Enriched Technology Education KLA Curriculum

S1 Teaching Material

2

Basic Understanding of Materials

Technology Module K3
(Materials and Resources)

EDB

Preface

To support the implementation of the Enriched Technology Education Key Learning Area Curriculum (Enriched Curriculum) at junior secondary level, the Technology Education Section of Curriculum Development Institute, Education Bureau, has developed a set of learning and teaching resource materials covering technological subjects learning element modules for teachers' reference and use.

The purpose of providing this set of teaching resource materials is to enable teachers to adopt the related technological subjects learning element modules under the Enriched Curriculum for students to acquire thorough understanding and mastery of the three key aspects in Technology Education Key Learning Area, viz. the technological understanding, technological capability and technological awareness, using a flexible approach with reference to the suggested learning progress.

The content of this learning and teaching resources was compiled with project approach. It gives students a purposeful and meaningful learning context through a series of diversified activities such as design projects, case studies, technological exploration and simulation experiments, and thus arouses their interest in technology and devotion in learning, as well as nurtures their ability in problem-solving, realisation, innovation and spirit of entrepreneurship.

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Relevant Knowledge

1.1 Types of Material

In modern society, human uses a variety of equipment, machinery and buildings. Actually, stationery, wardrobes, cars, bridges, etc.; are all made of different materials (Figure 1). Individual material not only has its unique features, but also has different usages. For example, the commonly used material for stationery is plastic whereas the common material for wardrobes is wood; metals are commonly used for automobiles, whereas the material commonly used by bridges is concrete. In recent years, synthetic materials (such as glass fibre) are increasingly being used to produce lightweight and robust appliances such as the canoes.

Figure 1 (a) Stationery

(b) Wardrobe

(c) Car

(d) Flyover

Many types of materials are being used by human; the commonly used engineering materials include timber, metal, plastics, synthetic materials and concrete. Other common materials are stone, ceramics, cloth, glass, paper, leather, rubber and so on. The two major categories of materials are naturally-occurring materials and man-made materials. Natural materials are collected from the nature and can be used after some initial processing, such as timber and metal. Man-made materials have to go through more complicated processes before they can be produced, such as plastic, concrete and synthetic materials. Figure 2 lists the classification of some commonly used materials.

Figure 2 Classification of commonly used materials

1.2 Naturally-occurring Materials

Naturally-occurring materials include timber, metal, rock, rubber, clay, wool and leather, etc.

Commonly used naturally-occurring materials

(a) Timber

Human has a long history of using timber and the usage of timber is very extensive, such as manufacturing household goods, constructing buildings, etc. (Figure 3).

Figure 2 (a) Wood Product

(b) Wood Building

Solid timber

Solid timber is the wood material obtained after removing the leaves and barks, and can be grouped into the two kinds of softwood and hardwood.

Figure 3 (a) Solid timber

Relevant Knowledge

Softwood

Material	Products
Pine	Furniture
Fir	Wooden ladder, wooden packing boxes, outdoor structures
White poplar	Drawing board, matches or surface layer of plywood

Table 1 Examples of softwood

(i) Hardwood

Material	Products
Serayah	Those with higher quality can be used to manufacture furniture, inferior ones used as hoardings in construction, for temporary buildings or for the production of plywood
Teak	The surface layer of plywood, high class furniture
San Chong	The workbench in the workshop

Table 2 Examples of hardwood

Figure 4 (a) Softwood examples: Red pine and ponderosa

(b) Hardwood examples: Maple strip and teak flooring

(b) Metal

Metals are extracted and refined from mineral ore, such as gold, silver, copper, iron and tin.

Figure 5 (a) Iron ore

Metal can be grouped into the two main kinds of ferrous metal and non-ferrous metal.

Figure 6 (a) Ferrous metal product

(b) Non-ferrous metal products

(i) Ferrous metal

Ferrous metal refers to metal containing iron elements such as pig iron, cast iron, wrought iron, etc.

Material	Products
Cast iron	The lathe bed and guiding rail of machine tools
Wrought iron	Iron pipe, dock, railway tracks, anchors, gears, chains, etc.

Table 3 Examples of metal iron

(a) Guiding rail of machine tools

(b) Gears

(ii) Non-ferrous metal

Non-ferrous metal refers to metal not containing iron elements such as gold, copper, aluminum, zinc and lead. Many non-ferrous metals are commonly used as engineering materials.

Bold metal	Products
Gold	Coins, jewelries
Copper (red copper)	Wire, electric soldering iron, copper alloy
Aluminum	Aluminum alloy
Zinc	Galvanized iron sheet (galvanized sheet), used as plating materials
Lead	Batteries, soldering materials, used as equipment in radiation protection

Table 4 Properties and sample applications of commonly used pure metals

Figure 8 Lead sinkers

Relevant Knowledge

1.3 Man-made materials

Man-made materials refer to materials not taken from the nature, but are synthetic materials through chemical methods. These include glass, nylon, styrofoam, acrylic sheet and so on.

(a) Plastics

Today commonly used plastic materials are mostly produced by chemical processes from oil, coal or coal gas. In our daily lives, we often use products manufactured by plastics. With the continuous development of science and technology, today the characteristics of plastic products are no longer inferior to other traditional materials.

Material	Products
Acrylic	Neon signs, photo frames, window dressing display shelves
Styrofoam	Product packing, food containers, model making
Polyvinyl chloride	Pipes, containers, plastic bottles

Table 5 Plastics examples

Figure 9 Different plastic products

Plastics can be grouped into two major kinds of thermoplastic and thermosetting plastic:

(i) Thermoplastic

Thermoplastic will be softened after being heated, and then it will melt. After cooling it will be hardened and restored to the original strength and properties. Such plastics can be physically changed many times without limit or without changing its plastic properties. Thus such plastics are good electrical insulators, but are not suitable for manufacturing thermal products such as cups for hot water, etc.

Figure 10 (a) Plastic toy (Thermoplastic)

(b) Pleated plastic belt (Thermoplastic)

Synthetic plastic is also a kind of thermoplastic extracted from crude oil. It is flexible and has good insulation, waterproof and anti-erosion properties, it is usually used to manufacture automobile tires, slippers, rubber gloves, etc.

Figure 11 Synthetic plastic products
(a) Mouse pad *(b) slippers*

(ii) Thermosetting plastic

In the process of manufacturing, thermosetting plastic material becomes hard and solid after going through the chemical processes.

Figure 12 (a) Melamine formaldehyde resin *(b) Bakelite powder products*

(b) Composite materials

Composite material is a mixture of a variety of materials, the more commonly used are layered composite materials and fibre-type composite materials, and so on. It maintains some of the physical and chemical properties of the different composing materials.

(i) Layered composite material

Layered composite material is made up of multiple layers of plastic material bonded together (Figure 13a). For example, formica is a man-made thin plastic sheet with varying colours and patterns. It has a hard surface, is wear resistance, and can prevent heat and moisture, so it is commonly used to manufacture kitchen cabinets, wardrobe and the surfaces of furniture (Figure 13b).

Figure 13(a) Layered composite material

(b) Surface of kitchen cabinets manufactured with formica (Left) and surfaces of bookshelves (Right)

(ii) Fibre composite material

Fibre composite material is to combine a set of threadlike materials into yarn bundles, and have them woven into mats (Figure 14a). The mats are placed on moulds coated with mould stripping wax. They are then coated with a suitable adhesive (e.g. epoxy resin) to become fibre composite materials. For example, glass fibre reinforced plastic (GRP) is a kind of fibre composite materials referred to as glass fibre, which is generally more rigid than other plastics.

Figure14 (a) Woven mat *(b) Windsurfers made of glass fibre*

Glass fibre has a very high strength even greater than steel, the elasticity is also comparable to steel but with a lower density. It can be used to make canoes, windsurfers (Figure 15b), speedboats, the outer layer of cars, and so on.

(c) Concrete

Concrete is commonly known as combining three types of soil together, its ingredients include cement, sand, fine stone and water. Its organisation was formed by a variety of particles bonded as composite materials. Cement is a mixture of limestone and clay, which can stick together with other ingredients. When the various components have been mixed, water and cement will generate a chemical reaction and form a slime to stick together the components.

Figure 15 Particles in concrete *Figure 16(a) Concrete blocks* *(b) Concrete buildings*

Concrete becomes very hard when dried and can be used for various purposes (Figure 16a). Concrete is characterised by fireproof, insects resisting, moisture-proof, easy maintenance, cheapness in price and easy moulding, etc. It can also be further processed and coated with paintings, and is frequently used to construct buildings, bridges, roads, dams and so on. As modern cities always use concrete to build tall buildings, so they are being called the "concrete jungle" (Figure 16b).

Relevant Knowledge

1.4

The characteristics and usage of materials

Timber is the raw material for manufacturing different types of daily necessities. After understanding that different materials have different properties, handling and processing methods, a variety of items can then be made. For example, timber generally has the advantages of being cheaper, robust, can be easily processed and aesthetics, so it is used to make tables, chairs and wardrobes. On the other hand, plastic is durable, waterproof and easy to manufacture, so it is used in mass production of buckets or containers

(a) Timber

The two types of timber being used are solid timber and manufactured board.

(i) Solid timber

Softwoods commonly used in Hong Kong are pine, fir and white poplar. Their characteristics are generally more flexible and fragile, but the wood grain is beautiful and easy in processing.

Figure 4 (a) Fir ladder

(b) Drawing board made of poplar

Commonly used hardwoods are teak, maple, San Cheong, serayah and light wood / balsa, etc. Their characteristics are generally harder, with higher density, quite beautiful and very durable.

Figure18 (a) Serayah

(b) Rosewood furniture

Relevant Knowledge

General usage of solid timber

Usages of softwood	Usages of hardwood
➢ General softwood can be used as raw material for paper pulp ➢ The external rod for utensils, such as a kitchen knife handle ➢ Making plywood ➢ Manufacturing packing boxes, barrels, carriages, ships furniture, etc. ➢ White poplar can be used to manufacture the surface layer of plywood, match sticks and drawing boards	➢ Serayah is mainly used to manufacture the inner layer of plywood and construction site hoardings ➢ Teak is mainly used to manufacture sculptures, floor tiles, countertops of laboratory bench, etc. ➢ San Cheong can also be used to manufacture the workbench of school workshop ➢ Beech is commonly used in railroad crossties, making of hull and furniture ➢ Balsa is usually used to make models

Table 6 Usage of solid woods

(ii) Manufactured board

Manufactured board is to use thin veneers, wood strips or wood chips as raw materials and manufactured through bonding and pressure. The surface of manufactured board is smooth, and its general characteristics are that the wood is tough, uneasy to deform due to moisture.

Plywood

Plywood is made up of three layers or more of thin veneers bonded together, it is suitable for making high quality buckling appliances (Figure 20)。

Figure 19.Plywood of different thicknesses

Plywood has many advantages, such as:

- ➢ there is wide plain surface.
- ➢ high resistance to bending.
- ➢ tough and durable.
- ➢ uneasy to expand, contract, deform or rupture due to changes in humidity.
- ➢ easy for storage, no need for seasoning treatment.
- ➢ Thin plywood has good ductility for easy blending.

Figure 20 (a) Thin bended plywood

(b) Thick bended plywood

Fibreboard

Fibreboard is made by smashing and mixing wood, paper, bagasse and plant fibers, then stir and add glue, and finally apply high pressure to form the board. Examples of fibreboard include the fiber plate and the wan flower plate, etc.

Fibre plate (Figure 21) is usually used to manufacture the back panel or desktop or furniture. Clipboard plate is usually used to manufacture the lock down accessories of furniture (Figure 22)。

Figure 21 Fibre plate

Figure 22 Clipboard cabinet

(b) Metal

Ferrous metals are generally harder and stronger, which is suitable for manufacturing tools and mechanical parts.

As pure metal is difficult to extract and many of its features fail to meet the requirements of engineering or production, usually a number of different metals or substances are added to the metal being refined to change it into another kind of metal called alloy.

Steel

The strength of pure iron is low, but after refining and adding appropriate amount of carbon elements, it will become steel which is very strong, such as mild steel and stainless steel. Steel is more appropriate for making tools, machinery, structures, etc. It has a very wide usage and is important to the modern society. Steels can be grouped into carbon steel and alloy steel, etc.

Material	Products
Mild steel	Steel wire fence, screw
Alloy steel	Mechanical cutting tools
Stainless steel	Utensils, containers

Table 7 Examples of steel

Examples of carbon steel products

Figure 22 (a) Medium carbon steel hand tools

(b) High carbon steel cutting tools

Examples of alloy steel products

Figure 23 (a) High speed steel drills

(b) Stainless steel tableware, kitchen utensils

Non-ferrous alloy

Non-ferrous metals generally have good ductility and corrosion resistance, with high density and more adorable colours, and usually with better electrical and thermal conductivity.

Take aluminum as an example, its surface is silvery gray, a brighter effect can be obtained by grinding and polishing for shining surfaces, which is easy to process and anti-corrosive, but the hardness is weak and not easy for soldering. Yet while maintaining the bright colour, anti-corrosive and lightweight characteristics, aluminum alloy is strengthened in its hardness and strength which become a more versatile material.

Material	Products
Aluminum alloy	Kitchen utensils, beverage packing, aircraft parts
Brass	Cable, bearing, propeller, jewellery
Bronze	Bronze and brass bell (bell metal), marine water pumps, bearings

Table 8 Examples of non-ferrous metals

Figure 24 (a) Aluminum windows

(b) Airplane

Figure 25 (a) Brass products

(b) Bronze products

(c) Plastics

Advantages of plastic products	Disadvantages of plastic products
➢ Light ➢ Tough ➢ Moisture proof ➢ Corrosion resistant ➢ Good insulation property ➢ High plasticity ➢ Easy processing, low manufacturing cost, suitable for mass production	➢ Difficult to decompose naturally, not environmental friendly ➢ Insufficient strength ➢ Easy burning, not high temperature resistant ➢ Prolonged exposure to the sun will cause aging and brittleness ➢ Will release toxic substances when burned ➢ Chemicals used in the manufacturing process are harmful to human health

Table 9 Advantages and disadvantages of plastic products

Plastics can mainly be grouped into the two kinds of thermoplastic and thermosetting plastic:

Thermoplastic products

Figure 26(a) Soft plastic products (b)Styrofoam boxes for food (c)School bag strap - PP strap

(d) Nylon robe ball, fishing line, gear

(e) Container for chemical agents - polyethylene

(f) PVC pipe

(g) Acrylic signs

Thermosetting plastic products

After the steps of heating, pressurizing, and then chemical conversion, cooling and solidification, thermosetting plastics will be transformed into products. The chemical transformation of such plastics cannot be reversed and the process can only be carried out once, the moulded product cannot be restored even after re-heating.

Figure 27 (a) Epoxy resin (b) Bakelite powder socket (c) Polyester resin

(d) Wood glue powder

(e) Melamine formaldehyde resin

1.5 Glossary of Terms

Material

天然物料	Naturally-occurring materials	鐵金屬	Ferrous metal
人工物料	Man-made materials	非鐵金屬	Non-ferrous metal
合成物料	Synthetic materials	合金	Alloy
複合物料	Composite materials	軟鋼	Mild steel
生物物料	Biological materials	不銹鋼	Stainless steel
木材	Timber	鋁	Aluminium
軟木	Softwood	紅銅	Copper
松木	Pine	黃銅	Brass
白楊木	White Poplar	青銅	Bronze
硬木	Hardwood	塑膠	Plastics
雜木	Serayah	熱塑性塑膠	Thermoplastic
柚木	Teak	熱固性塑膠	Thermosetting plastic
山樟	San Cheong	尼龍	Nylon
櫸木	Beech	亞加力膠	Acrylic
合成板	Manufactured board	發泡膠	Styrofoam
夾板	Plywood	PVC 膠	Polyvinyl chloride
纖維板	Fibreboard	聚乙烯	Polythene
科學瓷	Melamine formaldehyde resin	水晶膠（聚酯樹脂）	Polyester resin

Design

設計程序	Design process	資料搜集	Research
解難	Problem solving	解決方法	Solution
處境	Situation	實踐	Realization
設計概要	Design brief	測試	Testing
設計細則	Specifications	評估	Evaluation

Exercise 1A

Material information station

Search the information of one kind of material from the Internet, then fill in the following spaces with details of the data obtained:

Related website: http://www._____

Name of related organization:_____

Type / Name of the data collected:_____

Specifications of material dimensions:_____

Place of origin:_____

Appearance of Material:_____

(Diagram)

Quantity (for ordering):_____

Usage:_____

_____

Others:_____

_____

Project Activity
Design and Communication

Book buckles

Guidelines for project activity

1.1 Introduction to the project

In ancient time books were made from bamboo, the large quantity and heavy weighting were not convenient for carrying, so they were mainly carried by carriage. Later on paper and the press printing technique was invented in China, books became paper printed and can be carried by smaller containers such as the book basket (Figure 1.1), which was much more convenient and easier than before.

At present most students use backpacks (Figure 1.2a) to carry a large number of textbooks, whereas a smaller amount can be hand held, or fastened together by a book buckle (Figure 1.2b)

Figure1.1 Book basket was used to carry books in ancient time

Figure1.2 (a) Backpacks *(b) Book buckles designed and made by some students*

1.2 Guidelines to the project

(a) Situation

Wai Hung has to carry a very heavy school bag to school every day, causing much inconvenience in walking. Therefore during the examination day or when not too many books have to be carried, he would feel easy when just to take two to three books. In order to facilitate carrying a small number of books, he wants to design and make a lightweight and unique book buckle for himself.

(b) Design brief

Design and make a lightweight and unique book buckle to facilitate carrying a small number of books to school.

(c) Recommended materials

(i) Aluminum plate - Maximum size allowed: 75 mm(long) × 50 mm(width) × 3 mm(thick)

(ii) Book belt - Maximum size allowed: 1,750 mm(long) × 25 mm(width); the material must be PP belt.

(iii) Tools generally used for cutting and surface finishing.

(d) Design considerations

Figure 1.3 Factors to consider in designing a book buckle

The following problems should be considered in designing and producing the book buckles:

(i) The appearance is a pictographic shape, geometric or free graphics?

(ii) The length and width of the product.

(iii) The number of books to carry.

(iv) How many grooves are there in the books buckle and the usage of each groove?

(v) Angle of the inclined grooves.

(vi) Can the positions of grooves be combined?

(vii) Reduce the time to put on the belt.

(viii) Whether to use the spraying paints or polishing method for surface finishing.

(ix) Reduce the risk of being hurt when using the buckle.

(e) Recommended Time

6 teaching periods x 40 minutes (total 240 minutes)

(f) Procedure of making

(i) Design the shape and pattern of the book buckle.

(ii) Use Computer Aided Design (CAD) software to design the shape of the book buckle.

(iii) Use cardboard to make the model of the book buckle in order to test its feasibility.

(iv) Modify the design if problems arise during the testing.

(v) Use aluminum plate to make the physical book buckle.

(vi) Conduct the surface finishing procedures for the book buckle after the cutting step.

(vii) Lastly test the practicability of the book buckle.

1.3 Design process

The biggest difference between "Design" and "Art" is that they have different creative orientation. "Art" is about creative work from one's own subjective orientation irrespective of other people's preferences or opinions. From the start it is entirely one's own creation to satisfy one's own preferences. "Design" is about creative work mainly from an objective orientation, and the target is usually the users or an environment. Therefore the creative work has to consider and collect information about the object, such that products designed can meet the requirements of the users or environment.

"Design" is a problem-solving process with practical testing through creative thinking, and the products are manufactured after modifications.

Figure 1.4 The Design process

(a) Situation

Understand the problems or needs

(b) Design brief

Outline the direction of design or the form of problem solving.

(c) Design specifications

Use point form to list the design requirements or limitations.

(d) Data gathering

Collect relevant design information. If similar products are available in the market, we can use a camera to take photos of the products for analysis and comparison.

(e) Proposed solutions

Including:

Initial ideas: Freely record the various feasibilities of the design.

Development ideas: Focus on designs with higher feasibility.

Final decision: Determine the details and dimensions of the final design and draw the working diagram.

Activity 1.1: Collecting book buckles

There are many different features of book buckles in the market including their appearances and different buckling methods. Try to collect or use a digital camera to record the pictures of three to five different models of books buckle for references. You can get or take the pictures from the product promotion leaflets of stationery suppliers, Internet, newspapers, magazines, etc., or go to the stationery stores.

Data gathered can be retained for use in the design folio.

Activity 1.2: Design the outlook of the book buckle

During the collection process, understand the design of book buckles available in the market. Make reference to the advantages and disadvantages of the different designs, and then design by sketching for the outlook of the personal book buckle.

(f) Realisation

Use different kinds of materials for making the artefact and the design can be realised by means of models.

(g) Testing

Test whether the product fulfills the requirements of the design specifications.

(h) Evaluation

Evaluate the strength and weaknesses of the design artefact and make modifications. If the finished artefact does not meet the design requirements, the designer will need to find out what the problems are. If the design requirements are met, then the finished artefacts can formally be produced and the design process is completed.

Activity 1.3: Make and test the book buckles

Upon completion of the design and before making of the book buckle, cardboards can initially be used to make a model to test the feasibility of the design. After testing, modifications in product design should be done if problems arisen.

Activity 1.4: Materials for the book buckles

Book buckles can be made of various materials such as metal, plastic or cardboard, and different materials have their own advantages and disadvantages.

Try to compare the advantages and disadvantages of the materials used to make the book buckle, fill the results in the table below.

Material	Advantages	Disadvantages
Metal –Iron		
Metal – Aluminum		
Plastic		
Cardboard		

Based on the results of the above comparison, which material will you choose to produce the book buckle?_____

Why choose the above material?_____

1.4 Design folio

The design folio is an information book recording the designer's creation. This folio allows others to understand the creation process of the designer, and produce the same product accordingly. A complete design folio includes the following items:

(i) Cover

The cover can be drawn by using a computer aided or freehand sketching. The name, class number, year, school name and project title must be written on it.

(ii) Table of contents

The report should include page numbers and the number of pages of each item clearly to facilitate referencing.

(iii) Situation

(iv) Design brief

(v) Design specifications

(vi) Data collection

Collect relevant information or existing products, conduct comparative analysis by listing them on a table.

(vii) Proposed solutions

Organise the sketches of the preliminary ideas and final decision, together with the working diagram drawn by computer drawing (including projection, three-dimensional drawings and parts drawings).

(viii) Realisation

Pictures can be used to record part of the production process.

(ix) Testing

(x) Evaluation

Describe in words the advantages and disadvantages of the product and make recommendations for improvement.

Activity 1.5: Folio on the production of the book buckles

The design folio is a record about the design ideas and making. When making of the book buckle is completed, you can start preparing the folio to record the various steps from data collection to completed making of the book buckles.

Please refer to 1.4 for items to be included in the report.

1.5 At completion of the activity students should be able to:

(i) Understand the various consideration factors for the design process

(ii) Step in the design process

(iii) Selection of appropriate material to make a simple book buckle