Program Details + Learning Standards Alignments:

Structures

Learning By Design in Massachusetts
A K-12 architecture and design education program

How do buildings and bridges stand up? How are our bodies and buildings alike? Who designed our built our structures, and why? **K-8 students** will answer these questions when LBD:MA brings a wealth of hands-on structure activities and resources to your classroom.

Recognizing that there are existing *structures* curricula that teachers may already be putting to good use, LBD:MA can provide an architect to enhance a *structures or bridge-building project* on a per-session basis. That architect could visit for **1-2 class sessions**, discussing how architects and engineers design structures, show images of structures, and so on. Or he or she could co-teach **several sessions** with you, designing and building with the students, following the curriculum that you provide.

Alternately, if you would like LBD:MA to provide an entire structural design program for your students, we will help your students explore the connections between people, architecture and structural design. **Grades 5-8** may spend **six 1.5-hour sessions** on the project; a more basic hands-on introduction can be offered to **grades K-4** in **four 1-hour sessions.**

In *Structures* programs the students work alongside professional architects and explore design as a career path. Skills and concepts from across the **MA Curriculum Frameworks** that come into play include:

Science & Technology/Engineering: structures, materials, tools and construction technologies, the engineering design process,
Social Sciences: function, construction and significance of historic buildings, monuments and sites, science and technology in the context of society, history and human affairs,
Mathematics: geometry, estimation and measurement, scale and proportion,
Visual Arts: the elements and principles of design; methods, materials and techniques, inventions, technologies and the arts, interdisciplinary connections,
English Language Arts: research, vocabulary, composition, and oral presentation.

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In a typical program, students work in design-and-build teams. First, the teams **define their design problem** [e.g. to build a strong bridge or a tall tower]. Then they **investigate their problem**, learning about structures through traditional research, walking tours and physical and hands-on activities.

Structural Scavenger Hunt / Walking Tour: On a walking tour the students observe, draw, photograph, write about and discuss: architectural elements — natural forms in architecture — elements and principles of design — geometric shapes and structural elements.

"Being a Structure / Building a Structure" Activities: Students work in teams to act out structural terms and forces shown on the *Being a Structure* sheet: column; column and beam; cantilever; tension; compression; dome; arch; buttress; barrel vault; truss.

The students then use common materials to demonstrate structural forces and terms in quick, simple building activities:

— building columns, beams and vaults from paper
— building arches from block sets
— demonstrating the strength of triangular trusses using truss stick sets
— building cubes and pyramid structures from pipe cleaners or newspapers
— demonstrating tension and compression using wood blocks, truss sticks, straws and string.

Developing Ideas and Building Models

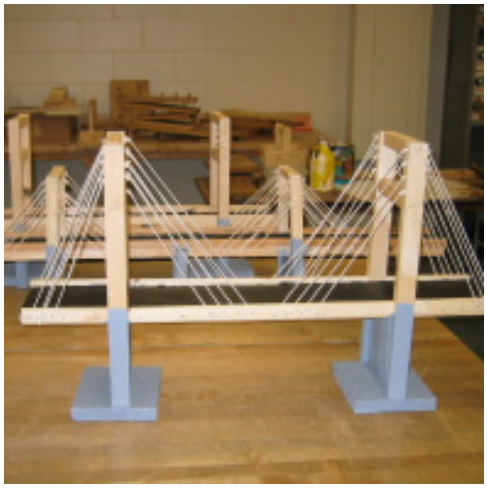
Next, through sketching and diagramming, the teams **generate ideas** for their structures and **choose the best solution**. After skill-building activities on scale, materials and building techniques, the students **describe their solution through a prototype**, i.e. they design and build their structural scale models. Mini-evaluations and group design meetings during the sketching and model-building phases give the students chances to **redesign their solutions as needed**.

The students **evaluate the success of their designs** by testing their structural integrity. In writing, they consider: "Does my design solution solve my design problem? How well does it solve my problem? Could the design be modified or improved?"

Finally, through graphic design boards, media presentations and/or oral presentations the teams **present their final projects**.

Structures programs stand up well on their own, yet easily connect with units that teach design through mathematics, or history through architecture. It is no wonder that teachers like them.

It is no wonder that students like them, too. As one teacher said, "We greatly enjoyed the human structure activity. The next time they sees a cathedral, I can imagine my students saying, "Hey, I was a part of a flying buttress!" Experiencing architecture took on new meaning because we were physically involved in the process."



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Science and Technology/Engineering Standards

Gr 3-5

Materials & Tools

1.1 Identify materials used to accomplish a design task based on a specific property, i.e., weight, strength, hardness, and flexibility.

1.2 Identify and explain the appropriate materials and tools (e.g., hammer, screwdriver, pliers, tape measure, screws, nails, and other mechanical fasteners) to construct a given prototype safely.

Engineering Design

2.1 Identify a problem that reflects the need for shelter, storage or convenience.

2.2 Describe ways a problem can be represented (sketches, diagrams, graphic organizers, lists).

2.3 Identify relevant design features (size, shape, weight) for a prototype of a solution to a given problem.

2.4 Compare natural systems with mechanical systems that are designed to serve similar purposes, e.g., a bird's wings as compared to an airplane's wings.

Gr 6-8

Engineering Design

2.1 Identify and explain the steps of the engineering design process, i.e., identify the need or problem, research the problem, develop possible solutions, select the best possible solution(s), construct a prototype, test and evaluate, communicate the solution(s), and redesign.

2.2 Demonstrate methods of representing solutions:. sketches, orthographic projections, multiview drawings.

2.5 Explain how such design features as size, shape, weight, function, and cost limitations would affect the construction of a given prototype.

Communication Technologies

3.2 Identify and explain tools, machines…drawing tools, computer-aided design, cameras… used to produce/reproduce design solutions (engineering drawings, prototypes, reports).

Construction Technologies.

5.1 Describe and explain parts of a structure, e.g., foundation, flooring, decking, wall, roofing systems.

5.2 Identify and describe three major types of bridges (e.g., arch, beam, and suspension) and their appropriate uses (e.g., site, span, resources, and load).

5.3 Explain how forces of tension, compression, torsion, bending, shear affect performance of bridges.

5.4 Describe and explain the effects of loads and structural shapes on bridges.

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Mathematics Standards

4.G.1 Compare and analyze attributes and features of two- and three-dimensional geometric shapes.
4.G.2 Describe, model, draw, compare, and classify 2d and 3d shapes.
4.G.4 Identify angles as acute, right, or obtuse.
4.G.5 Describe and draw intersecting, parallel, and perpendicular lines.
4.G.8 Identify and describe line symmetry in two-dimensional shapes.

4.M.1 Demonstrate an understanding of length, area, weight, and volume…
4.M.2 Carry out simple unit conversions within a system of measurement…, e.g. feet to inches.
4.M.3 Estimate and find area and perimeter of a rectangle, triangle, or irregular shape using diagrams, models and grids or by measuring.
4.M.5 Identify and use appropriate metric and English units and tools (ruler, angle ruler….) to estimate, measure, solve problems involving length, area, volume, weight and … angle size.

6.G.1 Identify polygons based:… types of angles, perpendicular or parallel sides, congruence of sides.
6.G.2 Identify 3-d shapes(cubes, prisms, spheres, cones, pyramids) based on properties.
6.G.3 Identify relationships among points, lines, and planes [intersecting, parallel, perpendicular].
6.G.7 Identify types of symmetry, including line and rotational.
6.G.9 Match 3-d objects and their 2-d representations [nets, projections, and perspectives.

6.M.1 Apply the concepts and formulas of perimeter and area to the solution of problems.
6.M.2 Identify, measure, describe, classify, and construct various angles, triangles, quadrilaterals.
6.M.3 Solve problems involving proportional relationships and units of measurement, e.g., scale models…

8.G.7 Identify 2d figures by their physical appearance…attributes, and spatial relationships.
8.G.8 Recognize and draw 2d representations of 3d objects:, nets, projections, and perspective drawings.

8.M.1 Select, convert (within a system of measurement);use appropriate units of measurement or scale.
8.M.4 Apply formulas and procedures for determining measures: area, perimeter, circumference…
8.M.5 Use ratio and proportion (including scale factors) in the solution of problems…

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History/Social Sciences Standards

3.3 Observe and describe local or regional historic artifacts and sites and generate questions about their function, construction, and significance.

3.12 Explain how objects or artifacts of everyday life in the past tell us how ordinary people lived and how everyday life has changed.

Gr 6: Human interaction with the environment encompasses the many ways in which people have adapted to their surroundings or altered them for economic reasons.

7.6 Identify the characteristics of civilizations…. (including) developed systems of …..architecture.

7.10 – 7.43 selected standards:
Describe important achievements of civilizations; describe the contribution of civilizations to architecture, engineering and technology.

Visual Arts Standards

STANDARD 1 Methods, Materials, and Techniques: demonstrate knowledge of the methods, materials, and techniques unique to the visual arts.

STANDARD 2 Elements and Principles of Design: demonstrate knowledge of elements and principles of design.

STANDARD 4 Drafting, Revising, and Exhibiting: demonstrate knowledge of the processes of creating and exhibiting artwork: drafts, critique, self-assessment, refinement, and exhibit preparation.

STANDARD 9 Inventions, Technologies, and the Arts: describe and analyze how artists use and have used materials, inventions, and technologies.

STANDARD 10 Interdisciplinary Connections: apply knowledge of the arts to the study of English language arts, foreign languages, health, history/social science, mathematics, science and technology/engineering

Language Arts Standards

Standard 1: Discussion
Standard 2: Questioning, Listening, and Contributing.
Standard 3: Oral Presentation
Standard 4: Vocabulary and Concept Development

Standard 19: Writing
Standard 20: Considering Audience and Purpose
Standard 21: Revising
Standard 22: Standard English Conventions
Standard 23: Organizing Ideas in Writing
Standard 24: Research
Standard 25: Evaluating Writing and Presentations