinking and doing to visualise and concretise design solutions for real-world contexts. It involves the manipulation of non-verbal codes (e.g. sketches, diagrams, objects) in the material culture to translate between abstract requirements (e.g. pleasurable use, appeals to children) and concrete objects; facilitating the constructive, solution-focused mindset in designing and making. Non-verbal codes are aids to imagining, creating, internal thinking and communicating ideas. The use of such codes is essential and effective for tackling the characteristically ill-defined or ill-structured problems that people face in everyday life.

1.3 D&T Education Teaching and Learning Framework

D&T education aims to nurture in our pupils a way of thinking and doing – designerly dispositions which are inherent in design practices – through designing and making. The designerly dispositions are as follows:

- embracing uncertainties and complexities
- be cognizant of and resolve real-world, ill-defined problems
- relentless drive to seek out how things work
- use of doodling and sketching, and 3D manipulation of resistant materials as a language for visualisation, communication and presentation

Central to this learning is the design process which requires pupils to apply basic design and technology knowledge and design thinking skills. They also acquire skills in doodling and sketching, and 3D manipulation as means of thinking and tinkering to develop design solutions. This learning approach is illustrated as a framework in Figure 1.

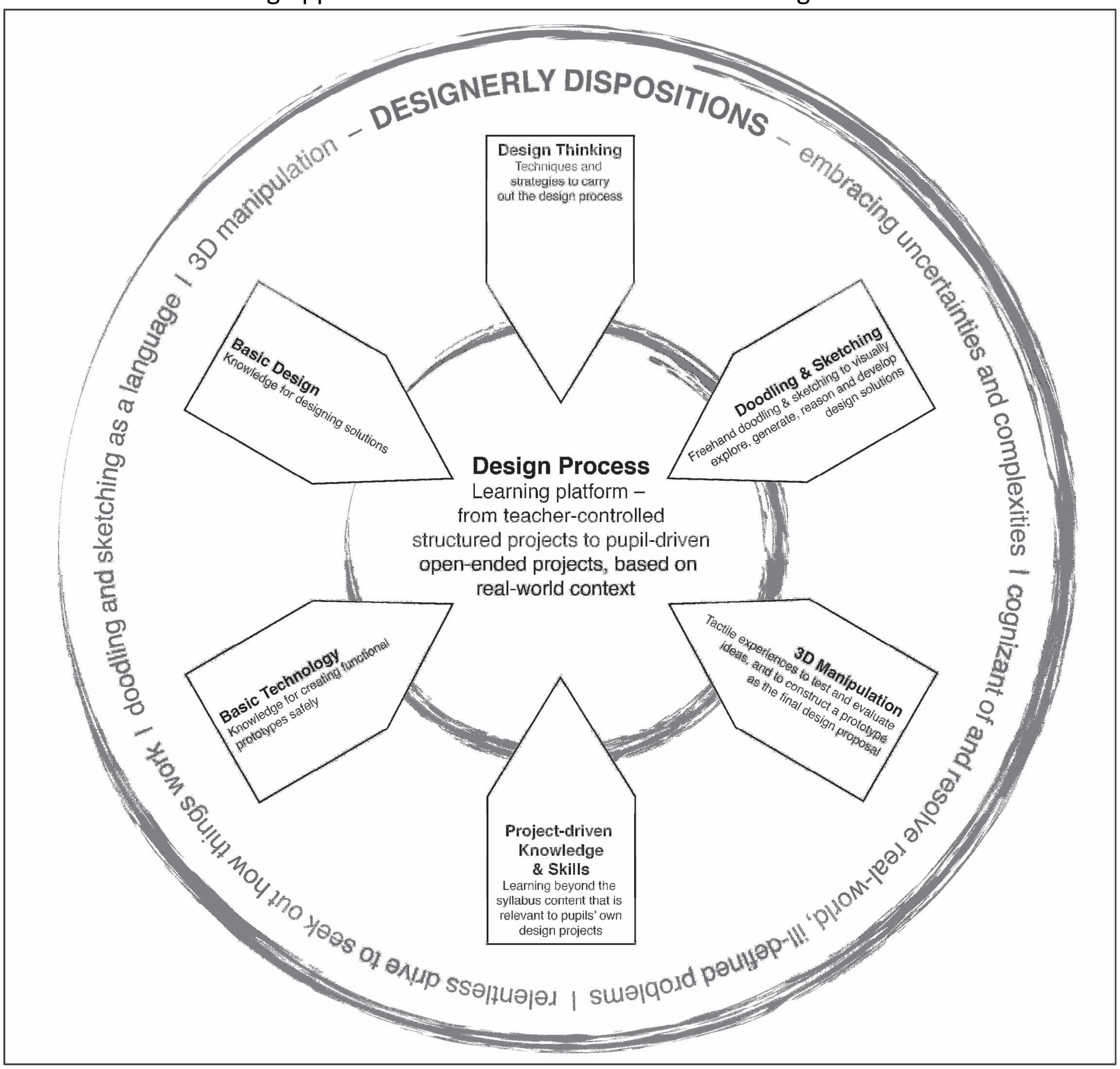

Figure 1: D&T education teaching and learning framework

1.3.1 Design Process as a Learning Platform

The design process is central to the learning experiences in D&T. It guides the act of conceptualising and creating design solutions that are practical and appropriate in everyday life. It is a set of stages that takes pupils from a design opportunity to a product solution to address user needs based on real-world contexts.

Through this learning platform, pupils undertake a series of projects progressively to consolidate their learning and to acquire new knowledge and skills. These projects range from teacher-controlled structured projects, at the start, to pupil-driven open-ended projects that are based on real-world contexts.

Teacher-controlled structured projects are project tasks that are focused and pupils are given substantial scaffolds and guidance in the enactment of the design process. In such projects, teachers may give directly a design brief to pupils or guide pupils closely to seek a design opportunity and work on a common design brief.
Pupil-driven open-ended projects are project tasks typically introduced at the upper secondary level. They are based on themes or design tasks that have no predefined design opportunities. Pupils seek their own design opportunities that are authentic and meaningful from the given themes or design tasks. Pupils' enactment of the design process tends to be more iterative and dynamic. Details of the enactment of the design process are explained in Section 1.4.

1.3.2 Six Essential Dimensions in D&T Learning

For the enactment of the design process, there are six essential dimensions that are characteristic of learning in D&T. They are:

(I) Basic Design
The thinking-and-doing process in D&T centres on basic design knowledge that allows pupils to be thoughtful, and to experience the visual language in the design of solutions. The knowledge includes ergonomics and anthropometry; design elements and design principles; influence of social, cultural, economic and sustainable factors, and designers' responsibilities.

(II) Basic Technology
As pupils create functional prototypes, they leverage on appropriate technology to fulfil the purpose. The basic technology in D&T includes structures, mechanisms, electronics and simple control systems. It also involves a safe working knowledge of resistant materials and its properties, and the relevant practical processes to manipulate these materials.

(III) Project-driven Knowledge and Skills
As pupils embark on their own design projects, they take on learning areas that are based on real-world design context. This encourages learning relevant to pupils' own projects that may be beyond the syllabus content. For example, pupils may seek to understand the behaviour of users at a public space for a design opportunity, find out the use of a musical instrument to value-add its function, or learn about sound reverberation to design a device for beat boxing.

(IV) Design Thinking

Design thinking is a way of thinking in designing which pupils will acquire over time as they immerse in the design process. It is an amalgamation of thought processes that engage pupils as they seek solutions based on thoughtful consideration of user, functionality and environment. Pupils will learn techniques and strategies such as the opportunities-interpret-imagine protocol, shape borrowing and SCAMPER to develop good design thinking.

(V) Doodling & Sketching

Freehand doodling & sketching are skills in designing that are used to visually explore, generate, reason and develop design solutions. As pupils gain confidence in doodling and sketching, these skills would serve as another language for communication, conceptualisation and creation of ideas and solutions. Doodling and sketching plays a significant role in the creation of ideas as it is the prevalent design thinking tool.

(VI) 3D Manipulation

Manipulating 3D objects in the form of quick mock-ups and working with resistant materials serves as tactile experiences to tinker, test and evaluate ideas, and to construct a prototype as the final design proposal. These tactile experiences bring about the uniqueness of D&T, in which pupils take an idea from conception on paper to fruition via a prototype. 3D manipulation serves as an extension of the cognitive development of the pupils through practical processes.

1.4 The Design Process in D&T

The design process in D&T is the key platform for pupils to make meaning of their learning, facilitated by their teachers. Pupils learn the design process through experience via design-and-make projects.

It is the vehicle for designing to create change so as to affect empathy, practicality and appropriateness in everyday life. As a way of thinking and doing, it focuses on creating solutions using appropriate technology for purposeful intent. This broadly involves rational thought processes and intuitive responses that are nested within a holistic fabric of analytical, creative and critical thinking. The design process involves five phases; namely Needs Analysis, Idea Conceptualisation, Development and Prototyping, all supported by Research as shown in Figure 2.

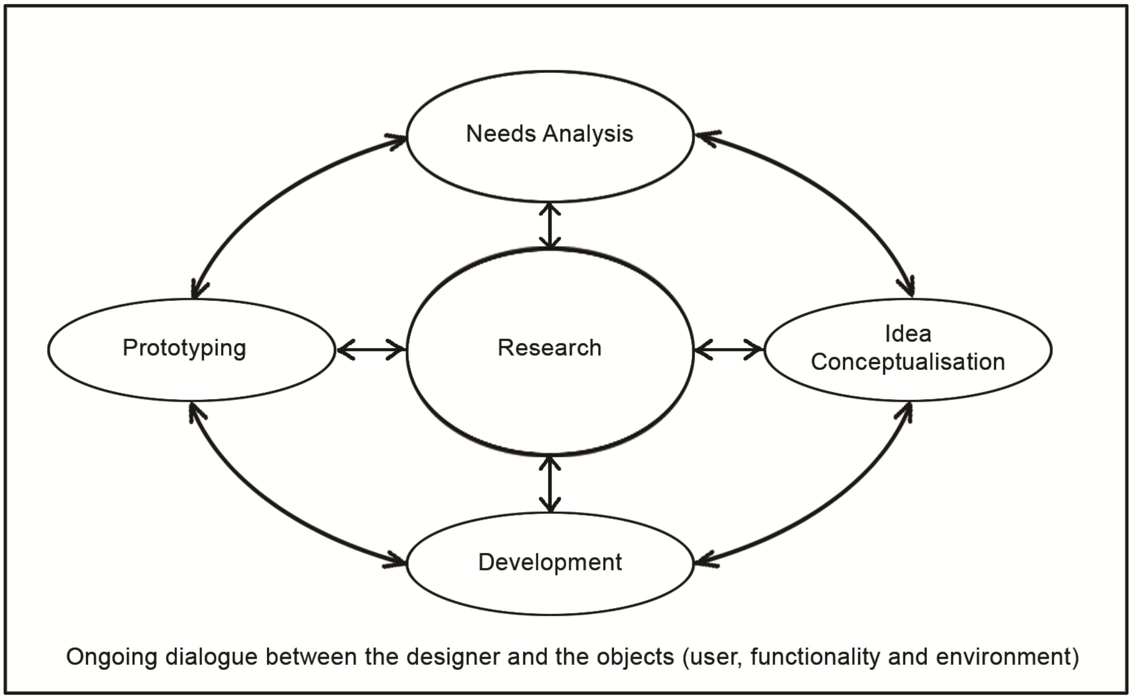

Figure 2: The design process model

(I) Research

Research is a necessary endeavour to support all stages of the design process. Information from various credible sources is used for decision making to propel the design process. In this phase, pupil design activities may include:

- observing and recording a user in-action in real-world context to identify design opportunities
- gathering visuals to create an image board to trigger idea generation and development
- analysing design features of relevant products for idea conceptualisation and development
- testing and evaluating configurations of a mechanism/electronic circuit/structure via a mock-up for functionality and practicality
- obtaining feedback on ideas from identified user for further exploration or refinements
- seeking alternative construction methods during prototyping when the planned method failed

(II) Needs Analysis

Needs Analysis is the phase where user needs are established and defined through the writing of the design need, design brief and design specifications. This writing sets the direction and focus for design-and-make projects. It may undergo iterations as design opportunities become clearer and compelling. Pupil design activities may include:

- writing guiding questions for investigation and exploration
- studying stimulus (e.g. visuals or videos), observing or interacting with people to identify design opportunities
- doodling quick tentative ideas in response to potential design opportunities
- rationalising the design need for clarity and worthiness for undertaking

(III) Idea Conceptualisation

Idea conceptualisation is the phase of generating ideas using doodles/sketches/drawings and/or mock-ups, with reference to the user, functionality and the environment. The extent of how these references are considered may vary from idea to idea. The process calls for imaginative and creative thinking. Pupil design activities may include:

- sketching basic elements like lines and circles or applying other ideation techniques (e.g. SCAMPER, shape borrowing)
- considering relevant factors like the user, functionality and the environment
- creating mock-ups of the conceptual idea/s to seek user feedback
- reviewing the design need, design brief and design specifications as the pupil gain clarity in the design opportunities
- deciding on a viable conceptual idea for development

(IV) Development

The Development phase involves exploring and developing details for the chosen conceptual idea using sketches/drawings and/or mock-ups, with in-depth consideration of the user, functionality and the environment, where applicable. The outcome is a proposed design solution that is practical and appropriate in addressing the design need. Pupil design activities may include:

- exploring the configuration for shape, forms, design compactness and/or functionality with respect to the user and the environment
- exploring the use of mechanisms/electronic kits for functionality
- gathering relevant anthropometric data and measurements for sizing the design
- building mock-up/s to test whole or part of the design
- gathering user feedback
- deciding on the materials choice and construction details for realising the prototype
- preparing a working drawing for use during prototype realisation and the accompanying materials list for materials request

(V) Prototyping

This phase is about realising the prototype using suitable resistant materials. Substitute materials may be used if it is not feasible to work with the suitable materials in the D&T Studios, e.g. replacing stainless steel with aluminium. Safety must be observed at all times during this phase. Pupil design activities may include:

- learning and applying knowledge beyond the syllabus and/or how to use tool/equipment/machines that are not learnt previously
- exploring alternative ways to realise the prototype when the planned methods failed
- tinkering and experimenting to ensure that the mechanisms/electronics work
- evaluating their design proposal by having the users test the prototype

1.4.1 Design Process at the Lower Secondary Level

At the lower secondary level, the Idea Conceptualisation, Development and Prototyping phases through teacher-controlled structured projects take centre stage in pupils' learning experiences. This approach allows frequent pupil practice in sketching and basic practical processes for developing essential design skills while applying basic knowledge in design and technology. It also allows for pupils to appreciate the iterative nature of the design process.

1.5 Goals and Aims of D&T Education

All pupils can sketch and make. This is based on the primordial dispositions of mankind evidenced by cave drawings and stone-age artefacts like the prehistoric wheel and tools. It is the goal of D&T education to build on this innate human ability for pupils to grow their confidence in sketching and making to create and innovate. Hence the aims across the different syllabi in the Express, Normal (Academic) and Normal (Technical) course are common.

The lower secondary D&T focuses on the development of freehand sketching skills through idea generation and development and offers tactile learning experiences for pupils to construct prototypes of the developed ideas. It aims to enable pupils to:

- cultivate visual-spatial thinking through sketching, experimenting and prototyping using appropriate materials and basic hand tools/equipment/machines safely
- develop an appreciation of function, aesthetics and technology in design through everyday products and their implication on sustainability
- exercise judgements for design appropriateness with respect to the users, functionality and the environment
- develop confidence and pride through turning ideas into physical objects

The knowledge, skills and values gained at this level lay the foundation for D&T learning at the upper secondary level.

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

2. CONTENT

2.1 Preamble

The contents are organised in two sections; namely (i) Design and (ii) Technology. They define the foundational knowledge and skills for pupils to work on design-and-make projects. Learning of the contents is integrative in nature via the design process. The broad attainment levels for learning are as follows:

- appreciate the design process
- grow confidence in sketching to design
- gain basic working knowledge of technology (materials, workshop processes, structures, mechanisms and electronics)

Health and safety is one important aspect of the D&T classrooms. They must be taught together with the respective contents. For example,

- safety precautions for specific tools/equipment/machines
- steps in finishing an acrylic edge using the disc-belt sander should follow only after removing the waste close to the finishing line

Practices that promote the health and safety of all users in the D&T classrooms should be highlighted, reinforced and enforced. For management of health and safety, refer to the School Safety Handbook on the MOE Intranet.

Any ICT tools/platforms used in the D&T classrooms should enhance pupils' learning experiences. Learning to use the tools/platforms should not require an inordinate amount of time for pupils to use them effectively and efficiently.

2.2 Content

Section 1 Design

Pupils should be able to:		**Content**
1	explain the design process	Needs Analysis (observations, interviews, 5W1H), Idea Conceptualisation (product analysis, SCAMPER, shape borrowing), Development (testing/experimenting, sizing), Research, Prototyping, design brief, design specifications
2	identify the different design activities	
3	apply techniques appropriate to the different design activities	
4	define a design need	
5	write a design brief	
6	write design specifications	
7	sketch in freehand combinations of basic shapes and forms	line, circle, sphere, cube, cone, pyramid, crating (isometric, perspective)

Pupils should be able to:		Content
8	consider relevant factors when generating and developing ideas	anthropometric data, ergonomics, user, functionality, environment, size and proportion, materials, construction methods, aesthetics, structures, mechanisms, electronics
9	sketch working drawings for the purpose of prototyping	orthographic projection, proportion, dimensioning, symbols, materials list
10	sketch and render the developed idea	isometric/perspective crating, colour pencil rendering

Section 2 Technology

Pupils should be able to:		Content
11	build quick mock-ups for experimenting and evaluating ideas	basic modelling materials (objects, scrap materials, paper, cardboard, foam board, masking tape, glue)
12	understand properties of materials and how they affect the way in which materials are used	toughness, durability, stiffness, strength, hardness, elasticity
13 14	work with at least one resistant material from each classification in a safe manner plan the steps for prototyping	wood (jelutong, meranti, plywood), metal (aluminium, brass, mild steel), plastics (acrylic, polystyrene, polyester resin), marking out, shaping, joining and assembling, finishing
15 16	demonstrate awareness in circuit connection and the use of common electronics components assemble and solder simple circuits for practical applications	batteries, switches (rocker switch, slide switch, membrane switch), light emitting diodes, resistors
17 18	describe the use of mechanisms in conversion and transmission of motion in everyday products create simple mechanisms	levers, linkages, pulleys, gears
19 20 21	explain the need for structures in everyday life recognise the use of different methods of reinforcing structures create structures that are rigid and stable	natural and man-made structures, frame and shell structures, static load, dynamic load, tension, compression, bending, torsion, shear, gussets, braces

3. Assessment

3.1 Formative Assessment

Formative assessment is a learning partnership between teachers and pupils. It provides information for teachers to understand the pupils' learning and, where necessary, regulate and modify their teaching to impact learning. It is an integral part of the teaching-learning process where both teachers and pupils are intentional learners.

The opportunities for formative assessment are ample in the design process in-action. When designing, three central questions that both teachers and pupils can ask themselves are:

- What is the status of the current achievement?
- Where should my learning be progressing?
- What are the necessary actions to progress learning?

The process of formative assessment involves deliberate teacher actions so as to elicit feedback on pupils' learning through what they do, say, sketch, write or make. The feedback via doodling & sketching, 3D manipulation and verbal/written form help teachers to assess learning, and adjust ongoing intervention (e.g. instructions, demonstrations and visual stimuli) for pupils' further learning. Examples of specific scenarios for formative assessment are as follows:

- a think-aloud teacher demonstration on generating ideas via whole class discussion to elicit pupils' contribution to shape the ideas
- group critique sessions of pupils' ideas in the form of sketches or mock-ups
- pupils capturing thought process in their design journal
- pupils presenting their design project in-progress
- testing functionality using mock-ups
- reflecting and evaluating on pupils' outcomes arising from observations, questioning, discussion, presentations, games, short quizzes, short tests and/or others

Worksheets to formatively assess pupils' learning in applying knowledge should be considered.

3.2 Examination

3.2.1 Assessment Objectives

The assessment objectives for each content section reflect the syllabus aims and act as reference for assessing pupils' learning. They are provided in Table 1.

Table 1: Lower secondary D&T assessment objectives

Content Section	Pupils should be able to:
Section 1 Design	1 define design needs, design briefs and design specifications base on relevant research information 2 generate and develop ideas using appropriate techniques 3 consider relevant factors when generating and developing ideas 4 sketch in freehand to explore, generate and develop ideas 5 plan the steps for realising their prototypes
Section 2 Technology	6 build quick mock-ups to explore and/or test ideas 7 incorporate structures/electronics/mechanisms appropriately in their prototypes 8 work with resistant materials safely when realising their prototypes

3.2.2 Assessment Modes

Pupils will be assessed through the Design Project that requires demonstration of the learning outcomes across the content sections. This assessment mode comprises the following components; namely an A3-size design journal, mock-ups and prototypes. They should reflect real-time designing. Schools may include presentation boards for assessment.

Pupils may also be assessed through the Written Paper. Schools have the autonomy on the paper format and questions set with reference to the learning outcomes and assessment objectives across the two content sections.

Table 2 shows the recommended weighting of the two assessment modes.

Table 2: Recommended weightings for lower secondary D&T assessment modes

Assessment Mode	Weighting	
Design Project	80% (min)	100% (max)
Written Paper	20% (max)	---
Total	100%	100%

Design Project

The assessment grid for assessing pupils' learning outcomes across the two content sections is in Table 3.

Table 3: Lower secondary D&T assessment grid

<table>
<tr><th>Content Section</th><th>Criteria</th><th>Maximum Mark</th><th>Weighting</th></tr>
<tr><td rowspan="4">Design</td><td>Stating of design need, design brief and design specifications</td><td>5</td><td rowspan="4">60%</td></tr>
<tr><td>Considering relevant factors when generating and developing ideas</td><td>10</td></tr>
<tr><td>Sketching to design</td><td>8</td></tr>
<tr><td>Rendered sketch of the developed idea</td><td>7</td></tr>
<tr><td rowspan="3">Technology</td><td>Building quick mock-ups for designing</td><td>5</td><td rowspan="3">40%</td></tr>
<tr><td>Planning the steps for prototyping</td><td>3</td></tr>
<tr><td>Realising the prototype</td><td>12</td></tr>
<tr><td colspan="2">Total</td><td>50</td><td>100%</td></tr>
</table>

The weighting gives an indication of the relative importance between the two content sections. The maximum mark for each criterion reflects the relative emphasis of the various aspects of the design project. It can be translated into relative demands on pupils and time allocation for the various design activities.

As a guide, four to six projects may be planned for the lower secondary (Sec 1 and 2) programme. Each project would be allocated five to eight weeks and provides pupils the opportunity to work with at least one resistant material from each classification. Pupils will be assessed based on particular criteria across the two domains for each project. Collectively, the entire set of criteria will be used to assess pupils' learning over the two years. Schools may decide on the weighting of each project based on its extent.

Pupils' ability in sketching and making should be assessed across all projects. This is essential for building pupils' confidence and competency in visual-spatial thinking.

An example to illustrate the guide described above is given in Table 4 on Page 13. It shows the computation of the total mark at the end of the Secondary one programme for Pupil X.

The assessment rubrics are shown in Table 5 on Page 14.

Table 4: Example of computation of total mark at the end of secondary one for Pupil X

Criteria / Project	Design Learning Domain: Stating of design need, design brief and design specifications	Design Learning Domain: Considering relevant factors when generating and developing ideas	Design Learning Domain: Sketching to design	Design Learning Domain: Rendered sketch of the developed idea	Technology Learning Domain: Building quick mock-ups for designing	Technology Learning Domain: Planning the steps for prototyping	Technology Learning Domain: Realising the prototype	Score	Total Mark	Weighting (%)	Weighted Score (score / total mark) x weighting
[Max Mark]	[5]	[10]	[8]	[7]	[5]	[3]	[12]				[100]
1	*	*	6	5	--	*	10	21	27	20	15.6
2	*	6	5	7	--	3	8	29	40	50	36.3
3	*	8	7	7	4	--	--	26	30	30	26.0
Total mark for Pupil X at the end of Secondary One											77.9

* Teacher-provided materials are used to induct pupils into the design process. This is aimed at maximising opportunities for sketching and making as early in the programme as possible.

Note: Opportunities for sketching and making (of mock-ups and/or prototypes) should be provided in all projects.

Table 5: Assessment rubrics for lower secondary D&T design project

Criteria [max mark]	Level 0	Level 1	Level 2	Level 3
Stating of design need, design brief and design specifications	No design need, design brief and design specifications stated.	The design need, design brief and design specifications stated are unrelated, and/or unfocused.	The design need, design brief and design specifications stated are general and/or superficial.	The design need, design brief and design specifications stated are clear and concise.
[5]	0	1	2 - 3	4 - 5
Considering relevant factors when generating and developing ideas	No factor is considered when generating and developing ideas.	Little or no consideration of relevant factors when generating and developing ideas.	Relevant factors are generally considered when generating and developing ideas.	Relevant factors are thoughtfully considered when generating and developing ideas.
[10]	0	1 - 3	4 - 7	8 - 10
Sketching to design	No sketch is made.	Sketches are rarely used to explore and develop ideas, and to work out details for prototyping.	Sketches are occasionally used to explore and develop ideas, and to work out details for prototyping.	Sketches are frequently used to explore and develop ideas, and to work out details for prototyping.
[8]	0	1 - 2	3 - 5	6 - 8
Rendered sketch of the developed idea	No rendered sketch of the developed idea.	Rendered sketch does not provide a reasonable impression of the developed idea.	Rendered sketch shows a general impression of the developed idea.	Rendered sketch shows an accurate impression of the developed idea.
[7]	0	1 - 2	3 - 5	6 - 7
Building quick mock-ups for designing	No evidence of using mock-up.	Mock-up has no purpose for exploring and developing ideas.	Mock-up is superficial for exploring and developing ideas.	Mock-up is purposeful for exploring and developing the ideas.
[5]	0	1	2 - 3	4 - 5
Planning the steps for prototyping	No evidence of a plan.	The plan shows broad steps for prototyping.	The plan shows steps with few details for prototyping.	The plan shows steps with adequate details for prototyping.
[3]	0	1	2	3
Realising the prototype	No prototype submitted.	Prototype is incomplete or reflects poor making skills. Limited quality control has resulted in minimal level of accuracy and an outcome that barely functions.	Prototype reflects fair making skills. Average quality control has resulted in few inaccuracies and functions more or less as intended.	Prototype reflects competent making skills. Adequate quality control has resulted in an outcome that functions as intended.
[12]	0	1 - 4	5 - 8	9 - 12

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Teaching Design & Technology to Develop Pupils as Persons: A Singapore Vision

Chia Soo Chin
chia_soo_chin@moe.gov.sg
Sciences Branch / Design & Technology Unit
Ministry of Education

Tan Seng Chong, Jason
jason.tan@nie.edu.sg
Natural Sciences & Science Education Academic Group
National Institute of Education / Nanyang Technological University

Abstract

Since its first implementation in the mid-eighties, teaching of Design & Technology (D&T) in Singapore secondary schools has progressed from a focus on what-to-teach to one that emphasises on how-to-teach for effective learning. Emerging from the latter is an ongoing pursuit for a philosophy of practice that is influenced by the works of eminent design educator-researchers; in particular Nigel Cross's three main areas of justification for design education within general education. The three areas are developing abilities in solving real-world, ill-defined problems; cognitive development in the concrete/iconic modes of cognition; and the development of a wide range of abilities in nonverbal thought and communication. In explicating these areas for the classroom, the D&T fraternity seeks a practice that contributes to the development of pupils as persons.

Introduction

Design & Technology (D&T) is a subject in the secondary school curriculum in Singapore. It was first implemented at Secondary One in 1986 to replace the two subjects Woodwork and Metalwork in response to Singapore's changing economic landscape. Currently, D&T is a compulsory subject at the lower secondary level for both boys and girls. At the upper secondary level, it is offered as an elective subject. Today, about 12% (12,000 pupils) of each cohort from more than 120 secondary schools study the subject.

As part of the holistic secondary school curriculum, D&T engages pupils in designing and prototyping ideas through the mind and hands. The design process offers opportunities to understand human needs and to create possibilities to make life better. Educationally, it offers an opportunity for pupils to develop skills that turn ideas into reality and values like mindfulness, empathy and sensitivity in the areas of social, culture and environment.

As a preparation to implement D&T, teachers teaching Woodwork and Metalwork then were re-trained, and engineers from various fields were recruited and trained to teach the subject. With the introduction of the product and industrial design degree programme at the National University of Singapore in 1999, there is a small but growing number of designers teaching the subject. Today, the D&T teaching force is formed mainly by engineers.

Phases of D&T Practice

What D&T was designed in the early eighties by looking closely at similar subjects offered by schools in the UK. The implementation had a strong flavour of craft and vocational emphasis akin to Woodwork and Metalwork. Generally the programme had three distinct areas, namely theory (content knowledge), design process, and practical skills training. The design process was then taught as content knowledge and deployed as a tool for project opportunities for problem-solving design activities. With a teaching force seeking to understand the new subject matter and to teach it at the same time, treatment of the design process in a linear fashion then was understandable.

Why Moving into the second decade of D&T, a two-year part-time Advanced Diploma in D&T was developed for in-service training by the Product and Industrial Design Department at the Temasek Polytechnic. The objective was for teachers to further develop design skills and to gain exposure to design work. As teachers sought to better understand design and gain design related knowledge and skills, they also turned to events like design graduate shows, design forums and conferences for additional exposure to industrial design practice. Some keen teachers also began to make reference from academic research on design and design-related education for their classroom practice.

Such exposures to industry practices and research led a group of teachers to think deeply into the value of design for general education, i.e. the education of children 16 years and below. The belief that D&T offers opportunities to shape the pupils' values and attitudes, and develop skills that are crucial to their development is shared by many teachers. This was expounded by Archer (1974) in his paper *Design in General Education* and encapsulated in a subsequent paper (Archer, 1975, p. 8) thus:

> *There exists an area of human experience, knowledge and action, centred on man's desire and ability to mould his physical environment to meet his material and spiritual needs, which is as important to his well-being as such well-recognised areas of learning as literacy and numeracy. We call this area of experience, knowledge and action, design.*

This forms the foundational lead in the search for a philosophy of practice in D&T education that will contribute to the holistic development and education of the young.

How As teachers gain deeper understanding of design practices and sharpen design skills, they grapple with mediating the demands of the multi-faceted and complex nature of the design process for the D&T classroom. Design process knowledge and skills, materials, technology, values and attitudes inherent in the fields of designing guide and drive the teaching and learning of D&T. Contents from these various domains are largely organised for projects in a just-in-time manner. The integrative approach, a shift from the early approach of distinct areas of learning, offers experiences for pupils to make better meaning of their learning.

In recent years, D&T practice grew more vibrant. Relating to real life becomes an impetus for more meaningful learning. For example, pupils experienced the ritual of tea drinking and discussed the design of related products to surface design needs. Folding bicycles featured in one programme in which pupils tried various models to understand the design features and to surface design opportunities. Establishments like furniture company, marine centre, child care centre, senior citizens corner and health care centre also provided real situations and real users for pupils to work on their projects. This is in contrast with the usually fictitious contexts and design needs that were formulated for projects in the initial years. The real life setting gives added meaning to classroom learning and heightens sensitivity in the areas of social, culture and environment.

In seeking to further understand what it takes to facilitate the design process in the classroom and to enable pupils to think design, pockets of research related to facilitating and scaffolding took place. Tan (1996) surfaced the theory of Double Looping Learning Model to help explain the dynamics of facilitating and scaffolding pupils in the design process. It aims to serve as a framework for the D&T classroom practice. In another research (Imram, 2010), pupils were observed to inevitably get stuck in the design process. The researcher coined this as the Stuck Syndrome and that it offers opportunity for knowledge construction and intervention to develop skills and to shape values and attitudes.

The pursuit of a D&T pedagogical content knowledge is on-going. There is firm belief that the teacher should model the design process through thinking aloud and through sketching for pupils to emulate and to better understand what it means to be engaged in design thought process. An example of the teacher modelling the design process is to show in action how he/she morph a design solution from scratch or visual reference, to an end product to serve a design need. This process is termed idea growing (Tan, 2010) and is currently beginning to propagate in the classrooms through in-service training.

Philosophy of D&T Practice

Many researchers, especially design educator-researchers, have long been looking closely at design as an epistemological domain of knowledge liken to literacy and numeracy, and design-and-make as another important platform that may contribute to the holistic human development (Archer, 1975; Cross, 2007).

In his justification for design education within the context of general education, Cross (2007, p. 29) identified five aspects of 'designerly' ways of knowing:

- *Designers tackle 'ill-defined' problems.*
- *Their mode of problem-solving is 'solution-focused'.*
- *Their mode of thinking is 'constructive'.*

- *They use 'codes' that translate abstract requirements into concrete objects.*
- *They use these codes to both 'read' and 'write' in 'object languages'.*

From these five aspects, three main areas of justification for design education within general education were defined (Cross, 2007, p. 30), namely:

- *Design develops innate abilities in solving real-world, ill-defined problems.*
- *Design sustains cognitive development in the concrete/iconic modes of cognition.*
- *Design offers opportunities for development of a wide range of abilities in nonverbal thought and communication.*

These three main areas of justification suggest a probable reference for the D&T fraternity to reflect on how D&T can contribute to general education. This seems logical as was pointed out by Cross (1980):

> *Since general education is in principle non-technical and non-vocational, design can only achieve parity with other disciplines in general education if it is organised as an area of study which contributes as much to the individual's self-realisation as to preparation for social roles* (p. 202).

Now that D&T is in its third decade of implementation, the quest for an educational philosophy to inform and to guide classroom practice becomes necessary. The above arguments have influenced the thinking of D&T education in the local context, and to a certain extent provided a direction for the D&T fraternity to continue to grow a philosophy of practice. They are instrumental in shaping the 'visuacy' and 'graphicacy' orientation and the concept of manipulation of three-dimensional object that are central to the D&T subject matter.

The three areas of justification, namely, developing abilities in solving real-world, ill-defined problems; cognitive development in the concrete/iconic modes of cognition; and the development of a wide range of abilities in nonverbal thought and communication (Cross, 2007) serve as sound and reasonable tenets for a philosophy of D&T practice to evolve, and for D&T education to work towards playing an important role in the Singapore school curriculum to develop the pupils in an area of cognition offered by design education.

The articulation of a philosophy of D&T practice serves to anchor a practice and provides good reason for the demanding role of being a teacher of design education that is well described by Adams (1991, p. 170):

> *The teacher's task is a complex and demanding one. It requires them to create opportunities for learning, to manipulate situations to stretch able pupils and support weaker ones; to introduce unfamiliar concepts and new ways of working appropriate for their pupils. It involves them in a variety of roles: organiser, mentor, devil's advocate, information source, guide,*

supervisor, instructor, commentator, demonstrator, facilitator, referee, critic, interpreter, counsellor and fellow traveller.

The meaning of *fellow traveller* may be interpreted as co-designers and co-learners alongside pupils as suggested by Tan (1996). This pedagogical stance is beginning to take root in the D&T classrooms as teachers begin to appreciate that design cannot be taught but to be coached and learned.

In conclusion, it is therefore reasonable to suggest at this infancy stage the philosophy of a practice in design education be centred on Nigel Cross's three main justification for design education within general education. Such understanding would bring about a more profound depth of practice that goes towards contributing to the human development - the development of pupils as persons.

Implications

It is understandable that a philosophy of practice did not exist when D&T was first implemented more than twenty years ago in Singapore schools. Today as D&T teachers grow in their pedagogical knowledge, there is an inclination to also question how the subject matter may educate pupils as suggested by the syllabus (SEAB, 2011).

With an emergent philosophy articulated, it offers the D&T fraternity a collective understanding of how D&T education can contribute to the development of pupils through design education. The understanding could help propagate an area of research-teaching practice among D&T teachers in seeking to build D&T pedagogical stances and related pedagogical knowledge.

The philosophy hence would provide assurance for a grounded focus in gearing and driving the diverse D&T curriculum practices in schools. It also paints a clear picture for D&T teachers to articulate the *why* and *how* to *what* they are teaching. This heightens their awareness in their pedagogical approaches, in particular their facilitation process in the teaching and learning of D&T. Last, the philosophy of D&T practice offers an initial framework for like-minded educators to rationalise the practice of D&T education; to have a common notion that D&T is not about training and developing future designers; and that it exists in the curriculum as a niche area that would contribute to the pupils' holistic education and development.

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