Civil Engineering and Architecture
PLTW Framework
Course Level

PLTW Framework - Overview

PLTW Frameworks are representations of the knowledge, skills, and understandings that empower students to thrive in an evolving world. The PLTW Frameworks define the scope of learning and instruction within the PLTW curricula. The framework structure is organized by four levels of understanding that build upon each other: Knowledge and Skills, Objectives, Domains, and Competencies.

The most fundamental level of learning is defined by course Knowledge and Skills statements. Each Knowledge and Skills statement reflects specifically what students will know and be able to do after they've had the opportunity to learn the course content. Students apply Knowledge and Skills to achieve learning Objectives, which are skills that directly relate to the workplace or applied academic settings. Objectives are organized by higher-level Domains.

Domains are areas of in-demand expertise that an employer in a specific field may seek; they are key understandings and long-term takeaways that go beyond factual knowledge into broader, conceptual comprehension.

At the highest level, Competencies are general characterizations of the transportable skills that benefit students in various professional and academic pursuits. As a whole, the PLTW Frameworks illustrate the deep and relevant learning opportunities students experience from PLTW courses and demonstrate how the courses prepare students for life, not just the next grade level.

To thrive in an evolving world, students need skills that will benefit them regardless of the career path they choose. PLTW Frameworks are organized to showcase alignment to in-demand, transportable skills. This alignment ensures that students learn skills that are increasingly important in the rapidly advancing, innovative workplace.

Competencies (C), Domains (D), Objectives (O), Knowledge and Skills (KS)

C1 Problem Solving and Process Thinking

Strategic and systematic design and inquiry processes guide the development of an effective solution to the problem.

D1 Engineering Mindset

Successful engineers exhibit specific personal and professional characteristics that lend themselves to the creative, collaborative, and solution-driven nature of the profession.

O1.1 Demonstrate independent thinking and self-direction in pursuit of accomplishing a goal.

KS1.1.1 Plan and use time in pursuit of accomplishing a goal without direct oversight.

KS1.1.2 Plan how to gain additional knowledge and learning to accomplish a goal.

O1.2 Demonstrate flexibility and adaptability to change.

KS1.2.1 Adapt to varied roles, job responsibilities, schedules, and contexts.

D2 Design Process

An engineering design process is an iterative systematic approach to problem solving.

O2.1 Explain and justify an engineering design process.

KS2.1.1 Describe major steps of a design process and identify typical tasks involved in each step.

KS2.1.2 Identify the step in which an engineering task would fit in a design process.

KS2.1.3 Document a design process in an engineering notebook according to best practices.

O2.2 Collect, analyze, and interpret information relevant to the problem or opportunity at hand to support engineering decisions.

KS2.2.1 Explain the role of research in the process of design.

KS2.2.2 Find relevant data in credible sources, such as literature, databases, and policy documents.

KS2.2.3 Explain the role of stakeholders and subject matter experts in the design process.

O2.3 Synthesize an ill-formed problem into a meaningful, well-defined problem.

KS2.3.1 Explain the importance of carefully and specifically defining a problem or opportunity, design criteria, and constraints to develop successful design solutions.

KS2.3.2 Identify and define visual, functional, and structural design requirements with realistic constraints, against which solution alternatives can be evaluated.

KS2.3.3 List potential constraints that may impact the success of a design solution. Examples include economic (cost), environmental, social, political, ethical, health and safety, manufacturability, technical feasibility, and sustainability.

O2.4 Generate multiple potential solution concepts.

KS2.4.1 Represent concepts using a variety of visual tools, such as sketches, graphs, and charts, to communicate details of an idea.

O2.5 Develop models to represent design alternatives and generate data to inform decision making, test alternatives, and demonstrate solutions.

KS2.5.1 Describe the use of a model to accurately represent the key aspects of a physical system. Include the identification of constraints, such as cost, time, or expertise that may influence the selection of a model.

KS2.5.2 Define various types of models that can be used to represent products, processes, or designs such as physical prototypes, mathematical models, and virtual representations. Explain the purpose and appropriate use of each.

O2.6 Select a solution path from many options to successfully address a problem or opportunity.

KS2.6.1 Explain that there are often multiple viable solutions and no obvious best solution. Trade-offs must be considered and evaluated consistently throughout an engineering design process.

D3 Engineering Tools and Technology

The practice of engineering requires the application of mathematical principles and common engineering tools, techniques, and technologies.

O3.1 Using a variety of measuring devices, measure and report quantities accurately and to a precision appropriate for the purpose.

KS3.1.1 Use dimensional analysis and unit conversions to transform data to consistent units or to units appropriate for a particular purpose or model.

O3.2 Use a spreadsheet application to help identify and/or solve a problem.

KS3.2.1 Populate a spreadsheet application with data and organize the data to be useful in accomplishing a specific goal.

O3.3 Apply mathematical models and interpret the output of models to test ideas or make predictions.

KS3.3.1 Represent data for two quantitative variables on a scatter plot and describe how the variables are related.

KS3.3.2 Fit a function to the data; use functions fitted to data to solve problems in the context of the data, especially linear, quadratic, and exponential functions.

KS3.3.3 In linear models, interpret the rate of change (slope) and the intercept (constant term) in the context of the data.

O3.4 Construct physical objects to represent design ideas.

KS3.4.1 Describe a process to build a physical object based on a conceptual communication such as a drawing or description.

O3.5 Apply computational thinking to generalize and solve a problem using a computer.

KS3.5.1 Interact with content-specific models and simulation to support learning and research.

KS3.5.2 Use modeling and simulation to represent and understand natural phenomena.

C2 Technical Knowledge and Skills

Every career field requires technical literacy and career-specific knowledge and skills to support professional practice.

D4 Building Design and Analysis

Architects apply art and science to plan, design, and analyze buildings and built environments to meet human needs that reflect functional, technical, social, environmental, and aesthetic considerations.

O4.1 Create building designs that successfully address and reflect the building's intended function, location, community, and desired aesthetic presentation.

KS4.1.1 Explain how historical innovations have contributed to the evolution of civil engineering and architecture.

KS4.1.2 Identify and describe the principles and elements of design as used in architectural works.

KS4.1.3 Determine the architectural style of a building through identification of building features, components, and materials.

KS4.1.4 Identify common roof styles and describe advantages and disadvantages of each style.

KS4.1.5 Investigate the legal, physical, and financial requirements of a project and consider the needs of the community to determine project viability.

O4.2 Develop a sustainable and affordable single-family residential design that complies with applicable codes and requirements, uses universal design features, and meets the needs of the client.

KS4.2.1 Identify local building regulations and applicable building codes with which a given development in a specified location must comply.

KS4.2.2 Identify components of a typical wood residential framing system.

KS4.2.3 Identify appropriate guidelines to guide the design of affordable residential structures (for example Habitat for Humanity).

KS4.2.4 Describe the purpose and give examples of universal design concepts in residential design.

KS4.2.5 Explain the LEED (Leadership in Energy and Environmental Design) certification program and its purpose.

KS4.2.6 Identify appropriate LEED for Homes credits available for a given residential project.

O4.3 Create a commercial building design incorporating sustainable building practices that complies with applicable codes and requirements.

KS4.3.1 Classify a commercial building according to its use, occupancy, and construction type using the International Building Code (IBC).

KS4.3.2 Use applicable Land Use and Development regulations to identify zoning designations and allowable uses of property.

KS4.3.3 Identify common commercial building framing systems.

KS4.3.4 Identify and compare a variety of commercial wall systems and select an appropriate system for a given commercial application based materials, strength, aesthetics, durability, and cost.

KS4.3.5 Identify and compare a variety of commercial low-slope roof systems and select an appropriate system for a given commercial application based on materials, strength, durability, and cost.

KS4.3.6 Identify the pros and cons of using a green roof in a commercial building design.

KS4.3.7 Identify sustainable building practices that are appropriate for the design of a given commercial facility.

O4.4 Accurately determine an estimated cost of a small building project.

KS4.4.1 Apply basic math skills to calculate the quantity of materials needed to construct a small building project.

O4.5 Select building components and construction techniques that will improve building energy performance and reduce ongoing energy cost.

KS4.5.1 Use energy codes to determine the minimum requirements for a building envelope.

KS4.5.2 Describe the meaning and significance of the terms R-value and U-factor and the relationship between the two.

KS4.5.3 Determine the overall R-value of a wall or roof section composed of multiple building components.

KS4.5.4 Compare the thermal resistance of building components and select components that meet specific thermal criteria.

KS4.5.5 Calculate the heat loss for a building envelope using environmental conditions appropriate for the project.

KS4.5.6 Identify energy conservation requirements for a given building based on the International Energy Conservation Code.

D5 Structural Design

Building professionals ensure that their designs are structurally sound and satisfy given design criteria based on safety, serviceability, and performance.

O5.1 Determine building design loads and predict the transfer of those loads through a building structure.

KS5.1.1 Given a structural form, describe how the structure resists and transfers applied loads.

KS5.1.2 Identify and differentiate between the various design loads that may influence the structural design of a building, including dead, live, snow, wind, earthquake, flood, and earth pressure loads.

KS5.1.3 Use building codes and other resources to determine design loading and deflection limits for a structural component.

KS5.1.4 Calculate the structural efficiency of a structure.

O5.2 Select appropriate beam sections to safely support design loads for a given simply supported commercial beam application.

KS5.2.1 Determine reaction forces and the maximum moment resulting in a simply supported beam from a given loading condition.

KS5.2.2 Sketch shear and moment diagrams to represent the magnitude of shear force and bending moment resulting from the application of a given loading condition to a simply supported beam.

KS5.2.3 Calculate the deflection of a simply supported beam subjected to a given loading condition.

KS5.2.4 Use structural analysis software to analyze and design simply supported structural beams.

KS5.2.5 Use load-span tables to select structural elements, especially metal decks, composite floor systems, and steel joists.

O5.3 Size spread footings to safely support structural design loads.

KS5.3.1 Identify and describe the appropriate application of various foundation types.

KS5.3.2 Determine the loads transferred from a steel framed structure to the ground through a foundation.

D6 Utilities and Services

Building professionals size services and utilities and design internal systems to adequately meet the equipment and occupant demands and comply with local regulations and codes.

O6.1 Size and locate new utility service connections for a building project.

KS6.1.1 Identify typical utility services required for a building, transmission/distribution methods for each utility, and methods for measuring usage.

KS6.1.2 Interpret and apply code requirements and constraints as they pertain to the installation of services and utilities.

KS6.1.3 Calculate the head loss and estimate the water pressure for a given water supply system.

KS6.1.4 Identify and describe wastewater management systems including publicly owned treatment works and on-site and decentralized wastewater treatment systems.

KS6.1.5 Design an appropriate sewer lateral that complies with applicable codes for a given facility.

O6.2 Create preliminary designs for plumbing and electrical systems for a building project.

KS6.2.1 Identify common plumbing system components, proper usage, and symbols used to represent those components in plumbing plans.

KS6.2.2 Identify common electrical system components, proper usage, and symbols used to represent those components in electrical/lighting plans.

KS6.2.3 Use building codes to inform the design of plumbing, electrical, and waste systems for a building project.

D7 Site Design

Building professionals consider a wide variety of factors when designing a building site, including site specific characteristics, local regulations and codes, safety and functionality, aesthetics, sustainability, and a sense of place.

O7.1 Complete a control survey to establish a point of known elevation on a project site.

KS7.1.1 Describe the various types of land surveys and the purpose of each.

KS7.1.2 Use an auto level to determine the elevation of a point of interest given the elevation of a known point.

KS7.1.3 Document the completion of a level loop using accepted land surveying protocol.

O7.2 Strategically locate a building on a site based on orientation, site-specific characteristics, and local regulations.

KS7.2.1 List environmental, building code, zoning ordinances, infrastructure, and site considerations that should be taken into account when locating a residential building on a site.

KS7.2.2 Identify important site-specific characteristics that will affect building orientation.

KS7.2.3 Create a site opportunities map to identify positive and negative site characteristics and design considerations.

O7.3 Analyze a site soil sample to determine the United Soil Classification System designation and predict soil characteristics important to the development of the site.

KS7.3.1 Explain the potential impact of the classification of soils present on a building site to the development of the site.

KS7.3.2 Perform a sieve analysis of a soil sample.

KS7.3.3 Describe the composition of a soil sample using soil type, gradation and/or plasticity descriptions, as applicable.

O7.4 Develop a site plan for a commercial facility that complies with building codes and incorporates Low Impact Development techniques.

KS7.4.1 Identify the boundaries of a property based on its legal description.

KS7.4.2 Design appropriate pedestrian access, vehicular access, and a parking lot for a commercial facility.

KS7.4.3 Explain the impact of site development on storm water runoff.

KS7.4.4 Calculate the storm water runoff from a site before and after development.

KS7.4.5 Create a preliminary design for a storm water storage facility.

KS7.4.6 Identify and explain the purpose of Low Impact Development techniques in site development.

D8 Building Design and Construction Documentation

Architects and engineers use 3D modeling software to aid in the design and documentation of building projects.

O8.1 Use Architectural 3D modeling software to document the design and specify the construction of a building project.

KS8.1.1 Identify and describe the typical components of a given architectural view or drawing component, including a schedule, site plan, floor plan, building section, or elevations.

KS8.1.2 Read and interpret drawings related to the design and construction of a building project.

C3 Professional Practices and Communication

Professional practice is guided by professional ethics and standards and requires effective communication and collaboration.

D9 Career Awareness

Engineers use professional skills and knowledge to pursue opportunities and create sustainable solutions to improve and enhance the quality of life of individuals and society.

O9.1 Understand the educational, professional, and technical skills required for professional engineering practice.

KS 9.1.1 Describe the educational and professional licensure requirements for professional engineers and architects.

O9.2 Describe the role of engineers in society.

KS9.2.1 Define engineering as the creation of solutions, such as new and improved products, technologies, systems and processes), to meet the needs of people and society.

O9.3 Describe and distinguish among the sub-disciplines of civil engineering and architecture.

KS9.3.1 Describe the primary duties of a civil engineer and the primary duties of an architect.

KS9.3.2 Explain that engineering disciplines continue to evolve and emerge as new interdisciplinary fields or sub-disciplines to better meet the needs of society. Examples include

D10 Professionalism and Ethics

Successful engineering professionals exhibit personal and professional characteristics and behaviors that involve considerations of the impact of their work on individuals, society, and the natural world.

O10.1 Assess an engineering ethical dilemma.

KS10.1.1 Explain that engineering solutions can have significantly different impacts on an individual, society, and the natural world. The nature of these impacts can be environmental, economic, social, political, health and welfare.

O.10.2 Strive to create sustainable solutions to meet the needs of society, without compromising the ability of future society to meet their needs.

KS10.2.1 Identify principles that help guide development of sustainable solutions. Considerations for sustainable development include people, planet, and profit.

KS10.2.2 Describe the life cycle of a product or service and identify energy consumption and wastes and emissions that are produced in the process.

D11 Collaboration

Demonstrate an ability to function on multidisciplinary teams.

O11.1 Facilitate an effective team environment to promote successful goal attainment.

KS11.1.1 Describe the various individual roles and interdependencies of a collaborative team.

KS11.1.2 Describe the importance of team norms and help develop those norms for a team.

KS11.1.3 Solicit, negotiate, and balance diverse views and beliefs to reach workable solutions.

KS11.1.4 Identify, describe, and justify a diverse composition of engineering (and other) disciplines that might work together to address challenges (including the Grand Challenges of Engineering).

KS11.1.5 Describe a design charrette and recognize the value of using a charrette to develop innovative solutions to support whole building design.

O11.2 Contribute individually to overall collaborative efforts.

KS11.2.1 Describe one's individual role and expectations of performance within the team.

KS11.2.2 Critically and realistically self-evaluate personal contributions and collaboration effectiveness within a team.

O11.3 Manage project timelines and resources as part of an engineering design process.

KS11.3.1 Explain the process of project management and the importance of elements, such as timelines, schedules, task assignments, and identification and mitigation of potential risks, in the effort to complete a project on time.

KS11.3.2 Develop a project plan using a project planning tool such as a Gantt chart.

D12 Communication

Engineering practice requires effective communication with a variety of audiences using multiple modalities.

O12.1 Communicate effectively with an audience based on audience characteristics.

KS12.1.1 Adhere to established conventions of written, oral, and electronic communications (grammar, spelling, usage, and mechanics).

KS12.1.2 Follow acceptable formats for technical writing and professional presentations.

KS12.1.3 Describe characteristics important to oral delivery of information (volume, tempo, eye contact, articulation, and energy). Vary these elements of delivery to convey and emphasize information and engage the audience.