PLTW Engineering Design and Development Course Framework

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.

Essential Questions

C0.1	Why do companies advertise the positive ecological and sustainable design attributes of products?
C0.2	How do you decide what key points are most important when given limited time to present findings?
C0.3	Why is it crucial to use a design process when trying to solve complex problems?
C0.4	What are attributes of successful project planning and management?
C0.5	Why is it important for engineers and designers to utilize known scientific and mathematical principles?
C0.6	What negative issues does successful project planning and management potentially prevent?
C0.7	Why is teaming often more effective than individuals working alone when solving a complex problem?
C0.8	Why is it crucial to use a design process when trying to solve complex problems?
C0.9	What are the roles and responsibilities of engineering in society?
C0.10	What justifies expenditure of resources to try and solve a problem?
C0.11	What are the critical checkpoints in a design process?
C1.1	How can one establish the validity of a problem?
C1.2	Why is it important to begin a design project with a valid problem statement?

C1.3 How are experts and mentors valuable to the design process?

C1.4 How can valuable and credible research be identified for use?

C1.5 Why should an individual or company be concerned with justification of the problem?

C1.6 How is market research used to aid research and development?

C1.7 What exactly is the problem? How do I phrase it as an objective problem statement?

C1.8 What is the background, context, or setting of the problem?

C1.9 Who says that this is a problem worth solving, and why should anyone believe them?

C1.10 What are all of the methods, products, or actions that are being used or have been developed to try to solve this problem? Exactly why doesn't each of them actually solve the problem?

C1.11 How do I/we prove to others that I/we have done an extensive search for possible current solution attempts?

C1.12 Who has helped me/us identify and state the shortcomings of the solution attempts found and why should anyone believe them?

C1.13 Now that I know what the problem statement is and why current solutions are not solving the problem well enough, what are the measurable things a new design would have to accomplish (in order of importance) to be seen as a real solution?

C1.14 How did I/we determine each of these design requirements?

C2.1 Why would an engineer need to identify the criteria and constraints required for a design solution?

C2.2 How would you explain the following statement? "Finding a good solution is an iterative process."

C2.3 Why is it important to take the time to thoroughly explore many potential solutions before selecting a solution path?

C2.4 What benefit does optimization provide at this point in the design process?

C2.5 What are advantages of using virtual solutions before and sometimes in place of physical prototypes?

C2.6 What brainstorming or idea generation techniques did I/we use to help define possible solutions? How can we show that I/we kept all of the design requirements in mind throughout the entire process?

C2.7 What was the best solution to try and why was it the best solution to try?

C2.8 How do we show that our design ideas were not just guesses and that my/our ideas and each of the proposed design attributes really is based on sound logic and subject-related knowledge?

C2.9 How do I/we show evidence that the proposed design has merit beyond the classroom or lab as a real solution?

C2.10 How can I/we show evidence that the design could realistically get into the hands of the people the design is trying to help in a sustainable way?

C2.11 What evidence would I/we have to offer to honestly ask a family to invest their life savings in this idea?

C3.1 What are the subsystems of products or systems that you are familiar with? Which subsystems are essential to system function and which are enhancements?

C3.2 What are advantages of using virtual solutions before and sometimes in place of physical prototypes?

C3.3 How does having a highly functional prototype relate to testing?

C3.4 What steps can be taken to lower the cost of your prototype?

C3.5 Why are test criteria important in test design?

C3.6 How do you know that you have enough step-by-step detail in your test procedure?

C3.7 What measurement practices are used to analyze your test results?

C3.8 What is the significance of seeking input from experts or non-team members?

C3.9 What is the plan to test the prototype design? How can I show others that the testing plan for each design requirement is a well thought out test and would yield believable data?

C3.10 What did I/we learn from testing about how well this design met the stated design requirements?

C3.11 Why should others believe my/our analysis of the data?

C3.12 What do end users and experts, who are directly related to this project and problem statement, think of the testing results and my/our conclusions about the effectiveness of this idea?

C4.1 What do end users and experts directly related to this project and problem statement think of the testing results and my/our conclusions about the effectiveness of this idea?

C4.2 If I/we were going to do this project over, what should be done differently during the design process to improve the project? How would those recommendations make the project better overall?

C4.3 Did I/we document each step of the design process in this portfolio well enough that anyone else interested in the problem could pick up this work and replicate what I/we have done, as well as continue working from where I/we ended up?

C5.1 How did I/we document each step of the design process in this portfolio so that anyone else interested in the problem could pick up this work and replicate what I/we have done as well as continue working from where I/we ended up?

C5.2 Throughout the entire portfolio, why is it critical that the explanations, descriptions and information in each section be developed and presented with a wide variety of readers in mind?

C6.1 Should I design an authentic solution, what steps could I take beyond this course?

Competencies, Domains, Objectives, Knowledge and Skills

Transportable Knowledge and Skills

Core workplace skills that students and workers need to acquire, that can be used across all stages of a career, and that, because of their universal utility, are transportable from job to job, from employer to employer, across the economy.

Critical and Creative Problem-Solving (CCP):

The skills necessary for students to generate ideas and solutions to problems.

CCP-A. Demonstrate independent thinking and self-direction in pursuit of accomplishing a goal.

CCP-A.1 List and prioritize goals with tangible success criteria.

Component:	0	1	2	3	4	5	6
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CCP-A.2 Plan and use time in pursuit of accomplishing a goal without direct oversight.

Component:	0	1	2	3	4	5	6
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CCP-A.3 Plan how to gain additional knowledge and learning to accomplish a goal.

Component:	0	1	2	3	4	5	6
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CCP-B. Demonstrate flexibility and adaptability to change.

CCP-B.1 Adapt to varied roles, job responsibilities, schedules, and contexts.

Component:	0	1	2	3	4	5	6
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CCP-C. Persevere to solve a problem or achieve a goal.

CCP-C.1 Describe why persistence is important when identifying a problem and/or pursuing solutions.

Component:	0	1	2	3	4	5	6
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CCP-C.2 Accept failure as part of an evolution of individual growth and necessary to the expansion of the engineering profession.

Component:	0	1	2	3	4	5	6
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CCP-C.3 Reflect critically on past experiences to inform future progress.

Component:	0	1	2	3	4	5	6
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CCP-A. Explain and justify an engineering design process.

CCP-A.1 Explain that there are many versions of a design process that describe essentially the same process.

Component:	0	1	2	3	4	5	6
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CCP-A.2 Describe major steps of a design process and identify typical tasks involved in each step.

Component:	0	1	2	3	4	5	6
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CCP-A.3 Identify the step in which an engineering task would fit in a design process.

Component:	0	1	2	3	4	5	6
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CCP-A.4 Outline how iterative processes inform engineering decisions, improve solutions, and inspire new ideas.

Component:	0	1	2	3	4	5	6
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CCP-A.5 Document a design process in an engineering notebook according to best practices.

Component:	0	1	2	3	4	5	6
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Competencies, Domains, Objectives, Knowledge and Skills

CCP-B. Collect, analyze, and interpret information relevant to the problem or opportunity at hand to support engineering decisions.

CCP-B.1 Explain the role of research in the process of design.

Component:	0	1	2	3	4	5	6
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CCP-B.2 Find relevant data in credible sources such as literature, databases, and policy documents.

Component:	0	1	2	3	4	5	6
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CCP-B.3 Explain the role of stakeholders and subject matter experts in the design process.

Component:	0	1	2	3	4	5	6
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CCP-B.4 Describe criteria for determining the reliability and credibility of information.

Component:	0	1	2	3	4	5	6
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CCP-C. Synthesize an ill-formed problem into a meaningful, well-defined problem.

CCP-C.1 Explain the importance of carefully and specifically defining a problem or opportunity, design criteria, and constraints, to develop successful design solutions.

Component:	0	1	2	3	4	5	6
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CCP-C.2 Identify and define visual, functional, and structural design requirements with realistic constraints, against which solution alternatives can be evaluated.

Component:	0	1	2	3	4	5	6
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CCP-C.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.

Component:	0	1	2	3	4	5	6
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CCP-D. Generate multiple potential solution concepts.

CCP-D.1 Describe multiple techniques and appropriate guidelines used to generate ideas.

Component:	0	1	2	3	4	5	6
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CCP-D.2 Represent concepts using a variety of visual tools, such as sketches, graphs, and charts, to communicate details of an idea.

Component:	0	1	2	3	4	5	6
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Competencies, Domains, Objectives, Knowledge and Skills

CCP-E. Develop models to represent design alternatives and generate data to inform decision making, test alternatives, and demonstrate solutions.

CCP-E.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.

Component:	0	1	2	3	4	5	6
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CCP-E.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.

Component:	0	1	2	3	4	5	6
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CCP-F. Select a solution path from many options to successfully address a problem or opportunity.

CCP-F.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.

Component:	0	1	2	3	4	5	6
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CCP-F.2 Develop and carry out a justifiable scheme to compare and evaluate competing solutions paths. A decision matrix is one tool used to compare and evaluate competing solutions based on design criteria.

Component:	0	1	2	3	4	5	6
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CCP-G. Make judgments and decisions based on evidence.

CCP-G.1 Explain that a conclusion is valid if the evidence supports the conclusion while acknowledging the limitations, opposing views, and biases.

Component:	0	1	2	3	4	5	6
	☐	☐	☑	☐	☑	☑	☐

CCP-G.2 Evaluate evidence and arguments to identify deficiencies, limitations, and biases or appropriate next steps in the pursuit of a better solution.

Component:	0	1	2	3	4	5	6
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COL-A. Facilitate an effective team environment to promote successful goal attainment.

COL-A.1 Describe the various individual roles and interdependencies of a collaborative team.

Component:	0	1	2	3	4	5	6
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COL-B. Contribute individually to overall collaborative efforts.

COL-B.1 Critically and realistically self-evaluate personal contributions and collaboration effectiveness within a team.

Component:	0	1	2	3	4	5	6
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COL-C. Analyze and evaluate the work of others to provide helpful and effective feedback.

COL-C.1 Describe the purpose and positive outcomes of a peer review process.

Component:	0	1	2	3	4	5	6
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COL-C.2 Describe the characteristics of effective feedback.

Component:	0	1	2	3	4	5	6
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COL-D. Manage project timelines and resources as part of an engineering design process.

COL-D.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.

Component:	0	1	2	3	4	5	6
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COL-D.2 Develop a project plan using a project planning tool such as a Gantt chart.

Component:	0	1	2	3	4	5	6
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COL-D.3 Select and use a system of collaborative tools, such as cloud-based tools, document sharing, and video and text functions, to successfully complete a project.

Component:	0	1	2	3	4	5	6
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COM-A. Communicate effectively with an audience based on audience characteristics.

COM-A.1 Adhere to established conventions of written, oral and electronic communications (grammar, spelling, usage, and mechanics).

Component:	0	1	2	3	4	5	6
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COM-A.2 Follow acceptable formats for technical writing and professional presentations.

Component:	0	1	2	3	4	5	6
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COM-A.3 Describe how the size and characteristics of an audience will affect communication.

Component:	0	1	2	3	4	5	6
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Competencies, Domains, Objectives, Knowledge and Skills

COM-A.4 Modify the content, format, level of technical detail, and length of communications to meet the needs of the audience.

Component:	0	1	2	3	4	5	6
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COM-A.5 Properly cite references for all communication in an accepted format.

Component:	0	1	2	3	4	5	6
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COM-A.6 Clearly label tables and figures with units and explain the information presented in context.

Component:	0	1	2	3	4	5	6
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COM-A.7 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.

Component:	0	1	2	3	4	5	6
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Technical Knowledge and Skills

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

Engineering Tools and Technology (ETT):

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

ETT-A. Using a variety of measuring devices, measure and report quantities accurately and to a precision appropriate for the purpose.

ETT-A.1 Explain that all measurements are an approximation of the true value of a quantity.

Component:	0	1	2	3	4	5	6
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ETT-A.2 Explain and differentiate between the accuracy and precision of a measurement or measuring device.

Component:	0	1	2	3	4	5	6
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ETT-A.3 Use dimensional analysis and unit conversions to transform data to consistent units or to units appropriate for a particular purpose or model.

Component:	0	1	2	3	4	5	6
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ETT-B. Interpret and analyze data for a single count or measurement variable.

ETT-B.1 Represent data for a single count or measurement with plots on the real number line, for example dot plots, histograms, and box plots.

Component:	0	1	2	3	4	5	6
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ETT-B.2 Use statistics appropriate to the shape of the data distribution to determine the center (median, mean) and spread (interquartile range, standard deviation) of a data set and/or compare data sets.

Component:	0	1	2	3	4	5	6
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ETT-B.3 Use the mean and standard deviation of a data set to fit it to a normal distribution and to estimate population percentages. Recognize that there are data sets for which such a procedure is not appropriate.

Component:	0	1	2	3	4	5	6
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ETT-C. Apply mathematical (including graphical) models and interpret the output of models to test ideas or make predictions.

ETT-C.1 Represent data for two quantitative variables on a scatter plot, and describe how the variables are related.

Component:	0	1	2	3	4	5	6
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ETT-C.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.

Component:	0	1	2	3	4	5	6
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ETT-C.3 In linear models, interpret the rate of change (slope) and the intercept (constant term) in the context of the data.

Component:	0	1	2	3	4	5	6
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ETT-C.4 Distinguish between sample statistics and population statistics and know appropriate applications of each.

Component:	0	1	2	3	4	5	6
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