Architecture, Engineering and Construction: Applied Concepts for Eighth Grade Science

Standards aligned to the following:

Illinois Learning Standards

State Goal 11: Understand the processes of scientific inquiry and technological design to investigate questions, conduct experiments and solve problems.

A. Know and apply the concepts, principles and processes of scientific inquiry.

B. Know and apply the concepts, principles and processes of technological design.

State Goal 12: Understand the fundamental concepts, principles and interconnections of life, physical and earth/space sciences.

C. Know and apply concepts that describe properties of matter and energy and the interactions between them.

D. Know and apply concepts that describe force and motion and the principles that explain them.

State Goal 13: Understand the relationships among science, technology and society in historical and contemporary contexts.

A. Know and apply the accepted practices of science.

B. Know and apply concepts that describe the interaction between science, technology and society.

National Science Standards

CONTENT STANDARD A:
As a result of activities in grades 5-8, all students should develop

- Abilities necessary to do scientific inquiry
- Understandings about scientific inquiry

CONTENT STANDARD B:
As a result of their activities in grades 5-8, all students should develop an understanding of

- Properties and changes of properties in matter
- Motions and forces
- Transfer of energy

CONTENT STANDARD E:
As a result of activities in grades 5-8, all students should develop

- Abilities of technological design
- Understandings about science and technology

CONTENT STANDARD G:
As a result of activities in grades 5-8, all students should develop understanding of

- Science as a human endeavor
- Nature of science
- History of science

National Educational Technology Standards for Students (NETS) - Prior to completion of Grade 8, students will:

Numbers in parentheses following each performance indicator refer to the standards category to which the performance is linked. The categories are:

1.Apply strategies for identifying and solving routine hardware and software problems that occur during everyday use. (1)

1. Basic operations and concepts

2. Demonstrate knowledge of current changes in information technologies and the effect those changes have on the workplace and society. (2)

2. Social, ethical, and human issues

3. Exhibit legal and ethical behaviors when using information and technology, and discuss consequences of misuse. (2)

3. Technology productivity tools

4. Use content-specific tools, software, and simulations (e.g., environmental probes, graphing calculators, exploratory environments, Web tools) to support learning and research. (3, 5)

4. Technology communications tools

5. Apply productivity/multimedia tools and peripherals to support personal productivity, group collaboration, and learning throughout the curriculum. (3, 6)

5. Technology research tools

6. Design, develop, publish, and present products (e.g., Web pages, videotapes) using technology resources that demonstrate and communicate curriculum concepts to audiences inside and outside the classroom. (4, 5, 6)

6. Technology problem-solving and decision-making tools

7. Collaborate with peers, experts, and others using telecommunications and collaborative tools to investigate curriculum-related problems, issues, and information, and to develop solutions or products for audiences inside and outside the classroom. (4, 5)

8. Select and use appropriate tools and technology resources to accomplish a variety of tasks and solve problems. (5, 6)

9. Demonstrate an understanding of concepts underlying hardware, software, and connectivity, and of practical applications to learning and problem solving. (1, 6)

10. Research and evaluate the accuracy, relevance, appropriateness, comprehensiveness, and bias of electronic information sources concerning real-world problems. (2, 5, 6)

Additional Resources:

1) DESIGN IT! Engineering in After School Programs - organization dedicated to providing after school experiences at the primary grades encouraging the learning of engineering related concepts in children. **Center for Science Education Designit - www.cse.edc.org**.

2) American Society for Engineering Education - **www.engineeringk12.org**

3) American Society of Civil Engineers - **www.asce.org**

4) Great Buildings OnLine - **www.greatbuildings.com**

5) Webquest: Designing a Home - **www.webquest.org**

6) Customizable Rubric Web Site - **www.rubistar.4teachers.org**

7) National Engineers Week: Future City Competition - **www.futurecity.org**

8) American Science and Surplus: Good source for science supplies and materials - **www.sciplus.com**

9) CIESE: Center for Innovation for Science and Engineering Education - **www.k12science.org**

10) Building Big Educator's Guide: **www.pbs.org/wgbh/buildingbig/educator/index.html**

11) BEST (Building Engineer and Science Talent) launched in September 2001 as a public-private partnership to follow through on the September 2000 recommendations of the Congressional Commission on the Advancement of Women and Minorities in Science, Engineering and Technology Development: **www.bestworkforce.org**

12) Architecture, Engineering and Construction - AEC Info: **www.aecinfo.com**

13) US Army Corps of Engineers: **www.usace.army.mil**

14) FSEA - Future Scientists and Engineers of America: **www.fsea.org**

15) Society of Women Engineers: **www.swe.org**

16) ENC Online is a K-12 math and science teacher center: **www.enc.org**

17) National Science Teachers Association: **www.nsta.org**

18) 42Explore - Thematic Pathfinders for All Ages/Applied Arts: Architecture, Building and Construction, etc: **www: 42explore.com**

19) American Council for Construction Education: **www: acce-hq.org**

20) Girls Raising Interest in Science and Engineering: **www.miamisci.org/girlsrise/index.html**

21) PreK-12 Engineering: **www: prek-12engineering.org**

22) The Center for Engineering Educational Outreach: **www:ceeo.tufts.edu**

23) International Technology Education Association: **www.iteawww.org**

24) Technology for All Americans: **www.iteawww.org/TAA/TAA.html**

25) Research for Better Schools/Mathematics and Science: **www.rbs.org/mathsci/index.shtml**

26) ENC Online - A K-12 math and science teacher center: **www.enc.org**

27) Yale-New Haven Teachers Institute: **www.yale.edu/ynhti/**

28) National Science Teachers Association: **www.nsta.org**

29) Building a House Lesson Plan: **www.contractor.edu/buildhouselp/buildhouselp.html**

30) Massachusetts Department of Education - Science and Technology/Engineering Curriculum Framework: **www.doe.mass.edu/frameworks/scitech/2001/standards/te6_81.html**

31) Benchmarks On-Line: **www.project2061.org/tools/benchol/bolintro.htm**

32) Architectural Education Resource Center: **www. okra.ncounty.net**

33) Science and Technology Concepts for Middle Schools: **www.stcms.si.edu/stcms.htm**

34) On-Line Ethics Center for Engineering and Science at Case Western Reserve University: **www.onlineethics.org**

35) Engineer Girl!: **www.engineergirl.org**

36) Math Counts, Science Matters, Technology Innovates!: **www. melroseschools.com/mms/tech_ed/**

37) Salvadori Center - Education and the Built Environment: **www: salvadori.org**

38) Project Lead the Way - Forging New Generations of Engineers: **www.pltw.org/aindex.htm**

39) Assessment in K-12 Science Curricula: **www.cse.edc.org/products/assessment/default.asp**

Ethics in Architecture, Engineering and Construction:

American Institute of Architecture (www.aia.org)

Code of Ethics and Professional Conduct:

Canon I - General Obligations
Canon II - Obligations to the Public
Canon III - Obligations to the Client
Canon IV - Obligations to the Profession
Canon V - Obligations to Colleagues

National Society of Professional Engineers (www.nspe.org)

Code of Ethics for Engineers:

Fundamental Canons

Engineers, in the fulfillment of their professional duties, shall:

1. Hold paramount the safety, health and welfare of the public.
2. Perform services only in the areas of their competence.
3. Issue public statements only in an objective and truthful manner.
4. Act for each employer or client as faithful agents or trustees.
5. Avoid deceptive acts.
6. Conduct themselves honorably, responsibly, ethically, and lawfully so as to enhance the honor, reputation and usefulness of the profession.

Construction Management Association of America (www.cmaanet.org)

Code of Professional Ethics:

1. Client Service
2. Representation of Qualifications
3. Standards of Practice
4. Fair Competition
5. Conflicts of Interest
6. Fair Compensation
7. Release of Information
8. Public Welfare
9. Professional Development
10. Integrity of the Profession

Math and Science Extension Activities

Materials:

1. Explain how your choice of materials, combined with your structural design, were successful in absorbing the impact of the telephone directory and protecting Mr. Marshmallow.

2. Explain how your group readily accepted some materials as useful and others as impractical for constructing Mr. Marshmallow's house.

3. Describe the properties of all the component materials in the kit provided. Discuss these properties in terms of weight, strength, hardness and flexibility.

4. Describe the importance of the construction phase of your experiment. Why is *how* Mr. Marshmallow's house was built as important as the materials used?

Forces:

1. Explain how your structure reacted to compressive and tensile forces. In what manner did this occur? Provide two examples from 'real life' of how these forces act on structures.

2. How does the mass of the telephone directory compare with that of the house you built. Explain how this was an important issue to your design and construction.

3. Explain how the shape of your design was a factor in successfully protecting Mr. Marshmallow.

Math Concepts:

1. Calculate the velocity of the telephone directory as it hit Mr. Marshmallow's house from the varying heights: 30, 40 and 50 cms. (V=D/T)

2. Describe the change in velocity at each height. How much does it change?

3. Find the perimeter of Mr. Marshmallow's house (Perimeter is equal to the sum of the sides).

4. Calculate the volume of Mr. Marshmallow's house (Volume = Side x Side x Side). If his house is a shape other then a square or rectangle you will have to use a different formula.

5. Compare the Mass of Mr Marshmallow with the telephone directory. Express this comparison as a ratio.

6. Calculate the density of your house, Mr. Marshmallow and the telephone directory. How do they compare? (D=M/V)

7. Explain how proportion, ratio and symmetry are key elements in understanding a structure.

Engineering Design Concepts:

Explain how your group addressed the steps of the engineering design process: identifying the need or problem, researching the problem, developing possible solutions, selecting the best possbile solution, constructing a prototype, testing and evaluating, communicating the solution(s) and redesign.

Architecture, Engineering and Construction - Activity Goals:

I. Students will work in groups to design, build and test a prototype of a house with given materials.

II Students will test their design simulating the catastrophic force of a meteorite colliding with the house.

III Students will examine their prototype for its ability to protect its inhabitant and make modifications where necessary through succeeding trials.

Objectives:

a) To have students engage in an Inquiry-Based Activity aligned to national and local science standards for this grade level.

b) To have students demonstrate learned science and math concepts as applied to this activity.

c) To have students design, build and test a prototype through several trials.

d) To have students safely and appropriately utilize tools and materials to complete this project.

e) To have students utilize technology to demonstate the design process and to produce a report that will be shared with the class.

f) To have students communicate the results of their experiment to the rest of the class.

Major Topics:

- Architecture (Planning and Design)
- Engineering (Problem Solving/Application)
- Construction (Building)

Activity 1: Building a Model to Scale

(This is a useful activity for reinforcing the concepts of Ratio and Proportion to students).

Concept: The scale for most model cars is 1/24. This simply means that 1" on the model is equivalent to 24" on the actual vehicle. In this case the units of neasure are standardized - in model building 1/12, 1/24, 1/32, 1/35, 1/350, 1/700 are all known units of scale in inches. You can adapt this excercise with any scale in mind as long as the units of measure are known, i.e., 1 cm = 1 ft or 1 cm/1 ft. In engineering, scale is used to describe proportion. Proportion is how the size of one thing compares to another.

Example: The Sears Tower is 1450' tall at 110 stories.

1. How many inches/feet would it be if 1/4" =1'? (4350"/362.5'}

What would the height of the model be in inches/feet if the scale were 1/2" = 1'? (8700"/725')

2. How many inches/feet tall would the model be if 1" = 1'? (1450"/121')

What scale would this be?

Our Task:

1.Measure the length and width of the room.

2. Your group will have to decide upon a scale, and draw a depiction of this room to that scale.

Sample scales might be:

1/10
1/24
1/32
1/35

Of course, this is assuming we are using modeler's scales. If your group uses measures of units other than inches to inches, make that clear in depicting your scale.

3. Using a piece of graphing paper draw a floor plan of this room, furniture included, to scale.

Question: If you a creating a floor plan to scale, what does this mean about the furniture that you illustrating in your drawing?

Activity 2 - Build a Free Standing Tower:

This is a good activity to reinforce the concepts of forces and their influences on structures.

It also encourages students to apply the concepts of Geometry of Shapes in their designs.

1. Go through the instructions as a group, discussing questions as you preview each step.

2. Select nine pieces of construction paper.

3. Decide on a design for constructing a free standing tower.

You may use any materials to secure the walls and roof, but the base of the structure may not be secured. Glue sticks, Elmer's Glue, staples, paper clips or other paper fastening devices are acceptable, but the only other material allowed are the sheets of construction paper. It may have no other external structures to support it.

You have two goals:

- Make it as tall as you can.

- Support as much weight as it can.

This can be a timed activity if the instuctor wishes. The idea being that at the end of the prescribed time the groups would all be told to add the *same* weighted materials acting as external stressors to the group's tower.

Example: *The first thing we will rest on your tower is your science journal. Do this now. The next weight we will add are your assignment agendas. Do this now. If your tower is still standing, next add your science textbook...* etc. (As long as everyone is adding the same material at the same time, it is understand that the same increments of weight are being added to the structures.

The instructor may also adapt this to have only one criteria as the one students are working toward: height or strength.

Architecture, Engineering and Construction:

Assessment would be done by:

1. Unit Pretest
2. Group Interaction - Rubric
3. Design and Model Building - Rubric
4. Observation Record and Results - Lab Sheet
5. Lab Report - Report Format
6. Class Presentation - Rubric
7. Unit Post Test/Objective Assessment

Data Record Sheet for Meteorite Impact and Damage Scale

Trial 1 Meteorite Imapct Height = 30 cm Results :

Mr. Marshmallow Survives: Circle One - YES NO

Trial 2 Meteorite Imapct Heigh = 40 cm Results :

Mr. Marshmallow Survives: Circle One - YES NO

Trial 3 Meteorite Imapct Heigh = 50 cm Results :

Mr. Marshmallow Survives: Circle One - YES NO

Damage Scale Identified by the following numbers:

1 - House Sustained Impact with Minimal Damage

2 - House Sustained Imapct with Moderate Damage/Repairable

3 - House Damage Extensive/Repairs Needed Extensive

4 - House A Total Loss. Back to Drawing Board.

Data Record Sheet for Meteorite Impact and Damage Scale

Trial 1 Meteorite Imapct Height = 30 cm Results : _____

Mr. Marshmallow Survives: Circle One - YES NO _____

_____

Trial 2 Meteorite Imapct Heigh = 40 cm Results : _____

Mr. Marshmallow Survives: Circle One - YES NO _____

_____

Trial 3 Meteorite Imapct Heigh = 50 cm Results _____

Mr. Marshmallow Survives: Circle One - YES NO _____

_____

Damage Scale Identified by the following numbers:

1 - House Sustained Impact with Minimal Damage

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