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Grade Three

Testing Materials and Designs

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Testing Materials and Designs

Before You Begin

Children are natural builders. The topic Testing Materials and Designs provides students with the opportunity to investigate the properties of various materials and their suitability for building various structures. The children examine the relationship that exists between the materials chosen to construct a structure and its design and function.

Topic C: Testing Materials and Designs

(Suggested time: 8 weeks)

Testing Materials and Designs should be introduced before Building with a Variety of Materials. Plan two months for the development of this unit and consider a three-month time period if you are going to teach the two units together.

Materials for this unit need to be gathered and organized ahead of time. By collecting materials from around the school, ordering equipment from a science supply company and writing a letter requesting parents to donate items, you can obtain an assortment of the items required. Parents whose occupations involve building, renovating or working at a local lumberyard may be able to contribute small pieces of wood or other building materials. Material from a recycling centre and cardboard from old boxes can be found either at school or home. Contact small industries for scrap materials. They may be able to put aside materials for your students to use.

Consider inviting a carpenter, engineer, bookbinder, fashion designer or a parent who works for a company that develops packaging. Materials can be sorted into bins—plastic bags, boxes, pails or store-bought containers —for easy access. Adequate table space for designing, testing and building activities will be necessary. Students need to be given adequate time to work on and finish their projects, as well as an opportunity to share their creations with the class.

Background Information

We learn to use materials effectively either through trial and error or through the more scientific method of testing materials to understand their properties. Such organized engineering tests, which came into common practice during the Renaissance, have led to steady improvement in the qualities of materials and structures.

Tests of materials typically use a relatively small sample of the material in question. Structural testing may involve a full-scale model, a small-scale model, or a computer-generated mathematical model. The quantification of key properties attained through materials testing makes comparison of materials meaningful. The following materials tests attempt to simulate the circumstances materials experience in actual use.

Compression Test

Compression testing measures how resistant a material is to crushing by adding force (weight) to the top of a sample until it fails (crushes).

Simple tests can reveal a lot about materials of similar size and shape. To demonstrate compression testing, make cylinders about 3 cm high and 2 cm in diameter out of backyard clay, play dough, Plaster of Paris, plaster (drywall compound is acceptable), topsoil mud and any similar materials you think of. When the cylinders are thoroughly dry, perform the following experiment on each. Set the cylinder on a hard surface. Hold a board on top of the cylinder and add weights on top of the board until the sample crushes. Some materials will crush easily, others will have so much compressive strength no reasonable amount of weight will do the job. Can the compressive strength of some of the materials be increased by mixing in grass or thin strips of paper? Try it.

Tension Test

Tension tests measure the tensile strength of a sample by pulling on each end until failure (breakage) occurs. *Tensile strength* is defined as the maximum load (weight) a material can support when being stretched, divided by the original cross-sectional area of the material. When a material is loaded, it stretches. Provided the load is less than the tensile strength of the material, the material returns approximately to its original shape and length when the load is removed—assuming the material is not ductile. Different kinds of thread and line can be tested for tensile strength by tying one end to a high fastener and the other end to a light paint bucket. Fill the bucket with water or gravel until the line snaps or stretches excessively. (Be prepared to catch the bucket to avoid a big mess!)

Bending Test

The *bending test* explores both the compressive and tensile strength of materials. When bent, a brittle material experiences tension on the outside of the bend and compression on the inside of the bend. If, like glass, the material is stronger in compressive strength than tensile strength, the failure (breakage) begins on the side experiencing tension.

Ductile materials deform permanently when subjected to force. A highly ductile material bends and flows easily—the opposite of a *brittle* material. A bendable steel nail, for example, is more ductile than a pane of glass.

Toughness measures the amount of energy required to deform a material permanently. Stainless steel is typically much tougher than ordinary steel, requiring much more energy to deform it to the same degree. If stretched close to the breaking point, a ductile material creates a narrow neck, where failure occurs if its tensile strength is exceeded. Clay is a ductile material than can be used to provide an excellent demonstration of this.

In the classroom, the bending test can be applied to a piece of spaghetti, a straw, a copper wire and a wooden shish kebab skewer. Each of these is roughly the same diameter and length. Clamp one end to a table and weight the other end until the sample bends or breaks.

In a similar manner, you can also demonstrate that strength is proportional to the cross-section of a material. Clamp one end of a Popsicle stick to the edge of a table (like a miniature diving board) and apply the bending test. The stick should snap quite readily. Now use a vice to hold the end of another Popsicle stick in place with its thin side up (i.e., rotated through 90° from the previous set-up) and apply the bending test again. You will find the stick is very difficult to break because you are applying the downward force of the weight through a much thicker cross-section of wood. **When materials are joined to form structures, it is important to arrange the materials so forces are applied across their greatest cross-section.**

Shear Test

Shear tests are applied primarily to sheet materials and measure the resistance to forces working on the material in opposite directions simultaneously, like the forces applied by the blades of a set of shears. Bolts and rivets also are shear-tested to specify the size required to resist the sideways forces on the assemblies they hold together.

Structural design and testing recognizes that structures must remain safe and usable over long periods of time and in unusual circumstances. Most structures in Alberta are designed to withstand high winds and considerable loads of snow. Buildings are also designed to contain and resist fire long enough to ensure safe evacuation and to allow the fire to be brought under control by firefighters.

Throughout history, bridges have been the focus of much design effort and testing because they must withstand the effects of wind, flood waters and heavy traffic loads that subject the structure to constant vibration. Bridges were among the first structures to which Renaissance engineers applied their new-found knowledge of triangular trusses that supplanted arch and lintel construction (see Fig. 1). At first, wood was used to make the trusses; later, iron and steel replaced wood. Weak common materials can be made into amazingly strong bridges if the triangular truss principle is applied.

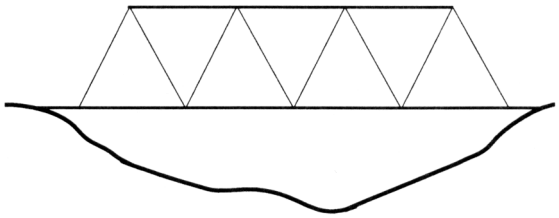

Figure 1.
Triangular truss bridge

Elementary Science Program of Studies

General and Specific Learner Expectations

The following general and specific learner expectations have been taken directly from the 1996 Elementary Science Program of Studies. The specific learner expectations (SLEs) are referred to by number in the second column of the activities table.

General Learner Expectation

Students will be able to:

Evaluate the suitability of different materials and designs for their use in a building task.

Specific Learner Expectation

Students will be able to:

1. Recognize that functional structures must be sufficiently strong and stable, and that unstable or weak structures are often unsafe to use.
2. Compare and evaluate the stability of different models or objects constructed.
3. Describe the distinctive properties of some common solids such as wood, paper or plastic that make them suitable for use as building materials.
4. Apply procedures to test the strength of construction materials, in particular, different stocks of paper, plastic or wood.
5. Apply procedures to test different designs.
6. Apply procedures to test the strength of different methods of joining.
7. Identify and apply methods for making a structure stronger or more stable; for example, by adding or joining parts to form triangles.

Cross-curricular Connections

Mathematics

- Measure the height and circumference of various containers using string, and comparing measurements.
- Order various container sizes, from smallest capacity to largest capacity.
- Compare the mass of different containers using balances.
- Estimate and then count to determine the actual number of building materials used in a given structure, for example, number of blocks, number of LEGO pieces, etc.
- Challenge students to take numerous measurements of their structures. These descriptions can be written onto cards and placed next to the object they describe.
- Select two or more fasteners and compare them.

- Survey to find out why people buy certain products over others, for example, do they buy the product because of the brand name, for environmental reasons, etc.

Language Arts

- Design advertisements to present the strongest structure.

Art

- Create structures using papier mâché and wire.
- Incorporate a variety of fasteners into student drawings.
- Design hanging sculptures using wool, toothpicks, Styrofoam, Popsicle sticks and craft supplies.
- Use one type of material to create murals or collages.
- Tie-dye fabric.
- Sew fabric swatches into hand puppets.
- Create fabric collages by cutting fabrics into interesting shapes.
- Make paper.

Technology

- Draw different designs/structures using the drawing tools.
- Create graphics, diagrams to compare the properties of different building materials.

Social Studies

- Discuss how paper and wood are tree products.
- Use maps to locate lumber resources in Alberta, in Canada and in locations worldwide.
- View films about the processes involved in developing wood and paper products.

Children's Alternative Frameworks

Children often have misconceptions concerning the relationships that exist between the physical dimensions of a material and its strength. It is advisable to start this topic with an open-ended activity that identifies the alternative frameworks your students possess.

Some possible misconceptions regarding Testing Materials and Designs are:

- the thicker the material the stronger it is;
- the larger the piece of material the strong it is; and
- the heavier the material the stronger it is.

Activities

Classroom teachers have identified the following activities that address the Specific Learner Expectations (SLEs) in the Program of Studies. The list is not prescriptive and teachers may select activities that are most appropriate for their students.

Activities have been listed under two headings. Key Activities and Extension Activities. Key activities are supported by authorized resources and identify "powerful and practical" means for achieving learner expectations. Extension activities represent alternative ways of achieving or supporting learner expectations.

Key Activities

These activities provide teachers with insights into children's initial ideas about building materials and designs. Encourage the children to add materials to the different bins. They may want to combine contents of various bins and should be encouraged to do so with a reminder to return all materials to their originals bins.

Key Activity	SLE	Print Resources	Essential Materials	Comments
Exploring, sorting and classifying different types of building materials	3	*Explorations in Science, Level 3, Design, Test, Build! (Free Exploration)*, p. 6	bins of various materials, as described in *Explorations*	This set of materials includes various papers, plastics, fabrics and cardboard.
		Explorations in Science, Level 3, Design, Test, Build! (What's Our Rule?), p. 10	bins containing pieces of wood, paper, plastic, fabric, metal, opaque bags	The two activities on p. 10 and 11 of *Design, Test, Build!* can be combined. Try identifying a sorting rule first, then placing items made of different materials into opaque bags (one bag to each group of items made of the same materials).
		Explorations in Science, Level 3, Design, Test, Build! (Creating a Collection), p. 11		
		Explorations in Science, Level 3, Designs that Work (Free Exploration), p. 7	bins of various fasteners as described in *Explorations*	This set of materials includes devices that are used to hold things together.
		Explorations in Science, Level 3, Fantastic Plastic (Free Exploration), p. 7	bins of various materials as described in *Explorations*	This set of materials includes various types of plastic and plastic items.
			an assortment of plastic items	
		Explorations in Science, Level 3, Fantastic Plastic (Classification Station), p. 15		

Key Activity	SLE	Print Resources	Essential Materials	Comments
Observing and comparing the properties of materials; considering which materials are best to use in different situations	3	*Explorations in Science, Level 3, Design, Test, Build! (What Would You Use?)*, p. 12	bins of various materials	Children communicate their understanding in small groups. Encourage all groups to respond to the same questions, for example, "Which materials would you use to build a boat, make a container, or hold ice cream? What would you use to make a pair of mittens?"
Exploring paper and plastics and evaluating their strength (tear resistance)	3, 4	*Explorations in Science, Level 3, Design, Test, Build! (Paper Pondering)*, p. 13	collection of paper samples, magnifying lenses	
		Explorations in Science, Level 3, Fantastic Plastic (Plastic and Paper: You Compare), p. 17	various types of paper (for example, tagboard, newsprint, bond, glossy), various types of sheet plastic, plastic bags, a large flat pan of water, magnifying lenses	Cut several thin strips from different kinds of paper. Cut some with the grain of the paper, some against. Cut similar strips from a variety of plastic sheets. Each group will need paper and plastic strips.
		Explorations in Science, Level 3, Fantastic Plastic (A Test of Strength), p. 18	various types of sheet plastic and plastic bags, scissors, glue, staples and stapler, heavy objects for weights, sand, line master 3	
Exploring the stability of different shapes	1, 2, 5	*Explorations in Science, Level 3, Super Structures (Stable Shapes)*, p. 11	cardboard strips, paper fasteners	Encourage students to make model squares, triangles and hexagons and invite them to share and explain their models. Compare all the designs for stability and moveability. Encourage students to find ways to make their models more stable by using the least amount of material possible. Explain that engineers and builders are challenged to keep costs down while maintaining aesthetics and safety.
		Explorations in Science, Level 3, Super Structures (More Stable, Most Stable), p. 12	cardboard strips, paper fasteners, hole punch, scissors	

Key Activity	SLE	Print Resources	Essential Materials	Comments
Testing the strength and stability of different construction materials and designs	4, 5	*Explorations in Science, Level 3, Super Structures (Paper Power)*, p. 15	different types of paper, small blocks	Have students investigate ways that paper will support blocks, for example, folding in various ways, changing its shape and diameter.
		Explorations in Science, Level 3, Super Structures (Tubular Support), p. 16	paper, scissors, tape, blocks	
		Explorations in Science, Level 3, Super Structures (Pillars of Strength), p. 17	as above plus shoe box lids	Students may enjoy building children's furniture, for example, tables and stools. Challenge them to test how many kilograms each chair will hold. Chart the results.
		Explorations in Science, Level 3, Super Structures (Strong Enough to Sit On?), p. 18	newspaper or paper, tape	
		Explorations in Science, Level 3, Super Structures (Strong Straws), p. 19	straws, tape, string, thread, materials as requested	
		Explorations in Science, Level 3, Design, Test, Build! (Constructing with Dowels), p. 22	newspapers, toothpicks, tape	The children will be surprised at the strength of these newspaper dowels. In order to make a stronger dowel, place a toothpick across the corner of a sheet of newspaper and roll the sheet as tightly around it as possible.
Investigating arches and beams	1, 2, 5	*Innovations in Science, Level 3, Bridgeworks (Support System)*, p. 18	thin boards, blocks or washers, sheets of paper, tape, scissors	
		Innovations in Science, Level 3, Bridgeworks (Under Cover), p. 24	long sheets of paper, tape, blocks, unsharpened pencils, string, paper clips, stiff paper, scissors	
		Innovations in Science, Level 3, Bridgeworks (Under Stress), p. 31	heavy construction paper, blocks, rulers	
Creating boxes and testing their strength and stability	1, 2, 5, 6, 7	*Explorations in Science, Level 3, Designs that Work (Shipshape)*, p. 25	thick paper, tape, scissors, ruler, measuring spoons, sand, line master 4	
		Explorations in Science, Level 3, Designs that Work (Box Your Idea), p. 27	thick paper, cardboard, corrugated board, Styrofoam, glue, tape, staplers, Velcro, scissors, rulers, recycled materials	Encourage students to record in their journals, the design and construction process.

Key Activity	SLE	Print Resources	Essential Materials	Comments
Testing the strength of different fasteners	6, 7	*Explorations in Science, Level 3, Designs that Work (A Smorgasbord of Fasteners)*, p. 14	a variety of tapes, a variety of glues, pins and tacks, stapler and staples, different types of paper, cardboard, string, spring scale, bathroom scale	
		Explorations in Science, Level 3, Design, Test, Build! (So, So Sticky), p. 20	different types of tape and glue	Have several groups design a test to find the stickiest tape while others test to find the stickiest glue.
		Innovations in Science, Level 3, Stuck On You (Tape Test), p. 12	variety of tapes, paper, small objects (for example, washers, paper clips)	Provide samples of a variety of tapes and have children compare their size, texture, stickiness and usefulness. After a discussion, have children choose one type of tape then predict and record which small objects can or cannot be picked up by the tape.
Investigating wood and ways of joining wood pieces	3, 4, 6	*Explorations in Science, Level 3, Designs that Work (Wooden Encounters)*, p. 20	hammers, screwdrivers (Philips, Robertson, slot), different types and sizes of screws, nails (clout, spiral, finishing, no-head), safety goggles, pieces of wood, line masters 2 and 3	Suggest that students keep a record of their work in their science journals. When students finish one investigation they can move on to the next one, until they have explored each set of simple machines and appropriate fasteners.
		Explorations in Science, Level 3, Design, Test, Build! (Wondering about Wood), p. 14	wood scraps	
Investigating ways of shaping the components used in construction so they do not require adhesives or fasteners	4, 5, 6, 7	*Explorations in Science, Level 3, Designs that Work (Let's Build)*, p. 30	construction materials such as paper, Styrofoam, plastics, wood, cardboard sheets, cardboard tubes and cardboard boxes. Construction toys may also be provided as a source of ideas.	In some approaches to construction, no adhesives or joining hardware are required. The shape of the materials, and the way they are fitted together, provides sufficient strength. In this activity, students should develop their own means of joining materials. They may base their ideas on methods they see used in commercially available construction toys. Encourage students to sketch and discuss their ideas before beginning construction.

Extension Activities

Extension Activity	SLE	Print Resources	Essential Materials	Comments
Observing and comparing the attributes of thin plastics and rubber (bags and balloons)	3, 4	*Explorations in Science, Level 3, Fantastic Plastic (It's in the Bag)*, p. 10	5 or 6 large plastic garbage bags, smaller plastic bags for each student, chart paper, felt markers, line master 1	Have students try to inflate their bags by swinging them through the air and sealing the ends. As a language arts extension, have students write a description of the ways plastic affects them in their daily lives.
		Explorations in Science, Level 3, Fantastic Plastic (Poking Fun), p. 12	plastic bags, plastic tape, scissors, various implements for poking (for example, pencils, chalk, crayons, rulers)	Have students work through these activities simultaneously.
		Explorations in Science, Level 3, Fantastic Plastic (Bursting Balloons), p. 14	balloons, pins, pencils, cellophane tape	Challenge students to predict what will happen before they burst the bags or the balloons. Encourage students to record their observations and to classify the plastics in new ways.
Investigating the design of plastic and metal containers	5	*Explorations in Science, Level 3, Design, Test, Build! (In the Container)*, p. 16	plastic containers, tin cans	
Investigating fabrics as construction materials	3, 4	*Explorations in Science, Level 3, Design, Test, Build! (Fabric Fascinations)*, p. 15	fabric swatches, magnifying lenses	
		Explorations in Science, Level 3, Design, Test, Build! (Holes in Your Knee!), p. 19	sandpaper, fabric swatches, magnifying lenses	
Investigating a variety of fabric fasteners	6	*Explorations in Science, Level 3, Designs that Work (Fabric Fasteners)*, p. 18	a variety of fabric swatches (felt, wool, polyester, silk, cotton, light and heavy denims, knits, jersey, windbreaker materials), needles, thread, hooks and eyes, snaps, buttons, Velcro, zippers	Provide students with a variety of fasteners and have them design a fair test to determine the strength and durability of several types of fasteners.

Extension Activity	SLE	Print Resources	Essential Materials	Comments
Investigating the use of a variety of fasteners	6	*Explorations in Science, Level 3, Designs that Work (Fasteners Galore)*, p. 10	chart paper, markers, collection of fasteners for example, paper clips (metal, plastic), alligator clips, bulldog clips, paper from the recycling bin	Encourage children, in small groups, to classify the fasteners. Present groups with a sample of each of the varieties of fasteners available and have them list some characteristics of the fasteners.
		Explorations in Science, Level 3, Designs that Work (Clip It), p. 11		
		Innovations in Science, Level 2, Stuck on You (Zip It Up!), p. 8 *Innovations in Science, Level 2, Stuck on You (Fascinating Fasteners)*, p. 5	chart paper, paper, magnifying glasses, variety of fasteners, felt pens, two colours of cardboard, pocket chart, sticky tags, paper	
		Make It Work! Building (Glover) *(Making Joints)*, p. 6	variety of papers, plastics, wood, string, metal fasteners	
Using a variety of fasteners to construct paper sculptures		*Innovations in Science, Level 3, Stuck On You (Stuck Together)*, p. 22	variety of papers, variety of fasteners, chart paper	
Investigating paper clip designs		*Explorations In Science, Level 3, Designs That Work (Let's Keep in Shape)*, p. 13	metal paper clips, thin wire, sculpture wire, thin hangers, pliers, safety goggles	Invite children to test a new model paper clip and provide the necessary materials.
Developing an awareness of the physical properties of glue	6, 7	*Innovations in Science, Level 2, Stuck on You (Sticky Stuff)*, p. 16	variety of glue, chart paper, cardboard, paper, toothpicks, plastic wrap, lined paper, black line master 2	Make a collection of glues. Some glues such as Krazy Glue, airplane glue and rubber cement are not safe to use in the classroom. Discuss why there are so many varieties. Have the children categorize types of glue. Provide students with the materials to design experiments to compare the consistencies of the various glues; have them predict the results of each test before they perform it.

Extension Activity	SLE	Print Resources	Essential Materials	Comments
Manufacturing glue	6	*Innovations in Science, Level 2, Stuck on You (Have We Got a Glue for You!)*, p. 19	paper, flour, paper cups, teaspoons, eyedroppers, Popsicle sticks, books, blocks or pennies, small plastic containers, poster paper, paint, crayons, pastels, black line master 22	Brainstorm, as a class, the properties of glue that might determine whether or not a consumer buys the product. Challenge the children to experiment with flour and water to make their own brand of glue in a paper cup. Do not store the student-made glue as it goes bad quickly.
		Explorations in Science, Level 3, Designs that Work (Sticky Fingers), p. 17	bowls or yogurt containers, measuring spoons, water, skim milk (or watered down 2% milk), white vinegar, baking soda, coffee filters or paper towels, line master 1	Have students predict what white glue is made of. Provide them with the essential materials and have them follow the recipe on line master 1. This recipe could be written on the chalkboard.
Investigating and evaluating different materials used in packaging		*Explorations in Science, Level 3, Designs that Work (Packages Galore)*, p. 22	a variety of packaging from home and school	
Building with boxes or cartons		*Explorations in Science, Level 3, Design, Test, Build! (Carton Constructions)*, p. 21	milk cartons, paste	
Creating unusual and unique uses for scrap plastic		*Explorations in Science, Level 3, Fantastic Plastic (Functional Junk)*, p. 25	assortment of plastic scrap items such as yogurt or sour cream containers, plastic pop bottles, unwanted plastic toys or tools, epoxy, scissors, utility knives	Challenge students to apply the knowledge they gained about the attributes of plastic to create unusual or unique uses for scrap plastic so that it can be used efficiently.
Exploring how weather affects building materials		*Innovations in Science, Level 3, Bridgeworks (Holding Up)*, p. 15	steel objects, clear plastic cups, salt, sand, wax, soap or oil	

Extension Activity	SLE	Print Resources	Essential Materials	Comments
Testing the insulative properties of plastic		*Explorations in Science, Level 3, Fantastic Plastic (Inside Insulation)*, p. 22	various plastic containers (Styrofoam cups, yogurt and sour cream containers), paper cups, ceramic mugs, glasses, electric kettle, thermometer, stopwatches	Have each group choose from the collection of different containers. Introduce the term *variable* and have them test for only one variable (for example, the type of plastic the container is made of).
Investigating how a building's shape helps it stay warm or cold		*How Buildings Work: A Teacher's Map to Exploration* (Scholastic) *(How Can a Building's Shape Help It Stay Warm or Cool?)*	thermometers, paper, tape	
Evaluating materials to use in different parts of home construction		*How Buildings Work: A Teacher's Map to Exploration* (Scholastic) *(What Materials Make Good Building Frames)*, p. 24	modeling clay, index cards, milk cartons, tape, plaster blocks	
		How Buildings Work: A Teacher's Map to Exploration (Scholastic) *(What Materials Make Good Walls)*, p. 36		
		How Buildings Work: A Teacher's Map to Exploration (Scholastic) *(What Materials Make Good Roofs)*, p. 40	cloth, aluminum foil, tar paper, scissors, wooden sticks, tape, pan, milk cartons, sponge, water	
Making walls using bricks and mortar		*An Early Start to Technology* (Richards) *(Bricks and Mortar)*, p. 76	bricks, sand, cement, measuring cup, plastic containers, large board, small cardboard boxes, cardboard tube, string, weight, toy truck	

Assessment

For a broader discussion of science classroom assessment techniques see *Assessing Student Learning* in the introduction of this publication on p. 15. Good places to begin looking for the unit-related ideas are *Explorations in Science* assessment handbooks, *Innovations in Science* teaching notes, Unit tests and Portfolio ideas, Alberta Education sample tests at **www.education.gov.ab.ca** and Alberta Assessment Consortium at **www.aac.ab.ca**

Bibliography

Alexander, N. *Stability*. Pearson Education Canada, 2000. ISBN 0-20164978-0.

Baker, Elaine et al. *Brain Waves* series. *Designing and Making: Towards Technology*. Age 7-11. Dunstable, England: Folens, 1992. ISBN 1-85276039-7.

Baker, Elaine et al. *Brain Waves* series. *Designing and Making: Primary Design*. Age 5-11. Dunstable, England: Folens, 1992. ISBN 1-85276038-9.

Bondar, Barbara and Dr. Roberta Bondar. *On The Space Shuttle, 8 Days in Space*. Toronto: Greey de Pencier, 1993. ISBN 1-89568812-4.

Bourgeois, Paulette. *The Amazing Paper Book*. Toronto: Kids Can Press, 1989. ISBN 0-92110382-4.

Brackett, Karen and Rosie Manley. *Beautiful Junk*. USA: Simon and Schuster, 1990. ISBN 0-82240626-8.

Brackett, Karen and Rosie Manley. *Beautiful Junk 2*. USA: Simon and Schuster, 1993.

Byam, Michele. *Arms and Armour*. Toronto: Stoddart, 1988. ISBN 0-77372179-7.

Campbell, Steve et al. *Explorations in Science, Level 3, Design, Test, Build!* Don Mills, Ontario: Addison-Wesley, 1992. ISBN 0-201-88132-2.

Campbell, Steve et al. *Explorations in Science, Level 3, Super Structures*. Don Mills, Ontario: Addison-Wesley, 1992. ISBN 0-201-88141-1.

Campbell, Steve et al. *Explorations in Science, Level 3, Fantastic Plastic*. Don Mills, Ontario: Addison-Wesley, 1992. ISBN 0-201-88153-5.

Campbell, Steve et al. *Explorations in Science, Level 3, Designs that Work*. Don Mills, Ontario: Addison-Wesley, 1992. ISBN 0-201-88160-8.

Cherrytree Press. *Bright Sparks* series: *We Can Shape It; We Can Built It; We Can Join It*. Avon, England: Cherrytree Press.

Cherrytree Press. *Learning Tree* series: *Technology: Paper; Tools*. Avon, England: Cherrytree Press.

Chronicle Books. *Things I Can Make With* series: *Boxes; Buttons; Cloth; Cork; Paper*. San Francisco: Chronicle Books.

Drew, David. *The Paper Skyscraper: The Technology of Materials (Big Book)*. Ginn, 1992. ISBN 0-73120626-6.

Dunn, Susan and Rob Larson. *Design Technology: Childrens' Engineering*. Bristol, England: Falmers, 1990.

Echols, Jean C. GEMS series: *Tree Homes*. Berkeley: University of California, 1993. ISBN 0-912511-87-8.

Fitzpatrick, Julie. *Towers and Bridges*. Evans Brothers, 1986. ISBN 0-23760213-X.

Forsyth, Adrian. *The Architecture of Animals*. Camden East: Camden House, 1989. ISBN 0-92065616-1.

Gadd, T. et al. *Blueprints Series: Technology Key Stage 1*. Bacon & Hughes, 1992. ISBN 1-89680404-1.

Gadd, T. et al. *Blueprints Series: Technology Key Stage 2*. Bacon & Hughes, 1992. ISBN 1-89680408-X.

Gibbons, Gail. *Up Goes the Skyscraper!* New York: Macmillan, 1986. ISBN 0-02736780-0.

Gibson, C. et al. *Rainbow Technology Series: Techniques for Primary Design and Technology*. Bacon & Hughes, 1991. ISBN 0-74871123-6.

Glover, David. *Make It Work Building!* Scholastic, 1995.

Gravett, Christopher. *Castle*. Toronto: Stoddart, 1994. ISBN 0-77372770-1.

Harrison, Patricia and Chris Ryan. *Folens Technology in Action: Unit 2*. Dunstable: Folens, 1990. ISBN 1-85276152-0.

Hawkes, Nigel. *Structures. The Way Things Are Built*. New York: Macmillan Publishing Co., 1990. ISBN 0-02549105-9.

Hickman, Pamela. *Habitats*. Toronto: Kids Can Press, 1993. ISBN 1-55074066-0.

Hughes, Shirley, *The Cement Mixer*. London: Walker, 1989.

Idle, Iris K. *Hands-On Technology*. England: Stanley Thornes, 1991.

Irvine, Joan. *Make It with Boxes*. Toronto: Kids Can Press, 1991. ISBN 0-68812081-4.

Jessop, Joanne. *The X-Ray Picture Book of Big Buildings of the Ancient World*. New York: F. Watts, 1993. ISBN 0-53114286-8.

Kaner, Etta. *Bridges*. Toronto: Kids Can Press, 1994. ISBN 1-55074146-2.

Lancaster, John. *Fresh Start* series*: Cardboard; Fabric Art; Paper Crafts*. New York: Franklin Watts.

MacLeod, Elizabeth. *The Recycling Book*. Toronto: Greey de Pencier Books, 1991. ISBN 0-92077558-6.

Mainwaring, Sheila and Clay Shouse. *Learning Through Construction*. Yspilanti: High/Scope Educational Research Foundation, 1983.

Maynard, Joyce. *New House*. San Diego: Harcourt Brace Jovanovich, 1987. ISBN 0-15257042-X.

McGraw, Sheila. *Papier Mâché For Kids*. Firefly Books, 1992. ISBN 0-92066892-5.

Moore, Nancy. *Design and Technology System*. Exclusive, 1984.

National Geographic Society. *Animal Architects*. National Geographic Society, 1987. ISBN 0-87044612-6.

Peturson, Rod and Neil McAllister. *Innovations in Science Process and Inquiry, Level 2*. Toronto: Harcourt Brace & Company, Canada, 1996. ISBN 0-7747-0189-7.

Peturson, Rod and Neil McAllister. *Innovations in Science Process and Inquiry, Level 3*. Toronto: Harcourt Brace & Company, Canada, 1996. ISBN 0-7747-0184-6.

Radford, Derek. *Building Materials and What They Do*. Cambridge, Massachusetts: Candlewick Press, 1991. ISBN 1-56402006-1.

Reynolds, Bill et al. *Technology IDEAS: (Integrating Design Education Activities for Students)*. Don Mills: Maxwell Macmillan Canada, 1993. ISBN 0-02-954154-9.

Richards, Roy. *An Early Start to Technology*. USA: Simon and Schuster, 1993.

Robbins, Ken. *Tools*. New York: Wind Press, 1983. ISBN 0-59007881-X.

Rose, D. et al. *Building and Testing with a Variety of Materials: Lessons for Grade 3 (Elementary Science and Technology Unit)* (2nd Edition), 1997.

Rowland-Warne, L. *Costume*. Toronto: Stoddart, 1992. ISBN 0-77372557-1.

Scholastic. *How Buildings Work: How People Use Materials to Build Structures: A Teacher's Map to Exploration*. Scholastic, 1995. ISBN 0-59027651-4.

Sneider, Cary and Jacqueline Barber. *GEMS* series*: Paper Towel Testing*. University of California, 1987.

Wilkinson, Philip. *Building*. Toronto: Stoddart, 1995. ISBN 0-77372844-9.

Zubrowski, Bernie. *Structure: Teacher Guide*. Cuisenaire Company of America, 1993. ISBN 0-938587-35-8.