PLTW Science Frameworks

PLTW Course: Civil Engineering and Architecture (CEA)

Science Strand being addressed: The Nature of Science and Engineering
Science Sub-strand being addressed: The Practice of Engineering

Science Standard being addressed: 9.1.2.2

Overview:

Science Standard and Benchmarks: 9.1.2.2.1, 9.1.2.2.2

Standard 9.1.2.2: Engineering design is an analytical and creative process of devising a solution to meet a need or solve a specific problem.

Benchmark 9.1.2.2.1: Identify a problem and the associated constraints on possible design solutions.

For example: Constraints can include time, money, scientific knowledge and available technology.

Benchmark 9.1.2.2.2: Develop possible solutions to an engineering problem and evaluate them using conceptual, physical and mathematical models to determine the extent to which the solutions meet the design specifications. *For example:* Develop a prototype to test the quality, efficiency and productivity of a product.
(Minnesota Department of Education, 2010)

Correlation to AAAS Atlas:

3B/H1, 3B/H4, 3B/H6, 11A/H2, 11B/H2*, 11B/H3*

3. The Nature of Technology
B. Design and Systems

- In designing a device or process, thought should be given to how it will be manufactured, operated, maintained, replaced, and disposed of and who will sell, operate, and take care of it. The costs associated with these functions may introduce yet more constraints on the design. 3B/H1
- Risk analysis is used to minimize the likelihood of unwanted side effects of a new technology. The public perception of risk may depend, however, on psychological factors as well as scientific ones. 3B/H4
- To reduce the chance of system failure, performance testing is often conducted using small-scale models, computer simulations, analogous systems, or just the parts of the system thought to be least reliable. 3B/H6

11. Common Themes
A. Systems

- Understanding how things work and designing solutions to problems of almost any kind can be facilitated by systems analysis. In defining a system, it is important to specify its boundaries and subsystems, indicate its relation to other systems, and identify what its' input and output are expected to be. 11A/H2

B. Models

- Computers have greatly improved the power and use of mathematical models by performing computations that are very long, very complicated, or repetitive. Therefore, computers can reveal the consequences of applying complex rules or of changing the rules. The graphic capabilities of computers make them useful in the design and simulated testing of devices and structures and in the simulation of complicated processes. 11B/H2*
- The usefulness of a model can be tested by comparing its predictions to actual observations in the real world. But a close match does not necessarily mean that other models would not work equally well or better. 11B/H3*

(American Association for the Advancement of Science, 2009)

References:

American Association for the Advancement of Science. (2009). *Benchmarks Online.* Retrieved July 1, 2011, from AAAS-Project 2061: http://www.project2061.org/publications/bsl/online/index.php

Minnesota Department of Education. (2010, May 24). *Academic Excellence: Academic Standards: Science.* Retrieved July 1, 2011, from Minnesota Department of Education: http://education.state.mn.us/mdeprod/groups/Standards/documents/Publication/013906.pdf

Essential Understandings/Big Ideas:

* In Civil Engineering and Architecture, students are required to design an affordable housing project through an analytic and creative process.
- The design must meet Habitat for Humanity guidelines, follow residential design codes, meet handicap accessible codes, and incorporate "green" features.
- Using the design process, students will create a model in Autodesk Revit and produce print outs of such designs.
- Students must calculate the required water supply, wastewater, and run-off produced from the design.

The students are given a second design project called the Keystone Library Renovation Project. It, too, has many constraints that students must adhere to. They must produce the same type of work, just at a bigger scale and on a commercial project. An addition to this project is a more in depth discovery in loads and their effect on the structure of the library. Students must create a "green" roof. In doing so, the new roof will change the loads on the trusses, beams, column, and footings. The students must demonstrate the changes made in their design.

What should students know and be able to do [at a mastery level] related to these benchmarks?

Students will be able:

- Utilize the design process.

- Identify constraints.
- Brainstorm possible solutions.
- Create a model using software called Autodesk Revit.
- Solve specific mathematical problems that arise during the design process.
- Create solutions to a real-world problem.

Misconceptions:

Student Misconceptions

- Water supply and wastewater is dictated by the city and no other additional requirements need to be considered.
- Water run-off only pertains to the owner's property; once it is off your property you do not have to worry about it.
- If you leave or forget a constraint, it will not affect the outcome of the project.

Teacher Resources:

Teacher Notes

Students will explore and gain an understanding of:

- Where does this fit in?
- This standard, in its truest form, is completely embedded into Civil Engineering and Architecture.
- There are three major projects where the design process must be used by students.
- The students are exposed to this standard throughout the course.

How is it best to introduce the concept?

1. Follow the curriculum as written for these projects.
2. Read the instructor notes provided in the curriculum.
3. Ensure the students follow the steps laid out in the project sheets.

What students struggle with the most?
Students start to panic when seeing the amount of work required to solve this problem. Most do not know where to begin. The best thing teachers can do is facilitate and guide the students. Teachers can break down the steps one at a time. Assigning due dates for each step helps students manage their work.

New Vocabulary

Load: Forces or other actions that result from the weight of building materials, occupants and their possessions, and environmental effects. These are the vector forces that are applied to structures. They are used to calculate the required strength of the structure.

Vignette:

Since this standard is embedded throughout this course, this vignette will be a small picture of introducing one of the design projects, the Affordable Housing.

Students begin this project by defining what is meant by an affordable house. A Habitat for Humanity house is one such house. Using the guidelines for Habitat for Humanity, they begin to sketch some possibilities. Their designs must include those guidelines, must include green features, and be universal in nature.

After the students have been sketching for a while, the instructor covers the concepts of green and sustainable architecture, universal design, and building codes. Along with those, the instructor introduces the Leadership in Energy and Environmental Design (LEED) organization. This is an organization that provides guidelines on improving efficiency of building design and their impact on the environment. LEED has become a major stakeholder in the design of public buildings or structures.

The students finalize their design by conducting a client survey. Once completed, the student creates their design using Autodesk Revit. They are to calculate their required water supply, wastewater, and run-off of storm water. The completion of the project is when the students present their plans with all appropriate documentation. Their plans must meet all constraints.

Additional Instructional Resources

Engineering Design: An Introduction Karsnitz, Hutchinson, O'Brien ©2008ISBN-13: 978-1-4180-6241-5 Delmar, Cengage Learning PO Box 6904, Florence, Kentucky 41022t: 800-354-9706f: 800-487-8488. This book will provide information on the twelve- step design process.

Civil Engineering & Architecture, Matteson, Kennedy, Baur, ©2012ISBN-13: 978-1-4354-4164-4 Delmar, Cengage Learning PO Box 6904, Florence, Kentucky 41022t: 800-354-9706f: 800-487-8488.

Civil Engineering& Architecture Matteson, Kennedy, Baur, ©2012WorkbookISBN-13: 978-1-4354-4165-1, Instructor Resources, ISBN-13: 978-1-4354-4166-8Architectural Graphic Standards, 11th Ed.

The American Institute of Architects, ISBN-13:978-0-471-70091-3 Delmar, Cengage Learning PO Box 6904, Florence, Kentucky 41022t: 800-354-9706f: 800-487-8488.

Revit – 2011 tutorial books – go to www.leadinghighschools.com to receive a complimentary examination copy

Architectural Drafting and Design – ISBN-13 978-1-4018-6715-7 Alan Jefferis and David Madsen, Thomson, Delmar Learning, Jeanne.Blair@cengage.com, district rep and can provide information for you about the textbooks and can give you examination copies. Here is the website to get the examination copy: http://cengagesites.com/academic/?site=3243

Revit Architecture – ISBN-13: 978-1-4390-5715-5 Author Paul Aubin, cengage.com.

Francis D. K. Ching several books on architecture John Wiley & Sons, Inc. publisher

Architecture: Form, Space and Order, ISBN 978-0-471-75216-5.
Architectural Graphics, ISBN 0471209066.
Building Construction Illustrated, ISBN 0-471-35898-3.

Websites:
http://www.nasa.gov/audience/foreducators/plantgrowth/reference/Eng_Design_5-12.html
http://www.mos.org/EIE/engineering_design.php
http://www.teachengineering.org/engrdesignprocess.php
http://www.theworks.org/fb/teachers/engineering_design_process.html
http://www.youtube.com/watch?v=6PJTlzY0Aak
http://www.teachersdomain.org/resource/phy03.sci.engin.design.desprocess/
http://www.engineeringpathway.com/ep/k12/k12_design_process.jhtml
http://www.designadvisor.org/
http://wall.aa.uic.edu:62730/ahc/catalog/home.html
http://www.smartcommunities.ncat.org/buildings/affhousing.shtml
http://www.affordablehousingdesign.com/
http://www.access-board.gov/ada-aba/final.cfm#site
http://www.access-board.gov/ufas/ufas-html/ufas.htm
http://www.design.ncsu.edu/cud/pubs_p/docs/AffordableUHomes.pdf
http://www.design.ncsu.edu/cud/pubs_p/docs/UDinHousing.pdf
http://www.design.ncsu.edu/cud/pubs_p/docs/UD%20Demo%20home.pdf
http://www.design.ncsu.edu/cud/pubs_p/docs/qap_tech_screen.pdf
http://www.yourhome.gov.au/technical/fs43.html
http://www.myhome.ie/residential/advice-centre/1021-1133-2546/maximise-energy-efficiency-when-building-a-home.asp
http://www.consumerenergycenter.org/home/construction/solardesign/orientation.html
http://extension.missouri.edu/edninfo/sustain.htm
http://www.nrdc.org/cities/building/fhousing.asp
http://www.habitat.org/how/naexamples.aspx
http://www.usgbc.org/
http://www.nrdc.org/buildinggreen/leed.asp
http://www.leed.net/

Civil Engineering and Architecture activities and/or projects incorporating the standards:

Project 2.3.1 Affordable Housing Design – Students will design an affordable house for Habitat for Humanity. Their design must follow Habitat for Humanity guidelines, incorporate green and sustainable features, and be universal in design. Students must deliver all documentation in a report format. The documents include: renderings, project description, construction drawings, supporting documents, and calculations.

Project 3.1.1 Keystone Library Renovation – This project is a step up from the affordable house project. Students must perform the same design process but with different constraints. Students are faced with many more constraints due to the size of the structure. This project is a commercial project rather than a residential project. There are many additional activities that support the process and guide the students to the final design. The Keystone project involves adding a green roof design. This forces the students to modify the structural members within the building. Consequently, students need to perform beam analysis and foundation calculations. Their analysis must be reflected within their design.

Project 4.1.1 Commercial Building Design Problem – This is the final project for the course. Students will design a commercial building to fit a specific lot. This allows the students to create something of their own design. The students still must follow constraints given in the design statement. But, they are free to design what fits on the property. The final task for students is to sell their idea to a board/panel that represents the owners. Students must produce all the appropriate documentation and a model of their design.

Assessment:

Assessment Methods

Methods to incorporate explanation, application and perspectives:

1. A set of plans from which a structure will be built that includes floor plans, elevations and building sections to graphically convey the design solution is known as_____.

   A. presentation drawings C. isometric drawings
   B. working drawings D. thumbnail sketches

2. Which of the following is a local, regional or national set of conditions and rules defining and regulating minimum conditions for the construction of buildings in order to insure that structures are safe?

   A. building codes C. ordinances
   B. zoning codes D. building permits

3. This 1990 act makes it illegal to discriminate against disabled individuals in the areas of employment, public and private transportation, and access to public and commercial buildings.

   A. DOT C. FIMA
   B. ADA D. AIA

4. What document is created at the beginning of a project and reviewed throughout every stage of the project that states the initial problem and identifies the needs necessary to solve the problem?

   A. peer review C. critique
   B. design brief D. introduction

5. Which of the following would not be included in a final presentation?

   A. projected cost C. scale model
   B. rendering D. building material suppliers

6. A local town would like you to evaluate a small commercial building near the central business district. The building is an older two-story structure that was used for a mini- mall with several stores and restaurants. The present owner has put the

structure up for sale. The town is considering converting it into to a small community center.

List 5 items that you would like to discuss regarding handicap accessibility and green architectural issues, should the town decide to purchase and renovate the building.

*(**5 points total:** 1 point each)*

a) _____
b) _____
c) _____
d) _____
e) _____

Possible Answers:
Handicapped accessibility issues:
- Door widths
- Hallways width
- Elevator to 2nd Floor
- Ramp access from street level to 1st floor
- Bathrooms

Green Architecture issues:
- Reduce energy usage
- Green roofs/rain gardens
- Interior Green Building Materials – like bamboo flooring,
- Solar Energy
- Greywater

Differentiation:

Gifted and Talented

The two projects are open to a variety of possible solutions. This allows for those gifted or talented to expand in their design. They are only limited to the constraints of the problem. It is their solution that brings out the complexity level of their project.

Special Education

All students typically will work in groups of two or three. This should help as the assignment load is divided out amongst all the members. Each special education student should be paired with another student that has or shows ability to master the design concepts. Most work is hands on with the computer and other tools. This typically aids in their understanding. Timely scheduled due dates on each major step are an important factor to keep them moving forward. When the concepts of mathematics arise, additional practice maybe required to aid in their understanding. Coordination with the individual's case manager would be extremely helpful for any modifications to assignments and assessments. Formative assessments should be used for planning and determining the needs of the students.

English Language Learners

Building structures is a global occupation. ELL students will be able to design some of the most creative solutions. To help them, post lessons, lectures, activities, and vocabulary with definitions on a class website or an online instructional tool such as Moodle. This will allow ELL students the opportunity to review the vocabulary at their convenience. The best resource will be your district's ELL instructor. They will be able to translations documents, give advice, or assist the ELL students in your classroom.

Parents and Administration:

Administrative/Peer Classroom Observation

Students Are:	**Teachers Are:**
Researching and brainstorming some solutions.	Observing and assisting in their research.
Identifying and applying the constraints to their design solutions.	Giving explanations on Habitat for Humanity and Green design.
Creating a model of the house using the program Revit.	Assist students using Revit.
Calculating the requirements of water supply, wastewater, and runoff.	Demonstrate how to calculate water supply, wastewater, and runoff.
Producing the final documentation for credit.	Assisting the students in printing the final product.

Professional Learning Communities:
Reflection: PLTW instructors should have a continual discussion on the design process and what makes a good design.

Materials: PLTW instructors should use the resources found above as well as student work within their discussion.

Parent Resources:

Refer parents to the suggested lists and searches found in Additional Instructional Resources.

It would be very helpful to create a website in which the instructor can communicate with parents on assignments, topics, and additional support.

References:

American Association for the Advancement of Science. (2009). *Benchmarks Online.* Retrieved July 1, 2011, from AAAS-Project 2061: http://www.project2061.org/publications/bsl/online/index.php.

Minnesota Department of Education. (2010, May 24). *Academic Excellence: Academic Standards: Science.* Retrieved July 1, 2011, from Minnesota Department of Education: http://education.state.mn.us/mdeprod/groups/Standards/documents/Publication/013906.pdf.