Civil Engineering and Architecture™ Course
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Introduction

This document is intended to be a complete teaching curriculum, not just a guide, or an outline. The curriculum is composed of units, which contain lessons and activities. The teacher guidelines and resource materials are integrated, via links, into the curriculum to make it easier for teachers to have access to the teaching tools needed to implement the course.

Each Unit begins with a Purpose, a listing of Concepts, Essential Questions, and Lessons for the Unit with a recommendation for Unit Evaluations. The Concepts are the broad learning objectives for the unit. The intent of the Essential Questions, in combination with the Purpose of each lesson that is an anticipatory set, is to create a framework for teachers and students to focus student learning. Course specific projects can be developed by the students to solve problems posed by the questions. The Concepts and Essential Questions along with the anticipatory set should be communicated to the students at the beginning of every Unit to establish the focus of the unit's learning objectives.

Each Unit is composed of lessons. Included in the Lessons are the Concepts specific to each Lesson; a listing of technology, science, mathematics, and English language arts national standards; Performance Objectives aligned with the national standards; Assessment suggestions; Essential questions aligned with the Concepts; Key Terms; a Day-by-Day Lesson plan; and a listing of instructional resources to aid instruction. Each of these components is clearly discussed and described in the **Lesson Template** and **Activities Template** in the **Teacher Guidelines** section. Each Lesson is to begin with the instructor presenting the Lesson's Purpose and Essential Questions to the students for them to think about and to develop solutions to, by the end of the Lesson. These questions are repeated for students at the end of an activity that is designed to help students help them focus their thoughts, learn skills, and apply those skills to solve problems, a key tenet of project-based learning.

This curriculum is designed to be taught to high school students within a "typical" high school schedule. This means that a class which meets each day for 40 minutes, 175 days a year should be able to cover the content of this course. Some minor adjustments will need to be made by those schools that teach under a "double block" system. For the most part, this will simply entail combining two "days" worth of activities into one.

Unit 1 – Overview of Civil Engineering and Architecture™

Preface

This unit is an introduction to civil engineering and architecture and will emphasize the following – history, the influence and impact of engineering and architecture, the relationship of civil engineering and architecture, and the responsibilities of both fields, including ethics and values. Students will be introduced to the stakeholders and role players involved. Students will be asked to consider questions, such as what effect did the pyramids or aqueducts have on the development of civil engineering or architecture? They will do research about civil engineering and architecture and reflect on their findings.

Concepts

1. The fields of civil engineering and architecture have influenced the evolution of how people live and work.
2. Making responsible decisions is important in the actions of engineers and architects, as choices will affect the lives and well-being of others.

Essential Questions

1. Are civil engineering and architecture the same? From the viewpoint of the civil engineer, what is civil engineering? From the viewpoint of an architect, what is architecture?
2. When a structure, such as the aqueducts, was built, what was known about civil engineering? How has it evolved since then? From the time of the pyramids, architecture has taken many forms or styles. How are modern structures influenced by past designs?
3. How do the major individuals and agencies involved in the design and development of a civil engineering or architectural project affect the outcome of the project?
4. How do I know what career opportunities in civil engineering or architecture are available to me?

Lessons

- **Lesson 1.1 Overview of Civil Engineering and Architecture™**

Unit Evaluations

The Essential Questions or the Assessment suggestions provided in each lesson may be used to develop summative assessment tools, such as tests or end of unit projects.

Unit 2 – Introduction to Projects

Preface

In this unit, students will be introduced to a preliminary project to give an overview of what students will be learning and the main project for the course.

Students will be exposed to a small design problem that will lead to learning the basic elements of design and software use. Students will be instructed on setting up project documentation. They will identify and discuss the major components of a project, what it encompasses, and what is meant by design and development. A list of criteria for the proposed project will be provided to ensure concepts are covered in the student experiences.

Concepts

1. Current Civil Engineering and Architectural common practices must be identified and utilized to develop a viable solution to a project.
2. All designs continuously evolve as they are developed.
3. Critiques and reviews are used to inform and provide suggestions for improvement.
4. A high-quality presentation of a project will determine its acceptance and support implementation.
5. Project documentation is necessary to solve complex design problems and provide accurate communication.

Essential Questions

Lesson 2.1 Overview of Project Design

1. As a designer, how did you try to influence your client?
2. How does making sketches when working with a client facilitate the design process?
3. What relationship do the various drawings and renderings have to each other?
4. During the design of a project, in what ways would you use your journal differently if you could charge a client for changes after a floor plan is prepared?
5. What are some of the things you would do differently next time, and how would you change the process to accomplish them?
6. What impact will the property have on the surrounding area if it is developed?
7. How do you know if your design is ready for implementation?
8. How does the use of software and other tools aid in the development of an idea?
9. What design ideas would you incorporate in your vacation house versus your year-round house?

Unit 3 – Project Planning

Preface

Students will be introduced to project planning with team teaching and team work. They will collectively conduct activities on site discovery (e.g., interview realty companies to discover information about the site property, investigate county hall records, and learn about local regulations) and provide the information to the class for use on project planning.

Students will be divided into teams of four during this unit to work together for the rest of the course on the extended design project. During the first three topics of Unit 3, the teacher will select representatives from all teams to form three new study groups to learn the topics of Site Discovery, Regulations, and a Generic Viability Analysis. These teams will report to the class and teach other students in their own teams about their topic.

Concepts

1. A client's needs and desires are all essential components of a project.
2. The selection of a site and the project being planned are inter-related.
3. Planning of a project is essential to its success.

Essential Questions

Lesson 3.1 Site Information – Student Team Teaching

1. How do you know when the design you've chosen for a site is the correct one?
2. As a developer for the site, how does knowing about past owners and the property uses help you develop the site?
3. In what ways does the view of a site, its terrain, the solar aspects, wind, and sound influence site orientation?
4. How does knowing about current neighbors help you in developing a site?
5. What difference does it make if you do or do not abide by the regulations and requirements for developing and building property?
6. What regulatory agencies should you know, and why is it important to work with them in preparing to develop property?
7. Zoning is not a requirement in all localities. How does zoning help or hinder land development?
8. The environment is affected when land is developed. How does an environmental impact study help or hinder a developer in preparing to develop property?
9. What do wetlands, covenants, and prior ownership have to do with site selection?
10. How did doing a traffic analysis around the property help in providing information about the property?
11. As an owner of the property, what issues are a concern to you and may affect the development of the property after you completed a viability analysis?
12. What relationship do the regulations have to the viability analysis?

Lesson 3.2 Development Options, Selection of Project, and Revisiting Viability Analysis

1. As the developer of a piece of property, what factors must you consider for cost effectiveness and success of your development?
2. How are the selection of a site and the project being planned for the site inter-related?
3. What criteria or constraints are imposed on you that can be changed, you would change if you could, and how would this affect you or help you in making a decision about the development of property?
4. As a developer of the property, in what ways did you try to influence your team to select a design option that you favored?
5. How did using the information gathered in Lesson 3.1 Site Information help you in making a project selection?
6. What do we mean by a “Viability Analysis?” What kinds of questions should be included or excluded?
7. What makes a viability analysis helpful in making decisions about a project?
8. In what ways did the viability analysis used for your project cause your team to change your plans or make adjustments?
9. Identify an example of how your team plans to manage resources in an ethical manner.

Lessons

- **Lesson 3.1 Site Information – Student team teaching**
    - Site Discovery
    - Regulations
    - Viability Analysis for Site
- **Lesson 3.2 Development Options, Selection of Project, and Revisiting Viability Analysis**

Unit Evaluation

The Essential Questions or the Assessment suggestions provided in each lesson may be used to develop summative assessment tools, such as tests or end of unit projects.

Unit 4 – Site Planning

Preface

During this unit students will learn the basic concepts of site planning and explore the application of those concepts with related software. All students will be exposed to the seven topics in this unit with small lessons that take them through the software. Students will work in teams and make decisions on what each team member will do to complete the site planning as it pertains to each team’s project. The unit will close with students completing 3D renderings and appropriate

critiques and reviews that will help students refine their solutions. Students will continue to document their work and make appropriate entries for their project documentation.

NOTE: All students will be exposed to the seven topics discussed in this unit during the first two-week period of the course. Techniques in verifying and documenting information will be explored. This will be followed by the students breaking back into their respective teams and applying the information to their chosen projects.

Concepts

1. Responsible designers maximize potential of the property, minimize impact on the environment, and create an attractive visual and functional space.
2. Codes and building requirements define and constrain the location of structures, utilities, and landscape components placed on a site.
3. The use of a site defines the utilities/services needed and how they are delivered.

Essential Questions

Lesson 4.1 Description of Property

1. What information is found in a legal description?
2. How does the legal description impact decisions about the acquisition or development of a property?

Lesson 4.2 Site Plan Requirements

1. How do contours describe the topography of land?
2. What topographic characteristics impact the use of a site?
3. Why is it necessary to construct a bubble diagram of a parking lot area?
4. When developing a bubble diagram, how does it enable you to make decisions regarding the design of your site?
5. How are the needs of a user of a site and the circulation patterns for the site interrelated?

Lesson 4.3 Site Plan Layout

1. How is the location of a structure on a site determined?
2. What effects does topography have on the site design?
3. What information is important when considering the placement of driveways, parking spaces, and utility lines?
4. Who benefits from the local, state, and federal regulations that must be considered in designing a site layout?
5. What are the regulations that govern utility placement, and how does the availability of utilities impact the design of the site?
6. Why is solar orientation of the structure important?

7. What impact did setbacks, codes, and restrictions have on the placement of the site design elements?
8. Why is the attention to aesthetics and building orientation important in site planning and layout?
9. What is the advantage of providing a separate entrance for service?

Lesson 4.4 Public Ingress and Egress

1. In what ways do engineers use design differently to control traffic on an arterial opposed to a feeder street?
2. What are some of the factors you would have to consider if you were asked to design a new parking lot for your local library?
3. How would the design of ingress or egress change if a building were to be used as a day care center instead of a senior center?

Lesson 4.5 Site Grading

1. What steps must be taken to ensure that the improvements made on a property will not adversely affect neighboring properties?
2. When planning site grading, why is it necessary to have the soil tested, and what types of information will be discovered in the process?
3. What is the relationship between the soil testing procedures and the plan for altering and excavating the property?
4. What site information must be identified and examined prior to the development of a grading plan?

Lesson 4.6 Utilities

1. How do you determine how large the utility supply will need to be in order to support the demands of the service?
2. When planning a project how does the availability of public utilities impact the design?
3. What impact does the location of your project have on the layout of the sanitary wastewater disposal?
4. If you are located in an area where wells supply water for drinking and other uses, how is water for fire protection obtained?
5. If you are located in an area where wells supply water for drinking and other uses, how is it tested and monitored for potable water standards?
6. If the water does not pass potable water testing, how would you research and select a treatment system?
7. How does the phasing of electricity impact the types of uses for a property?

Lesson 4.7 Landscaping

1. Why does it matter if a site is landscaped?

2. How can landscaping improve the aesthetic appeal of a site and the structures on the site?
3. What do you need to consider if you are to understand how to manage a site's resources or how the landscaping affects the local environment?

Lesson 4.8 Water Supply and Wastewater Treatment

1. Why is understanding about water pressure and how it is controlled important in designing a structure on property?
2. Why is proper wastewater management critical for the health and welfare of society and the environment

Unit 5 – Architecture

Preface

The study of architecture will provide you with an opportunity to explore the many aspects of design. In the American Heritage Dictionary, *architecture* is defined as "the art and science of designing and erecting buildings." The architect is typically thought of as the artist that designs how the building will look. Vitruvius, a Roman architect said that architecture was "convenience, strength, and beauty." For this to be true today, a structure must be designed to serve a purpose, withstand the natural elements, such as wind, air, and water, as well as a variety of catastrophic episodes, such as earthquakes and hurricanes, and be aesthetically pleasing, all in one design.

The lessons in this unit explore the responsibilities of the architect along with the related skills that are necessary to appropriately design a structure that will function as intended and be acceptable to the client's needs and wants.

Concepts

1. A responsible architectural designer takes into consideration the environment, the aesthetics, the structural integrity, and the safety and needs of occupants.
2. A good designer balances cost consideration with functionality and aesthetics.
3. Graphic communication is essential to successful communication and implementation of a design project.
4. Mathematics and physics are important tools in the design process.
5. Application of the principles and foundations of art will enhance the form and function of a design project.

Essential Questions

Lesson 5.1 Architectural Styles

1. How are lines, color, texture, rhythm, balance, unity, and proportion used in the design of a structure?

2. What architectural styles are typically seen in residential design? Industrial design? Commercial design?
3. What architectural style is most common in your area? What are the common components of that style?
4. What are the neighborhood and environmental influences that determine the style of a structure in your area?

Lesson 5.2 Floor Plans

1. How are the interior and exterior traffic flow patterns related? As a designer, why should you consider them in preparing a floor plan?
2. The Americans with Disabilities Act (ADA) of 1997 provided clear guidelines for universal accessibility. What accessibility issues are important with your project? How did you incorporate them in your floor plan?
3. What factors determine the functionality of a room and its size, proportion and location?
4. In preparing a floor plan, what are the purpose and value of floor plan symbols?

Lesson 5.3 Energy Systems

1. What is R-value and how is it determined?
2. Explain how the structure in your team's project might lose energy through radiation.
3. Where would you find air leakage, and how could it be prevented?
4. What is a vapor retarder? How is it used?
5. Considering the heat loss or gain information you collected about the structure for your team's project, how would you alter your design to maximize the energy resources?
6. What is a BTU and how would you calculate the BTUs needed for your building?

Lesson 5.4 Elevations

1. How is the elevation views used to communicate an important detail of a structure?
2. Why do elevations only show width and height?

Lesson 5.5 Sections and Details

1. What is the difference between a section and a detail drawing? What are their purposes?
2. Why is it important to set the scale of a detail drawing to at least 1 ½"= 1'?

Lesson 5.6 Schedules

1. What information is found on a schedule?
2. What is the main purpose for using schedules?

Lesson 5.7 Mechanical, Electrical, and Protection Systems

1. What are the important considerations when designing a complete plumbing system?
2. What are the important considerations when designing an HVAC system?
3. What is a mechanical system?
4. Why is it important for architects to be aware of how mechanical systems are designed or constructed?
5. What information does an architect have to provide to a mechanical engineer to ensure proper design and placement of the mechanical systems?
6. Why are some electrical plans placed on a floor plan and others on a separate sheet?
7. What types of devices would require multiple utilities and must appear on more than one plan?
8. What is important for an architect to know about electrical plans?
9. How does the design of the structure affect the electrical layout?
10. Why should a designer know about the different types of lighting and their applications?
11. Why are symbols used when constructing electrical plans? Are the symbols the same on all architectural plans?
12. Why is it important for architects to be aware of how protection systems are designed or constructed?
13. What information does an architect have to provide to a mechanical engineer to ensure proper design and placement of the mechanical systems?
14. What is being protected by the protection system? What hours and level of security will be needed?
15. How will the protection system be installed, activated, monitored, and controlled?
16. What limitations are specific to the type of technology a protection system utilizes?

Unit 6 – Structural Engineering

Preface

In this unit, students will learn about the basics of structural engineering. Based on the information the students gather, they will adapt it to suit the needs of their particular project. There will be time for applying structural data to formulas and tables, performing calculations, and adding those results in the form of structural details, to the prints.

A structural engineer must consider the three common characteristics of any structure: the structure must be stable, have strength, and be economical to build.

“Stability” is an important characteristic of a structure that is dependent upon balanced forces and equilibrium. This means that an unstable structure is one that has been designed without forces in mind or the consideration of equilibrium in relation to the various elements that may apply force to the structure or its pieces.

“Strength” refers to the ability of the structure to withstand the applied loads. That means that the materials used are not stressed to their breaking points and that there is room in the calculations to ensure safety. In addition to strength, a structure must have stiffness, which must have a

degree of flexibility under a given load. If a structure has strength, but not stiffness, it may deform too much when a load is applied.

The third common characteristic is the “economic value” of a structure, which involves cost of materials, fabrication, construction, maintenance, design, labor, energy consumption, and the speed of construction. The economics of constructing a structure affect the choices made about design, materials, and function. Often the correct choice is not necessarily the obvious one. Therefore, alternatives should be considered and thoroughly researched before decisions are made.

In addition to the three common characteristics, other factors should be considered: the intended use of the building; fire protection; integration of systems within the building; building safety (both psychologically and physically), and the architect’s understanding of the behavior of structures under load.

Concepts

1. Structural design encompasses how a structure is to be used, the conditions of that use, the occupants or users, and the geometric shapes from which it will be comprised.
2. A responsible designer takes into consideration the environment, aesthetics, structural integrity, available materials and their properties, and the safety of its occupants.
3. Graphic communication is essential to successful implementation of a design project.
4. Mathematics and physics are important tools in the analysis of a design.

Essential Questions

Lesson 6.1 Introduction to Structural Engineering

1. What is structural engineering?
2. How does the design of a structure impact how loads are dispersed?
3. In what ways are wind, snow, and dead and live loads similar or different?
4. How does the use of mathematics help in understanding about the forces and loads on a structure?
5. How do you determine what loads are applied to a structure?
6. How does the design of a structure impact how loads are dispersed on it?
7. In what ways are wind, snow, and dead and live loads similar or different? How does the use of mathematics help in understanding about these types of loads?
8. Where would you locate a load table to assist your design process?

Lesson 6.2 Roof Systems

1. How are trusses able to span large distances?
2. What do I have to understand in order to use mathematics to predict truss strength?
3. How are different roof styles and pitches related to different architectural styles?
4. What is the effect of different materials on the strength of a rafter or a truss?

Lesson 6.3 Columns and Beams

1. If a beam bends in one direction, what is the effect on the column?
2. If a column compresses too severely, how does that affect a beam?
3. In the design of a column and beam system, what are the geometric and physical principles that must be considered for safety and sustainability of a structure?
4. What information is provided in column schedules? What additional information is needed in designing a column and beam bracing system?

Lesson 6.4 Foundations

1. How do weight and applications of loads affect the design of a structure?
2. What are the factors that determine if soil is suitable to support a structure?
3. How are the various load types, soil bearing capacities, drainage, and the kinds of piers related to the design of a foundation?
4. What components other than foundation walls must have a footing?