STEAM MINDED WV

Student and Educator Practices for STEAM Education

Grades 6-12

#STEAMmindedWV

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Welcome

Welcome to the student and educator practices support document for 6-12 STEAM instruction. The purpose of this document is to demonstrate the transdisciplinary nature of STEAM, and to provide support for each of the sets of standards and practices that can be covered through transdisciplinary STEAM education. For example, it is clear that both science and math standards are easily covered by a STEAM activity, but during this course of a STEAM activity, students can also demonstrate engineering practices, mastery of the arts, as well as an understanding of the Technology and Computer Science standards, all while demonstrating the social and emotional development contained within the WV Standards for Student Success. All of these standards, when combined, lead to a lesson, activity, or unit being classified as STEAM-minded, as students both learn content and develop the soft skills for student success while completing the STEAM investigation.

This document contains information about STEAM in WV, as well as an explanation of the STEAM Mindsets and Skillsets that are developed as a student becomes STEAM minded. Information about the standards and practices of science, technology, engineering, and math are included, as well as guidance on making the STEAM classroom inclusive for all students. Design thinking, as a method for problem solving presented, as well as the links between the WV Standards for Effective Schools and transdisciplinary STEAM integration are described. This document contains information on STEM and STEAM careers and provides links for student investigation of careers. Lastly, a STEAM glossary is included so that as the STEAM-minded WV initiative moves forward, a glossary provides a common language. Throughout this document, the acronyms STEM and STEAM are occasionally used interchangeably. STEM, by design, is intended to be a transdisciplinary endeavor, including the traditional STEM disciplines, as well as the arts and the humanities.

This document is designed for educators that are looking to transform their teaching in order to develop STEAM-minded students. This guide can serve as a tool for Professional Learning Communities, departments, or individual educator professional learning.

For more information on developing STEAM-minded students visit *http://wvde.us/STEAMmindedWV*.

What is STEAM?

STEAM is an acronym for the transdisciplinary integration of the five disciplines of Science, Technology, Engineering, Arts, and Mathematics. The STEAM acronym is built upon the STEM acronym, and often they are used interchangeably. STEAM education places a priority on the study of science and math with purposeful integration of the arts, technology, and the engineering design process. STEAM education is an opportunity for students to collaboratively solve engaging and relevant problems using innovation and creativity. The engineering design process allows students to identify problems, design possible solutions, test and evaluate those solutions until the best solution is discovered (See Figure 2). STEAM in the classroom engages students in real-world situations and allows students to experience solution-finding for problems that are relevant to today's world.

Best practices in STEAM education wrap around a transdisciplinary approach (See Figure 1, Vasquez, 2013) where rigorous academic concepts are blended with real-world applications (see Table 1, English, 2016).

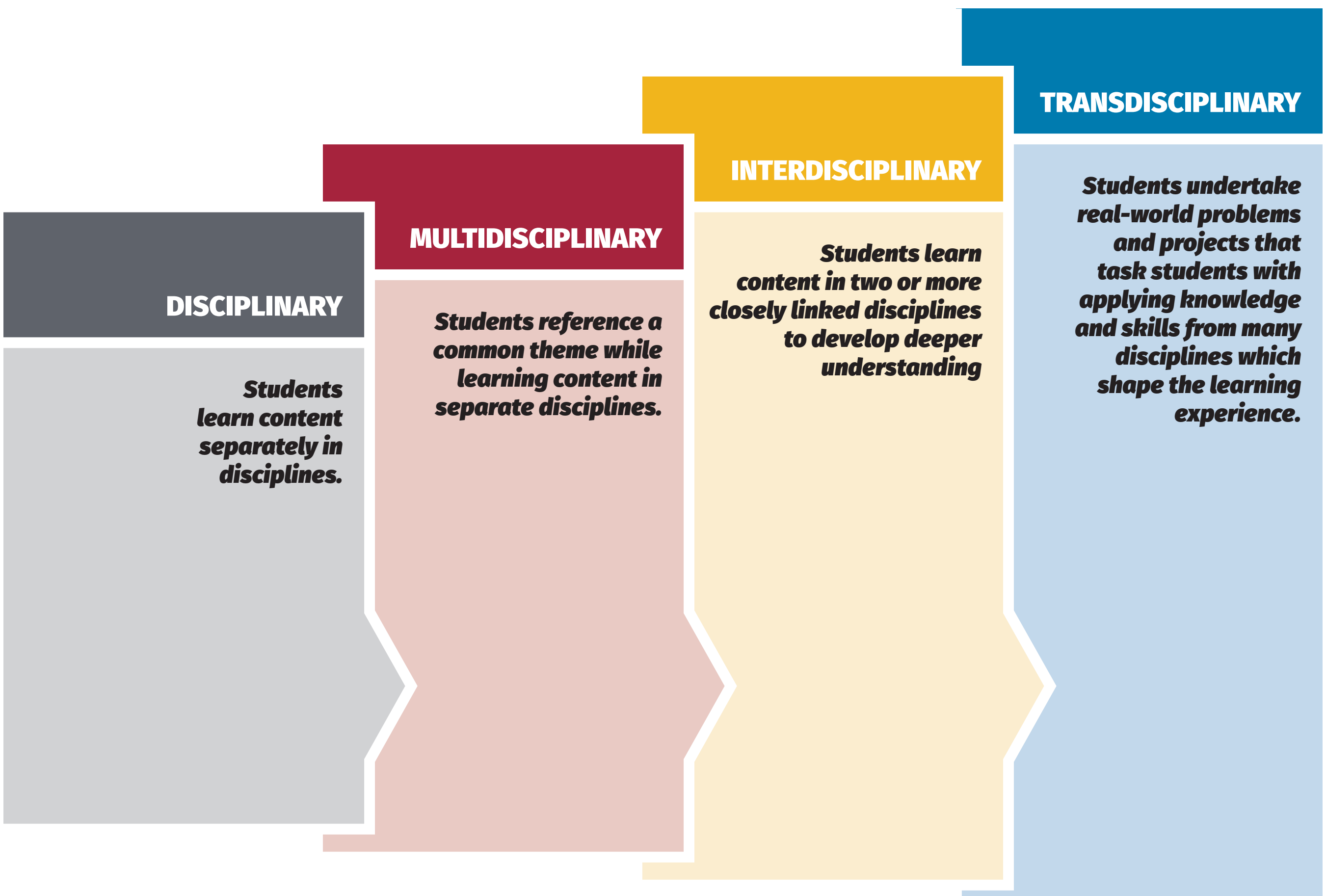


Figure 1. Increasing levels of STEM integration. (Vasquez, 2013)

Integration Level	Features of disciplinary integration.
1. Disciplinary	Concepts and skills are learned separately in each discipline.
2. Multidisciplinary	Concepts and skills are learned separately in each discipline but within a common theme.
3. Interdisciplinary	Closely linked concepts and skills are learned from two or more disciplines with the aim of deepening knowledge and skills.
4. Transdisciplinary	Knowledge and skills learned from two or more disciplines are applied to real-world problems and projects, thus helping to shape the learning experience.

Table 1. Increasing levels of integration. (English, 2016)

STEAM allows students to make connections among school, community, work, and the larger world in which they live. Best practices in STEAM education allow for the inclusion of the arts and the humanities in order to broaden and deepen the scope of instruction. Best practices in STEAM education convey not only skills such as critical thinking, problem-solving, communication, collaboration, and creativity, but also personal competencies such as adaptability, resiliency, perseverance, courage, and optimism. Both mindsets and skillsets are critical to develop STEAM minded students.

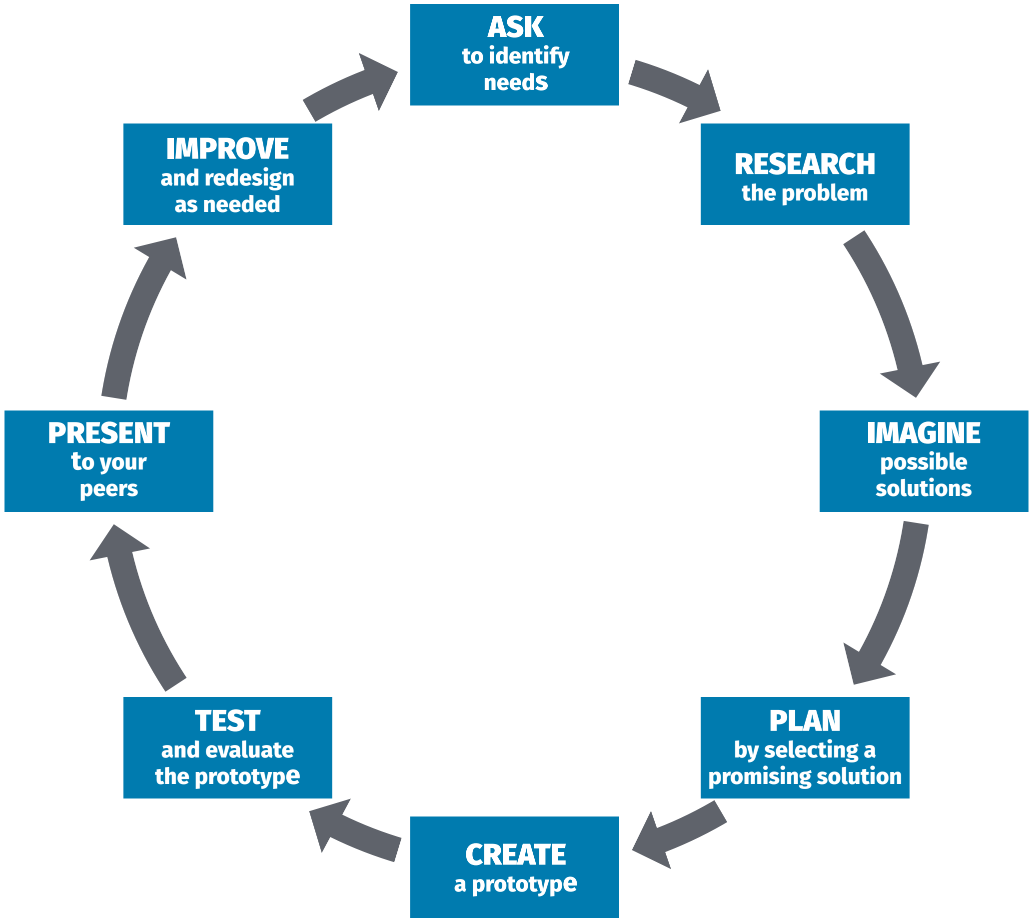


Figure 2. The engineering design process (adapted from Teach Engineering, n.d.).

STEAM-MINDED WV

West Virginians are aware of the changes in the workplace and the global economy. Education is the driving force for students to keep pace with the evolving landscape of business and careers. Many factors influence the need for educators to make intentional choices when developing curriculum and establishing a culture that promotes a comprehensive approach to learning that effectively weaves content disciplines, collaboration, and essential skills. West Virginia students should be prepared to become productive citizens in a world driven by a STEM focused marketplace. STEAM-minded WV is a conduit to equip students, families, and school personnel with the tools necessary to become active learners and to maintain a competitive edge in the world.

wvde.us/steammindedwv

ACTION STEPS

Teachers should develop their own understanding of STEAM. Across the various STEAM disciplines, STEAM looks different. STEAM may look different for different students, or at a different time in a STEAM project, or investigation. Developing an understanding of what STEAM looks like is best done in collaborative groups of content teachers with a goal of developing STEAM opportunities for their students.

Reflect on these key questions when implementing STEAM across the disciplines:

- Are our students engaged in solving real-world problems, relevant issues, and global concerns?
- Are our students provided ample opportunities to personalize learning, develop understandings and mindsets that reflect a positive attitude toward learning, engage in collaborative learning that supports student strengths, and emphasize their unique abilities?
- What is our goal? Have we developed lessons, units, and / or activities to actively engage our students in STEAM that are aligned with West Virginia College- and Career-Readiness Standards?
- Are our students regularly engaged in STEAM-related activities?
- Do our students make connections to STEAM in the activities in our classes?
- Have we given our students opportunities to identify personal interests and in achieve personal goals related to STEAM education?
- Have we identified external STEAM partners from our community who engage with students and educators to support STEAM learning?
- Do we inform families and the community of the school's STEAM activities and invite families and the community to participate?

SECTION REFERENCES

Engineering Design Process. (n.d.). Retrieved August 20, 2020, from https://www.teachengineering.org/

English, L.D. STEM education K-12: perspectives on integration. *IJ STEM Ed* 3, 3 (2016). https://doi.org/10.1186/s40594-016-0036-1

Vasquez, J. A. (2013). *STEM lesson essentials, grades 3-8: Integrating science, technology, engineering, and mathematics*.

STEAM MINDED

MINDSETS *and* SKILLSETS

Mindsets are attitudes held by an individual that play a major role in motivation and achievement. Mindsets determine how individuals make decisions, approach opportunities, and handle adversity. Skillsets are specific abilities that allow individuals to accomplish tasks. The STEAM mindsets and skillsets are those necessary for student success in a STEAM-rich future.

CURIOSITY & IMAGINATION

Students value originality, generate new ideas, investigate life with curiosity, and ask questions.

GROWTH MINDSET

Students think about their thinking and reflect upon their actions and ideas.

COURAGE & RISK-TAKING

Students work outside their comfort zones, embrace adventure, stay open to new ideas, and strive to achieve their goals.

PERSISTENCE & GRIT

Students see a task through to completion, push through obstacles, and work to create solutions to problems. Students see challenges as a learning opportunity.

OPPORTUNITY-SEEKING

Students identify community issues and act to find solutions.

PROBLEM-SOLVING

Students generate alternative solutions to problems, think critically, recognize solutions, and proactively develop creative solutions.

OPTIMISM

Students feel confident and hopeful in their ability to innovate solutions.

RESOURCEFULNESS & ADAPTABILITY

Students explore quick and clever ways to overcome challenges, with the understanding that they can always make adjustments.

EMPATHY & ALTRUISM

Students think about other people's needs and feelings and keep these in mind when solving problems.

CREATIVITY

Students are bold and imaginative.

TEAMWORK

Students learn from new people and work with people with diverse perspectives, skills, and talents.

DESIGN THINKING

Students learn processes for problem solving that originate with empathy and compassion.

PROTOTYPING

Students create simple models to explain their ideas, get feedback, and learn how their solutions can be improved.

PUBLIC SPEAKING

Students create and deliver short, clean, persuasive arguments to rally people around their ideas.

ACTION STEPS

A growth mindset is the belief that with practice, perseverance, and effort, people have unlimited potential to learn. Students operating in a growth mindsets, as opposed to a fixed mindset, face challenges without concern for making mistakes. Instead their focus is on the process of growing as a learner and as a person (Dweck, 2006). Teaching a mindset has become more and more important in recent years, and our understanding of mindsets has grown due to the work of Carol Dweck and other researchers. In addition to the larger growth mindset, however, there are other specific mindsets that are integral to life success.

Review the mindsets and skillsets:

- Curiosity and Imagination
- Growth Mindset
- Courage and Risk-taking
- Persistence and Grit
- Opportunity-Seeking
- Problem-Solving
- Optimism
- Resourcefulness and Adaptability
- Empathy and Altruism
- Creativity
- Teamwork
- Design Thinking
- Prototyping
- Public Speaking

Create two lists. Which of these mindsets and skillsets do you regularly ask student to develop and practice in your classroom, and which do you need to work on adding to your practices, so that students develop these in their own lives?

Mindsets and Skillsets Regularly Addressed	Mindsets and Skillsets NOT Regularly Addressed

On your own, or with a group, brainstorm ideas for how you can incorporate these additional mindsets and skillsets into your classroom practice. Review the resources at *www.edutopia.org/article/growth-mindset-resources*.

Create a list of strategies for incorporating the teaching of these mindsets in your classroom. A few examples are listed below:

Strategies:

- Praise the process
- Allow students to experience productive struggle
- Be honest with students and support them when they need to make changes

Note: Three variations of the STEAM Mindsets and Skillsets can be found on the STEAMminded WV website, a 1 page summary, a printable poster of all of the STEAM Mindsets and Skillsets, and individual sheets for each STEAM Mindset and Skillset. These may be useful when incorporating these into your practice.

Link: *https://wvde.us/stemmindedwv/stem-mindsets-and-skillsets/*

SECTION REFERENCES

Dweck, C. S. (2006). *Mindset: The new psychology of success*. New York: Ballantine Books.

STEAM Planning Tool

When planning for STEAM lessons and units, different aspects of STEAM may be of greater or lesser importance at different times in the investigation or project. When planning a STEAM investigation or project, the key is to make connections – connections among the five main disciplines of STEAM – while completing the larger STEAM investigation or project. The STEM planning tool is simply a tool that is designed to be helpful but not prescriptive. The tool is designed to assist educators in collaborative planning for STEAM, while focusing the lessons or activities on the practices in which students will engage. The tool guides educators in developing a real-world, standards-based, STEAM opportunities for students.

PLANNING TOOL

Lesson / Unit Description:

Time Frame:

What is the real-world connection? What problem are students solving?

Science Standards Addressed:	Technology and Computer Science Standards Addressed:	Math Standards Addressed:

If standards addressed are not on grade level, educators assume responsibility to address grade-level standards.

STUDENT PRACTICES

Science and Engineering Practices
- ☐ Asking Questions and Defining Problems
- ☐ Developing and Using Models
- ☐ Planning and Carrying Out Investigations
- ☐ Analyzing and Interpreting Data
- ☐ Using Mathematics and Computational Thinking
- ☐ Engaging in Argument from Evidence
- ☐ Obtaining, Evaluating, and Communicating Information

Check at least 1.

Technology Practices
- ☐ Access to up-to-date and primary source material
- ☐ Methods of collecting/recording data
- ☐ Ways to collaborate with students, teachers, and experts around the world
- ☐ Opportunities for expressing understanding via multimedia
- ☐ Learning that is relevant and assessment that is authentic
- ☐ Training for publishing and presenting their new knowledge

Check at least 1.

Mathematical Habits of Mind
- ☐ Make sense of problems and persevere to solve them.
- ☐ Reason abstractly and quantitatively.
- ☐ Construct viable arguments and critique the reasoning of others.
- ☐ Model with Mathematics.
- ☐ Use appropriate tools strategically.
- ☐ Attend to precision.
- ☐ Look for and make use of structure.
- ☐ Look for and express regularity in repeated reasoning.

Check at least 1.

Arts Domains

☐ Create ☐ Connect ☐ Explore ☐ Perform ☐ Relate ☐ Respond

Engineering Design Process
- ☐ Identify the Need & Constraints
- ☐ Research the Problem
- ☐ Develop Possible Solutions
- ☐ Select a Promising Solution
- ☐ Build a Prototype
- ☐ Test and Evaluate Prototype
- ☐ Redesign as Needed

Check at least 3.

Literacy Connections:

Other curricular wand community-based (real-world) connections:

STEAM Reflection Tool

The STEAM Reflection Tool is designed to assist educators in reflecting upon a STEAM lesson or activity. Additionally, the lesson reflection could be used by administrators as an observation tool in STEAM classrooms.

POST-LESSON REFLECTION

Practices that were employed or observed, but weren't planned:

STUDENT PRACTICES		
Science and Engineering Practices ☐ Asking Questions and De ining Problems ☐ Developing and Using Models ☐ Planning and Carrying Out Investigations ☐ Analyzing and Interpreting Data ☐ Using Mathematics and Computational Thinking ☐ Engaging in Argument from Evidence ☐ Obtaining, Evaluating, and Communicating Information *Check at least 1.*	**Technology Practices** ☐ Access to up-to-date and primary source material ☐ Methods of collecting/recording data ☐ Ways to collaborate with students, teachers, and experts around the world ☐ Opportunities for expressing understanding via multimedia ☐ Learning that is relevant and assessment that is authentic ☐ Training for publishing and presenting their new knowledge *Check at least 1.*	**Mathematical Habits of Mind** ☐ Make sense of problems and persevere to solve them. ☐ Reason abstractly and quantitatively. ☐ Construct viable arguments and critique the reasoning of others. ☐ Model with Mathematics. ☐ Use appropriate tools strategically. ☐ Attend to precision. ☐ Look for and make use of structure. ☐ Look for and express regularity in repeated reasoning. *Check at least 1.*
Engineering Design Process ☐ Identify the Need & Constraints ☐ Research the Problem ☐ Develop Possible Solutions	☐ Select a Promising Solution ☐ Build a Prototype ☐ Test and Evaluate Prototype	☐ Redesign as Needed *Check at least 3.*

The part of my lesson that went well was...

The part of my lesson that I would do differently next time was...

STEAM MINDSETS AND SKILLSETS PRACTICED		
☐ Curiosity and Imagination ☐ Growth Mindset ☐ Courage and Risk-taking ☐ Persistence and Grit ☐ Opportunity-Seeking	☐ Problem-Solving ☐ Optimism ☐ Resourcefulness and Adaptability ☐ Empathy and Altruism ☐ Creativity	☐ Teamwork ☐ Design Thinking ☐ Prototyping ☐ Public Speaking

Practices of Scientists and Engineers

The Practices of Scientists and Engineers are embedded into the *College- and Career Readiness Standards for Science*. Ensuring that the practices are taught, as well as the content and the science-connecting concepts in the standards, is key to fully addressing the standards. In addition, the practices form strong ties to the engineering process, as well as to the STEAM Mindsets and Skillsets. In this section, you'll *find information on the science and engineering practices produced by the authors of the Next Generation Science Standards*, as well as action steps for ensuring the practices are present in your STEAM teaching.

PRACTICE 1 ASKING QUESTIONS AND DEFINING PROBLEMS

> *Students at any grade level should be able to ask questions of each other about the texts they read, the features of the phenomena they observe, and the conclusions they draw from their models or scientific investigations. For engineering, they should ask questions to define the problem to be solved and to elicit ideas that lead to the constraints and specifications for its solution. (NRC Framework 2012, p. 56)*

Scientific questions arise in a variety of ways. They can be driven by curiosity about the world, inspired by the predictions of a model, theory, or findings from previous investigations, or they can be stimulated by the need to solve a problem. Scientific questions are distinguished from other types of questions in that the answers lie in explanations supported by empirical evidence, including evidence gathered by others or through investigation.

While science begins with questions, engineering begins with defining a problem to solve. However, engineering may also involve asking questions to define a problem, such as: What is the need or desire that underlies the problem? What are the criteria for a successful solution? Other questions arise when generating ideas, or testing possible solutions, such as: What are the possible trade-offs? What evidence is necessary to determine which solution is best?

Asking questions and defining problems also involves asking questions about data, claims that are made, and proposed designs. It is important to realize that asking a question also leads to involvement in another practice. A student can ask a question about data that will lead to further analysis and interpretation. Or a student might ask a question that leads to planning and design, an investigation, or the refinement of a design.

Whether engaged in science or engineering, the ability to ask good questions and clearly define problems is essential for everyone. The following progression of Practice 1 summarizes what students should be able to do by the end of each grade band. Each of the examples of asking questions below leads to students engaging in other scientific practices.

Grades 6 – 8

Asking questions and defining problems in 6–8 builds on K–5 experiences and progresses to specifying relationships between variables and clarifying arguments and models.

- Ask questions that arise from careful observation of phenomena, models, or unexpected results, to clarify and/or seek additional information.
  - to identify and/or clarify evidence and/or the premise(s) of an argument.
  - to determine relationships between independent and dependent variables and relationships in models.
  - to clarify and/or refine a model, an explanation, or an engineering problem.
  - that require sufficient and appropriate empirical evidence to answer.
  - that can be investigated within the scope of the classroom, outdoor environment, and museums and other public facilities with available resources and, when appropriate, frame a hypothesis based on observations and scientific principles.
  - that challenge the premise(s) of an argument or the interpretation of a data set.
- Define a design problem that can be solved through the development of an object, tool, process or system and includes multiple criteria and constraints, including scientific knowledge that may limit possible solutions.

Grades 9-12

Asking questions and defining problems in 9–12 builds on K–8 experiences and progresses to formulating, refining, and evaluating empirically testable questions and design problems using models and simulations.

- Ask questions
  - that arise from careful observation of phenomena, or unexpected results, to clarify and/or seek additional information.
  - that arise from examining models or a theory, to clarify and/or seek additional information and relationships.
  - to determine relationships, including quantitative relationships, between independent and dependent variables.
  - to clarify and refine a model, an explanation, or an engineering problem.
- Evaluate a question to determine if it is testable and relevant.
- Ask questions that can be investigated within the scope of the school laboratory, research facilities, or field (e.g., outdoor environment) with available resources and, when appropriate, frame a hypothesis based on a model or theory.
- Ask and/or evaluate questions that challenge the premise(s) of an argument, the interpretation of a data set, or the suitability of a design.
- Define a design problem that involves the development of a process or system with interacting components and criteria and constraints that may include social, technical, and/or environmental considerations.

PRACTICE 2 DEVELOPING AND USING MODELS

> *Modeling can begin in the earliest grades, with students' models progressing from concrete "pictures" and/or physical scale models (e.g., a toy car) to more abstract representations of relevant relationships in later grades, such as a diagram representing forces on a particular object in a system. (NRC Framework, 2012, p. 58)*

Models include diagrams, physical replicas, mathematical representations, analogies, and computer simulations. Although models do not correspond exactly to the real world, they bring certain features into focus while obscuring others. All models contain approximations and assumptions that limit the range of validity and predictive power, so it is important for students to recognize their limitations. In science, models are used to represent a system (or parts of a system) under study, to aid in the development of questions and explanations, to generate data that can be used to make predictions, and to communicate ideas to others. Students can be expected to evaluate and refine models through an iterative cycle of comparing their predictions with the real world and then adjusting them to gain insights into the phenomenon being modeled. As such, models are based upon evidence. When new evidence is uncovered that the models can't explain, models are modified.

In engineering, models may be used to analyze a system to see where or under what conditions flaws might develop, or to test possible solutions to a problem. Models can also be used to visualize and refine a design, to communicate a design's features to others, and as prototypes for testing design performance.

Grades 6 – 8

Modeling in 6–8 builds on K–5 experiences and progresses to developing, using, and revising models to describe, test, and predict more abstract phenomena and design systems.

- Evaluate limitations of a model for a proposed object or tool.
- Develop or modify a model—based on evidence – to match what happens if a variable or component of a system is changed.
- Use and/or develop a model of simple systems with uncertain and less predictable factors.
- Develop and/or revise a model to show the relationships among variables, including those that are not observable but predict observable phenomena.
- Develop and/or use a model to predict and/or describe phenomena.
- Develop a model to describe unobservable mechanisms.
- Develop and/or use a model to generate data to test ideas about phenomena in natural or designed systems, including those representing inputs and outputs, and those at unobservable scales.

Grades 9-12

Modeling in 9–12 builds on K–8 experiences and progresses to using, synthesizing, and developing models to predict and show relationships among variables between systems and their components in the natural and designed worlds.

- Evaluate merits and limitations of two different models of the same proposed tool, process, mechanism or system in order to select or revise a model that best fits the evidence or design criteria.
- Design a test of a model to ascertain its reliability.
- Develop, revise, and/or use a model based on evidence to illustrate and/or predict the relationships between systems or between components of a system.
- Develop and/or use multiple types of models to provide mechanistic accounts and/or predict phenomena, and move flexibly between model types based on merits and limitations.
- Develop a complex model that allows for manipulation and testing of a proposed process or system.
- Develop and/or use a model (including mathematical and computational) to generate data to support explanations, predict phenomena, analyze systems, and/or solve problems.

PRACTICE 3 PLANNING AND CARRYING OUT INVESTIGATIONS

> *Students should have opportunities to plan and carry out several different kinds of investigations during their K-12 years. At all levels, they should engage in investigations that range from those structured by the teacher—in order to expose an issue or question that they would be unlikely to explore on their own (e.g., measuring specific properties of materials)—to those that emerge from students' own questions. (NRC Framework, 2012, p. 61)*

Scientific investigations may be undertaken to describe a phenomenon, or to test a theory or model for how the world works. The purpose of engineering investigations might be to find out how to fix or improve the functioning of a technological system or to compare different solutions to see which best solves a problem. Whether students are doing science or engineering, it is always important for them to state the goal of an investigation, predict outcomes, and plan a course of action that will provide the best evidence to support their conclusions. Students should design investigations that generate data to provide evidence to support claims they make about phenomena. Data aren't evidence until used in the process of supporting a claim. Students should use reasoning and scientific ideas, principles, and theories to show why data can be considered evidence.

Over time, students are expected to become more systematic and careful in their methods. In laboratory experiments, students are expected to decide which variables should be treated as results or outputs, which should be treated as inputs and intentionally varied from trial to trial, and which should be controlled, or kept the same across trials. In the case of field observations, planning involves deciding how to collect different samples of data under different conditions, even though not all conditions are under the direct control of the investigator. Planning and carrying out investigations may include elements of all of the other practices.

Grades 6 – 8

Planning and carrying out investigations in 6-8 builds on K-5 experiences and progresses to include investigations that use multiple variables and provide evidence to support explanations or solutions.

- Plan an investigation individually and collaboratively, and in the design: identify independent and dependent variables and controls, what tools are needed to do the gathering, how measurements will be recorded, and how many data are needed to support a claim.
- Conduct an investigation and/or evaluate and/or revise the experimental design to produce data to serve as the basis for evidence that meet the goals of the investigation.
- Evaluate the accuracy of various methods for collecting data.
- Collect data to produce data to serve as the basis for evidence to answer scientific questions or test design solutions under a range of conditions.
- Collect data about the performance of a proposed object, tool, process or system under a range of conditions.

Grades 9-12

Planning and carrying out investigations in 9-12 builds on K-8 experiences and progresses to include investigations that provide evidence for and test conceptual, mathematical, physical, and empirical models.

- Plan an investigation or test a design individually and collaboratively to produce data to serve as the basis for evidence as part of building and revising models, supporting explanations for phenomena, or testing solutions to problems. Consider possible confounding variables or effects and evaluate the investigation's design to ensure variables are controlled.
- Plan and conduct an investigation individually and collaboratively to produce data to serve as the basis for evidence, and in the design: decide on types, how much, and accuracy of data needed to produce reliable measurements and consider limitations on the precision of the data (e.g., number of trials, cost, risk, time), and refine the design accordingly.
- Plan and conduct an investigation or test a design solution in a safe and ethical manner including considerations of environmental, social, and personal impacts.
- Select appropriate tools to collect, record, analyze, and evaluate data.
- Make directional hypotheses that specify what happens to a dependent variable when an independent variable is manipulated.
- Manipulate variables and collect data about a complex model of a proposed process or system to identify failure points or improve performance relative to criteria for success or other variables.

PRACTICE 4 ANALYZING AND INTERPRETING DATA

> *Once collected, data must be presented in a form that can reveal any patterns and relationships and that allows results to be communicated to others. Because raw data as such have little meaning, a major practice of scientists is to organize and interpret data through tabulating, graphing, or statistical analysis. Such analysis can bring out the meaning of data—and their relevance—so that they may be used as evidence.*
>
> *Engineers, too, make decisions based on evidence that a given design will work; they rarely rely on trial and error. Engineers often analyze a design by creating a model or prototype and collecting extensive data on how it performs, including under extreme conditions. Analysis of this kind of data not only informs design decisions and enables the prediction or assessment of performance but also helps define or clarify problems, determine economic feasibility, evaluate alternatives, and investigate failures. (NRC Framework, 2012, p. 61-62)*

As students mature, they are expected to expand their capabilities to use a range of tools for tabulation, graphical representation, visualization, and statistical analysis. Students are also expected to improve their abilities to interpret data by identifying significant features and patterns, use mathematics to represent relationships between variables, and take into account sources of error. When possible and feasible, students should use digital tools to analyze and interpret data. Whether analyzing data for the purpose of science or engineering, it is important students present data as evidence to support their conclusions.

Grades 6 – 8

Analyzing data in 6–8 builds on K–5 experiences and progresses to extending quantitative analysis to investigations, distinguishing between correlation and causation, and basic statistical techniques of data and error analysis.

- Construct, analyze, and/or interpret graphical displays of data and/or large data sets to identify linear and nonlinear relationships.
- Use graphical displays (e.g., maps, charts, graphs, and/or tables) of large data sets to identify temporal and spatial relationships.
- Distinguish between causal and correlational relationships in data.
- Analyze and interpret data to provide evidence for phenomena.
- Apply concepts of statistics and probability (including mean, median, mode, and variability) to analyze and characterize data, using digital tools when feasible.
- Consider limitations of data analysis (e.g., measurement error), and/or seek to improve precision and accuracy of data with better technological tools and methods (e.g., multiple trials).
- Analyze and interpret data to determine similarities and differences in findings.
- Analyze data to define an optimal operational range for a proposed object, tool, process or system that best meets criteria for success.

Grades 9-12

Analyzing data in 9–12 builds on K–8 experiences and progresses to introducing more detailed statistical analysis, the comparison of data sets for consistency, and the use of models to generate and analyze data.

- Analyze data using tools, technologies, and/or models (e.g., computational, mathematical) in order to make valid and reliable scientific claims or determine an optimal design solution.
- Apply concepts of statistics and probability (including determining function fits to data, slope, intercept, and correlation coefficient for linear fits) to scientific and engineering questions and problems, using digital tools when feasible.
- Consider limitations of data analysis (e.g., measurement error, sample selection) when analyzing and interpreting data.
- Compare and contrast various types of data sets (e.g., self-generated, archival) to examine consistency of measurements and observations.
- Evaluate the impact of new data on a working explanation and/or model of a proposed process or system.
- Analyze data to identify design features or characteristics of the components of a proposed process or system to optimize it relative to criteria for success.

PRACTICE 5 USING MATHEMATICS AND COMPUTATIONAL THINKING

> *Although there are differences in how mathematics and computational thinking are applied in science and in engineering, mathematics often brings these two fields together by enabling engineers to apply the mathematical form of scientific theories and by enabling scientists to use powerful information technologies designed by engineers. Both kinds of professionals can thereby accomplish investigations and analyses and build complex models, which might otherwise be out of the question. (NRC Framework, 2012, p. 65)*

Students are expected to use mathematics to represent physical variables and their relationships, and to make quantitative predictions. Other applications of mathematics in science and engineering include logic, geometry, and at the highest levels, calculus. Computers and digital tools can enhance the power of mathematics by automating calculations, approximating solutions to problems that cannot be calculated precisely, and analyzing large data sets available to identify meaningful patterns. Students are expected to use laboratory tools connected to computers for observing, measuring, recording, and processing data. Students are also expected to engage in computational thinking, which involves strategies for organizing and searching data, creating sequences of steps called algorithms, and using and developing new simulations of natural and designed systems. Mathematics is a tool that is key to understanding science. As such, classroom instruction must include critical skills of mathematics. The NGSS displays many of those skills through the performance expectations, but classroom instruction should enhance all of science through the use of quality mathematical and computational thinking.

Grades 6 – 8

Mathematical and computational thinking in 6–8 builds on K–5 experiences and progresses to identifying patterns in large data sets and using mathematical concepts to support explanations and arguments.

- Use digital tools (e.g., computers) to analyze very large data sets for patterns and trends.
- Use mathematical representations to describe and/or support scientific conclusions and design solutions.
- Create algorithms (a series of ordered steps) to solve a problem.
- Apply mathematical concepts and/or processes (e.g., ratio, rate, percent, basic operations, simple algebra) to scientific and engineering questions and problems.
- Use digital tools and/or mathematical concepts and arguments to test and compare proposed solutions to an engineering design problem.

Grades 9-12

Mathematical and computational thinking in 9-12 builds on K-8 experiences and progresses to using algebraic thinking and analysis, a range of linear and nonlinear functions including trigonometric functions, exponentials and logarithms, and computational tools for statistical analysis to analyze, represent, and model data. Simple computational simulations are created and used based on mathematical models of basic assumptions.

- Create and/or revise a computational model or simulation of a phenomenon, designed device, process, or system.
- Use mathematical, computational, and/or algorithmic representations of phenomena or design solutions to describe and/or support claims and/or explanations.
- Apply techniques of algebra and functions to represent and solve scientific and engineering problems.
- Use simple limit cases to test mathematical expressions, computer programs, algorithms, or simulations of a process or system to see if a model "makes sense" by comparing the outcomes with what is known about the real world.
- Apply ratios, rates, percentages, and unit conversions in the context of complicated measurement problems involving quantities with derived or compound units (such as mg/mL, kg/m3, acre-feet, etc.).

PRACTICE 6 CONSTRUCTING EXPLANATIONS AND DESIGNING SOLUTIONS

The goal of science is to construct explanations for the causes of phenomena. Students are expected to construct their own explanations, as well as apply standard explanations they learn about from their teachers or reading. The Framework states the following about explanation:

> *"The goal of science is the construction of theories that provide explanatory accounts of the world. A theory becomes accepted when it has multiple lines of empirical evidence and greater explanatory power of phenomena than previous theories."(NRC Framework, 2012, p. 52)*

An explanation includes a claim that relates how a variable or variables relate to another variable or a set of variables. A claim is often made in response to a question and in the process of answering the question, scientists often design investigations to generate data.

The goal of engineering is to solve problems. Designing solutions to problems is a systematic process that involves defining the problem, then generating, testing, and improving solutions. This practice is described in the Framework as follows.

> *Asking students to demonstrate their own understanding of the implications of a scientific idea by developing their own explanations of phenomena, whether based on observations they have made or models they have developed, engages them in an essential part of the process by which conceptual change can occur.*
>
> *In engineering, the goal is a design rather than an explanation. The process of developing a design is iterative and systematic, as is the process of developing an explanation or a theory in science. Engineers' activities, however, have elements that are distinct from those of scientists. These elements include specifying constraints and criteria for desired qualities of the solution, developing a design plan, producing and testing models or prototypes, selecting among alternative design features to optimize the achievement of design criteria, and refining design ideas based on the performance of a prototype or simulation. (NRC Framework, 2012, p. 68-69)*

Grades 6 – 8

Constructing explanations and designing solutions in 6–8 builds on K–5 experiences and progresses to include constructing explanations and designing solutions supported by multiple sources of evidence consistent with scientific ideas, principles, and theories.

- Construct an explanation that includes qualitative or quantitative relationships between variables that predict(s) and/or describe(s) phenomena.
- Construct an explanation using models or representations.
- Construct a scientific explanation based on valid and reliable evidence obtained from sources (including the students' own experiments) and the assumption that theories and laws that describe the natural world operate today as they did in the past and will continue to do so in the future.
- Apply scientific ideas, principles, and/or evidence to construct, revise and/or use an explanation for real-world phenomena, examples, or events.
- Apply scientific reasoning to show why the data or evidence is adequate for the explanation or conclusion.
- Apply scientific ideas or principles to design, construct, and/or test a design of an object, tool, process or system.
- Undertake a design project, engaging in the design cycle, to construct and/or implement a solution that meets specific design criteria and constraints.
- Optimize performance of a design by prioritizing criteria, making tradeoffs, testing, revising, and re-testing.

Grades 9-12

Constructing explanations and designing solutions in 9–12 builds on K–8 experiences and progresses to explanations and designs that are supported by multiple and independent student-generated sources of evidence consistent with scientific ideas, principles, and theories.

- Make a quantitative and/or qualitative claim regarding the relationship between dependent and independent variables.
- Construct and revise an explanation based on valid and reliable evidence obtained from a variety of sources (including students' own investigations, models, theories, simulations, peer review) and the assumption that theories and laws that describe the natural world operate today as they did in the past and will continue to do so in the future.
- Apply scientific ideas, principles, and/or evidence to provide an explanation of phenomena and solve design problems, taking into account possible unanticipated effects.
- Apply scientific reasoning, theory, and/or models to link evidence to the claims to assess the extent to which the reasoning and data support the explanation or conclusion.
- Design, evaluate, and/or refine a solution to a complex real-world problem, based on scientific knowledge, student-generated sources of evidence, prioritized criteria, and tradeoff considerations.

PRACTICE 7 ENGAGING IN ARGUMENT FROM EVIDENCE

> *The study of science and engineering should produce a sense of the process of argument necessary for advancing and defending a new idea or an explanation of a phenomenon and the norms for conducting such arguments. In that spirit, students should argue for the explanations they construct, defend their interpretations of the associated data, and advocate for the designs they propose. (NRC Framework, 2012, p. 73)*

Argumentation is a process for reaching agreements about explanations and design solutions. In science, reasoning and argument based on evidence are essential in identifying the best explanation for a natural phenomenon. In engineering, reasoning and argument are needed to identify the best solution to a design problem. Student engagement in scientific argumentation is critical if students are to understand the culture in which scientists live, and how to apply science and engineering for the benefit of society. As such, argument is a process based on evidence and reasoning that leads to explanations acceptable by the scientific community and design solutions acceptable by the engineering community.

Argument in science goes beyond reaching agreements in explanations and design solutions. Whether investigating a phenomenon, testing a design, or constructing a model to provide a mechanism for an explanation, students are expected to use argumentation to listen to, compare, and evaluate competing ideas and methods based on their merits. Scientists and engineers engage in argumentation when investigating a phenomenon, testing a design solution, resolving questions about measurements, building data models, and using evidence to evaluate claims.

Grades 6 – 8

Engaging in argument from evidence in 6–8 builds on K–5 experiences and progresses to constructing a convincing argument that supports or refutes claims for either explanations or solutions about the natural and designed world(s).

- Compare and critique two arguments on the same topic and analyze whether they emphasize similar or different evidence and/or interpretations of facts.
- Respectfully provide and receive critiques about one's explanations, procedures, models, and questions by citing relevant evidence and posing and responding to questions that elicit pertinent elaboration and detail.
- Construct, use, and/or present an oral and written argument supported by empirical evidence and scientific reasoning to support or refute an explanation or a model for a phenomenon or a solution to a problem.
- Make an oral or written argument that supports or refutes the advertised performance of a device, process, or system based on empirical evidence concerning whether or not the technology meets relevant criteria and constraints.
- Evaluate competing design solutions based on jointly developed and agreed-upon design criteria.

Grades 9-12

Engaging in argument from evidence in 9–12 builds on K–8 experiences and progresses to using appropriate and sufficient evidence and scientific reasoning to defend and critique claims and explanations about the natural and designed world(s). Arguments may also come from current scientific or historical episodes in science.

- Compare and evaluate competing arguments or design solutions in light of currently accepted explanations, new evidence, limitations (e.g., trade-offs), constraints, and ethical issues.
- Evaluate the claims, evidence, and/or reasoning behind currently accepted explanations or solutions to determine the merits of arguments.
- Respectfully provide and/or receive critiques on scientific arguments by probing reasoning and evidence, challenging ideas and conclusions, responding thoughtfully to diverse perspectives, and determining additional information required to resolve contradictions.
- Construct, use, and/or present an oral and written argument or counter-arguments based on data and evidence.
- Make and defend a claim based on evidence about the natural world or the effectiveness of a design solution that reflects scientific knowledge and student-generated evidence.
- Evaluate competing design solutions to a real-world problem based on scientific ideas and principles, empirical evidence, and/or logical arguments regarding relevant factors (e.g. economic, societal, environmental, ethical considerations).

PRACTICE 8 OBTAINING, EVALUATING, AND COMMUNICATING INFORMATION

> *Any education in science and engineering needs to develop students' ability to read and produce domain-specific text. As such, every science or engineering lesson is in part a language lesson, particularly reading and producing the genres of texts that are intrinsic to science and engineering. (NRC Framework, 2012, p. 76)*

Being able to read, interpret, and produce scientific and technical text are fundamental practices of science and engineering, as is the ability to communicate clearly and persuasively. Being a critical consumer of information about science and engineering requires the ability to read or view reports of scientific or technological advances or applications (whether found in the press, the Internet, or in a town meeting) and to recognize the salient ideas, identify sources of error and methodological flaws, distinguish observations from inferences, arguments from explanations, and claims from evidence. Scientists and engineers employ multiple sources to obtain information used to evaluate the merit and validity of claims, methods, and designs. Communicating information, evidence, and ideas can be done in multiple ways: using tables, diagrams, graphs, models, interactive displays, and equations as well as orally, in writing, and through extended discussions.

Grades 6 – 8

Obtaining, evaluating, and communicating information in 6–8 builds on K–5 experiences and progresses to evaluating the merit and validity of ideas and methods.

- Critically read scientific texts adapted for classroom use to determine the central ideas and/or obtain scientific and/or technical information to describe patterns in and/or evidence about the natural and designed world(s).
- Integrate qualitative and/or quantitative scientific and/or technical information in written text with that contained in media and visual displays to clarify claims and findings.
- Gather, read, and synthesize information from multiple appropriate sources and assess the credibility, accuracy, and possible bias of each publication and methods used, and describe how they are supported or not supported by evidence.
- Evaluate data, hypotheses, and/or conclusions in scientific and technical texts in light of competing information or accounts.
- Communicate scientific and/or technical information (e.g. about a proposed object, tool, process, system) in writing and/or through oral presentations.

Grades 9-12

Obtaining, evaluating, and communicating information in 9–12 builds on K–8 experiences and progresses to evaluating the validity and reliability of the claims, methods, and designs.

- Critically read scientific literature adapted for classroom use to determine the central ideas or conclusions and/or to obtain scientific and/or technical information to summarize complex evidence, concepts, processes, or information presented in a text by paraphrasing them in simpler but still accurate terms.
- Compare, integrate and evaluate sources of information presented in different media or formats (e.g., visually, quantitatively) as well as in words in order to address a scientific question or solve a problem.
- Gather, read, and evaluate scientific and/or technical information from multiple authoritative sources, assessing the evidence and usefulness of each source.

- Evaluate the validity and reliability of and/or synthesize multiple claims, methods, and/or designs that appear in scientific and technical texts or media reports, verifying the data when possible.
- Communicate scientific and/or technical information or ideas (e.g. about phenomena and/or the process of development and the design and performance of a proposed process or system) in multiple formats (i.e., orally, graphically, textually, and mathematically).

ACTION STEPS

Reflecting on the Practices of Science and Engineering
Engaging students in the practices of science and engineering outlined in this section is not sufficient for science literacy. It is also important for students to stand back and reflect on how these practices have contributed to their own development, and to the accumulation of scientific knowledge and engineering accomplishments over the ages. Accomplishing this is a matter for curriculum and instruction, rather than standards, so specific guidelines are not provided in this document. Nonetheless, this section would not be complete without an acknowledgment that reflection is essential if students are to become aware of themselves as competent and confident learners and doers in the realms of science and engineering.

1. Review standards that are the focus of lessons you are currently teaching; identify the science and engineering practices that are embedded in the standards.
2. Evaluate a current lesson and identify practices that are already a part of the lesson.
3. Re-vamp a lesson to add specific practices?

For additional information, see the resources below.

The Teaching Tools for Science, Technology, Engineering and Math (STEM) Education PDFs provide practice briefs which can prompt reflection and guide action steps for Science and Engineering Practices.

- *Practice Brief 3* - Practices should not stand alone: How to sequence practices in a cascade to support student investigations
- *Practice Brief 4* - Are there multiple instructional models that fit with the science and engineering practices? (Short answer: Yes.)
- *Practice Brief 19* - Why should students learn to plan and carry out investigations in science and engineering?

There are many Teaching Tools for Science, Technology, Engineering and Math (STEM) Education practice briefs that address Science and Engineering Practices. For additional guidance, visit *stemteachingtools.org/tgs/Practices.*

Technology Standards

Technology standards for all WV students are found in WVBE Policy 2520.14, *West Virginia College- and Career-Readiness Standards for Technology and Computer Science*. All West Virginia teachers are responsible for classroom instruction that integrates content standards, foundational skills, literacy, learning skills and technology tools. These technology tools are key components of STEAM instruction. STEAM instruction can be the vehicle for covering many of these technology standards.

GRADES 6-8 STANDARDS

The following chart represents the components of technology that will be developed in grades 6-8.

6-8 Technology Indicators
» Use a variety of age-appropriate technologies to assist with the learning process. » Deepen learning across a variety of content areas through the use of age-appropriate technologies. » Integrate technology responsibly.

Middle school students increase their technological literacy through exposure to real-world issues and problems. They become increasingly aware of the variety of technologies and programs available, understand their varied uses across content areas, and learn which technologies as most useful in given situations. Students use technology to enhance their creativity, strengthen their ability to communicate and collaborate, and expand their critical thinking and problem-solving skills in a wide variety of situations. They continue to deepen their understanding of digital citizenship including privacy and security issues, copyright laws and cyberbullying.

Empowered Learner	
T.6-8.1	Navigate a variety of technologies and transfer their knowledge and skills to learn how to use new technologies.
T.6-8.2	Actively seek performance feedback from people, including teachers and from functionalities embedded in digital tools to improve their learning process, and select technology to demonstrate their learning in a variety of ways.
T.6-8.3	Identify and develop online networks within school policy, and customize their learning environments in ways that support their learning, in collaboration with an educator.
T.6-8.4	Articulate personal learning goals, select and manage appropriate technologies to achieve them, and reflect on their successes and areas of improvement in working toward their goals.

Digital Citizen	
T.6-8.5	Manage their digital identities and reputations within school policy, including demonstrating an understanding of how digital actions are never fully erasable.
T.6-8.6	Demonstrate and advocate for positive, safe, legal, and ethical habits when using technology and when interacting with others online.
T.6-8.7	Demonstrate and advocate for an understanding of intellectual property with both print and digital media-including copyright, permission, and fair use by creating a variety of media products that include appropriate citation and attribution elements.
T.6-8.8	Demonstrate an understanding of what personal data is and how to keep it private and secure, including the awareness of terms such as encryption, Hyper Text Transfer Protocol Security (HTTPS), password, cookies and computer viruses; they also understand the limitations of data management and how data-collection technologies work.

Knowledge Constructor	
T.6-8.9	Communicate complex ideas clearly using various digital tools to convey the concepts textually, visually, graphically, etc.
T.6-8.10	Locate and collect resources from a variety of sources and organize assets into collections for a wide range of projects and purposes.
T.6-8.11	Practice and demonstrate the ability to evaluate resources for accuracy, perspective, credibility and relevance.
T.6-8.12	Demonstrate and practice the ability to effectively utilize research strategies to locate appropriate digital resources in support of their learning.

Innovative Designer	
T.6-8.13	Create original works or responsibly repurpose other digital resources into new creative works.
T.6-8.14	Select appropriate platforms and tools to create, share and communicate their work effectively.
T.6-8.15	Explore real-world issues and problems and actively pursue an understanding of them and solutions for them.

Computational Thinker	
T.6-8.16	Select and use digital tools to support a design process and expand their understanding to identify constraints and trade-offs and to weight risks.
T.6-8.17	Defend the selection of a specific technology tool to complete a learning task.

Creative Communicator	
T.6-8.18	Publish or present content designed for specific audiences and select platforms that will effectively convey their ideas to those audiences.
T.6-8.19	Use communication tools (such as email, discussion boards, online conferences, learning management systems, and portfolios) to gather information, share ideas, and respond to questions.

Global Collaborator	
T.6-8.20	Select collaborative technologies and use them to work with others to investigate and develop solutions related to local and global issues.
T.6-8.21	Use collaborative technologies to connect with others, including peers, experts, and community members, to learn about issues and problems or to gain broader perspective.
T.6-8.22	Use digital tools to interact with others to develop a richer understanding of different perspectives and cultures.

ACTION STEPS

The **Technology Clusters** represent the types of learners, thinkers, and citizens that we are teaching our students to become; e.g., Empowered Learner, Digital Citizen, Knowledge Constructor, Innovative Designer, Computational Thinker, Creative Communicator, and Global Collaborator.

Choose a lesson or unit that you currently teach. For that lesson or unit:

1. Review the technology standards for your grade band. Identify the standards that you cover in the activities for this lesson or standard.
2. Review the technology standards for your grade band. What activity(ies) could be updated to add more technology and to cover more of the technology standards for your grade band?
3. Review the technology standards for your grade band. What activity(ies) could be added to add value and complexity to the lesson or unit which would also cover more of the technology standards for your grade band?
4. Review the technology standards for your grade band with a team of teachers, your PLC, or a group of educators with which you collaborate. Identify the technology standards that can be covered through a collaborative lesson, activity, or unit.

GRADES 9-12 STANDARDS

The following chart represents the components of technology that will be developed in grades 9-12.

9-12 Technology Indicators

- Use a variety of age-appropriate technologies to assist with the learning process.
- Deepen learning across a variety of content areas through the use of age-appropriate technologies.
- Integrate technology responsibly.

High school students perfect their understanding of the myriad ways technology is used to share information, communicate, collaborate and create. They use technology to solve higher-order real-world problems, apply it to complex tasks, develop their own technology and explore career options that are technology-based. Students explore the benefits and limitations of social media, discuss the ramifications of the improper use of technology and media, and grasp the importance of checking facts, distinguishing points of view, confirming the reliability of sources, and verifying information obtained via electronic and social media.

Empowered Learner	
T.9-12.1	Articulate personal learning goals, select, and manage appropriate technologies to achieve them, and reflect on their successes and areas of improvement in working toward their goals.
T.9-12.2	Develop online networks within school policy, and customize their learning environments in ways that support their learning.
T.9-12.3	Utilize a variety of technologies efficiently and transfer their knowledge and skills to learn how to use new technologies.
T.9-12.4	Select appropriate platforms and tools to create, share, and communicate their work effectively.
T.9-12.5	Explore real-world issues and problems and actively pursue an understanding of them and solutions for them.
T.9-12.6	Locate and collect resources from a variety of sources and organize assets into collections for a wide range of projects and purposes.
T.9-12.7	Practice and demonstrate the ability to evaluate resources for accuracy, perspective, credibility, and relevance.
T.9-12.8	Utilize research strategies effectively to locate appropriate digital resources across all content areas.

Digital Citizens	
T.9-12.9	Keep their personal data private and secure, including the awareness of terms such as encryption, HTTPS, passwords, cookies, and computer viruses; understand the limitations of data management and how data-collection technologies work.
T.9-12.10	Understand how to manage digital identities and reputations within school policy, including demonstrating an understanding of how digital actions are never fully erasable.
T.9-12.11	Demonstrate and advocate for positive, safe, legal, and ethical habits when using technology and when interacting with others online.
T.9-12.12	Demonstrate and advocate for an understanding of intellectual property with both print and digital media including copyright, permission and fair use by creating a variety of media products that include appropriate citation and attribution elements.

Knowledge Constructor	
T.9-12.13	Publish, present, and defend content designed for specific audiences and select platforms that will effectively convey their ideas to those audiences.
T.9-12.14	Communicate complex ideas clearly using various digital tools to convey the concepts textually, visually, graphically, etc.
T.9-12.15	Create original works or responsibly repurpose other digital resources into new creative works.

Innovative Designer	
T.9-12.16	Engage in a design process and employ it to generate ideas, create innovative products or solve authentic problems.
T.9-12.17	Present ideas and information using appropriate tools that are appropriate for specific audiences.

Computational Thinker	
T.9-12.18	Find or organize relevant data and use technology to analyze and represent it in various ways to solve problems and make decisions.
T.9-12.19	Apply evaluation strategies when using electronic resources (such as publication/copyright date, fact vs. fiction, sources, credibility, ease of use).

Creative Communicator	
T.9-12.20	Actively seek performance feedback from people, including teachers, and from functionalities embedded in digital tools to improve their learning process, and select technology to demonstrate their learning in a variety of ways.
T.9-12.21	Use communication tools (such as email, discussion boards, online conferences, learning management systems, portfolios) to gather information, share ideas and respond to questions.

Global Collaborator	
T.9-12.22	Use collaborative technologies to connect with others, including peers, experts, and community members, to learn about issues and problems or to gain a broader perspective.
T.9-12.23	Use digital tools to interact with others to mutually develop a richer understanding of different perspectives and cultures.
T.9-12.24	Explore local and global issues and select collaborative technologies to use to work with others to investigate and develop solutions.

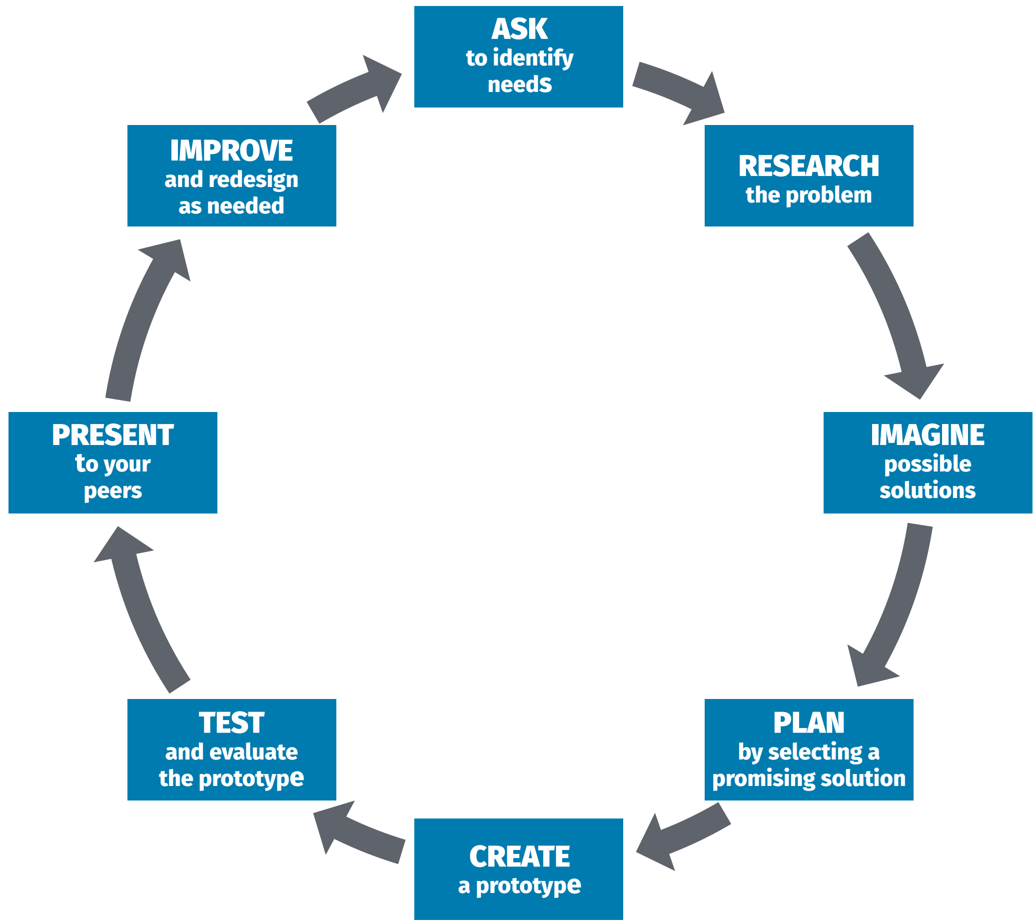
ACTION STEPS

The **Technology Clusters** represent the types of learners, thinkers, and citizens that we are teaching our students to become; e.g., Empowered Learner, Digital Citizen, Knowledge Constructor, Innovative Designer, Computational Thinker, Creative Communicator, and Global Collaborator.

Choose a lesson or unit that you currently teach. For that lesson or unit:

1. Review the technology standards for your grade band. Identify the standards that you cover in the activities for this lesson or standard.
2. Review the technology standards for your grade band. What activity(ies) could be updated to add more technology and to cover more of the technology standards for your grade band?
3. Review the technology standards for your grade band. What activity(ies) could be added to add value and complexity to the lesson or unit which would also cover more of the technology standards for your grade band?
4. Review the technology standards for your grade band with a team of teachers, your PLC, or a group of educators with which you collaborate. Identify the technology standards that can be covered through a collaborative lesson, activity, or unit.

Engineering Process



Ask: Identify the Need & Constraints

Engineers ask critical questions about what they want to create, whether it be something tangible like a skyscraper or a process like a more effective way to purify wastewater. These questions include:

- What is the problem to solve?
- What do we want to design?
- Who is it for?
- What do we want to accomplish?
- What are the project requirements?
- What are the limitations?
- What is our goal?

Research the Problem

This includes talking to people from many different backgrounds and specialties to assist with researching what products or solutions already exist, or what technologies might be adaptable to your needs.

Imagine: Develop Possible Solutions
You work with a team to brainstorm ideas and develop as many solutions as possible. This is the time to encourage wild ideas and defer judgment! Build on the ideas of others! Stay focused on topic and have one conversation at a time! Remember: good design is all about teamwork!

Plan: Select a Promising Solution
For many teams this is the hardest step! Revisit the needs, constraints and research from the earlier steps, compare your best ideas, select one solution and make a plan to move forward with it.

Create: Build a Prototype
Building a prototype makes your ideas real! These early versions of the design solution help your team verify whether the design meets the original challenge objectives. Push yourself for creativity, imagination and excellence in design.

Test and Evaluate Prototype
Does it work? Does it solve the need? Communicate the results and get feedback. Analyze and talk about what works, what doesn't and what could be improved.

Presentation of Solution
Designs, tests and discussion do little without presenting your findings to a panel of your peers. Peer review will help to draw attention to things that you might not have seen or been able to see as you were working on your design.

Improve: Redesign as Needed
Discuss how you could improve your solution. Make revisions. Draw new designs. Iterate your design to make your product the best it can be. And now, REPEAT!

"This material is adapted from the Teach Engineering digital library collection at *www.TeachEngineering.org*.

ACTION STEPS

Explore the following resources:

- What is engineering? *https://www.teachengineering.org/k12engineering/what*
- Why teach engineering in K-12? *https://www.teachengineering.org/k12engineering/wh*y
- Types of engineering *https://www.teachengineering.org/k12engineering/types-of-engineering*

Browse the classroom resources at Teach Engineering: *https://www.teachengineering.org/curriculum/browse*. Note that some lessons are only partial design activities, while some are full design activities.

Answer the following questions:

- Where do I already include the Engineering Design Process in my teaching?
- What is a lesson that I could easily adapt to include more of the Engineering Design Process?
- What would I need to do to make that adaptation?

STEAM - Integrating the Arts

When students incorporate the arts in STEM, they are given the freedom to unleash creativity, personal expression, and empathy into their activity. The arts bring STEM to a broad and diverse group of students, deepening the experience for all learners. STEM, by design, is intended to be a transdisciplinary endeavor, including the traditional STEM disciplines, as well as the arts, the liberal arts, and the humanities. Integrating the arts demonstrates the power in the integration of all disciplines into STEM problem-solving activities.

WVBE Policy, 2520.9, the West Virginia College- And Career-Readiness Standards for The Arts promote proficiency in performing a range of material or creating two- or three-dimensional artworks, analyzing and processing feedback, the application of verbal and non-verbal communication, and integrity in responsible collaboration with peers. Students will develop problem solving and critical thinking skills independently and collaboratively as they engage in the common domains of the arts – create, connect, explore, perform, relate, respond, and others germane to specific arts disciplines. Each of these skills will enhance the development of STEAM-minded West Virginia students.

Domains in the Arts are the broad components that make up all arts disciplines. When planning STEAM instruction, the domains provide a framework for Arts integration.

- **Create** - In the arts, to create is to generate, conceptualize, and express artistic ideas and work. It can include a performance, a composition, and/or a two- and three-dimensional piece of art.
- **Connect** - In the arts, to connect is to synthesize and relate knowledge and experiences to make art. It can include relating artistic ideas and works with societal, cultural and historical context to deepen understanding.
- **Explore** - In the arts, to explore is to study, analyze, experience, describe and interpret arts disciplines.
- **Perform** - In the arts, to perform is to interpret, develop and refine artistic ideas and works for presentation and study. It can include individual and group efforts.
- **Relate** - In the arts, to relate is to understand the relationship of a single arts discipline to other arts disciplines, other disciplines outside the arts, and to a variety of cultures and historical periods.
- **Respond** - In the arts, to respond is to perceive, interpret, and analyze artistic work giving it meaning. It can include applying criteria to evaluate artistic work.

Visual Art has its own unique set of domains – media, techniques and processes, elements of art and principles of design, subject matter, symbols, and Ideas, art history and diversity, reflection and analysis and multi-disciplinary connections. The domains specific to visual art may be a valuable planning resources for teachers as they integrate the arts into STEAM instruction.

ACTION STEPS

Choose a lesson or unit that you currently teach. For that lesson or unit:

- Review the arts standards for your grade band. Identify the standards that you cover in the activities for this lesson or standard.
- What activity(ies) could be updated to add more arts and to cover more of the arts standards for your grade band?
- What activity(ies) could be added to add value and complexity to the lesson or unit which would also cover more of the arts standards for your grade band?
- Review the arts standards for your grade band with a team of teachers, your PLC, or a group of educators with which you collaborate. Identify the arts standards that can be covered through a collaborative lesson, activity, or unit.

Mathematical Habits of Mind

The Mathematical Habits of Mind and the Mathematics Content Standards are integral components of the West Virginia College- and Career-Readiness Standards for Mathematics. These standards address the attributes and characteristics that students should develop to foster mathematical understanding and expertise, as well as concepts, skills, and knowledge — what students need to understand, know, and be able to do. The standards require that Mathematical Habits of Mind and Mathematics Content Standards be connected. These connections are essential to support the development of students' broader mathematical understanding, as students who lack understanding of a topic may rely too heavily on procedures.

To achieve optimal effectiveness, the two components of the West Virginia College- and Career-Readiness Standards for mathematics — the Mathematical Habits of Mind and the Mathematics Content Standards — must both be taught carefully and practiced intentionally. The two should work in tandem rather than operate in isolation. The eight Mathematical Habits of Mind (MHM) describe the attributes of mathematically proficient students and expertise that mathematics educators at all levels should seek to develop in their students. The Mathematical Habits of Mind provide a vehicle through which students engage with and learn mathematics. As students move from elementary school through high school, the Mathematical Habits of Mind are integrated in the tasks as students engage in doing mathematics and master new and more advanced mathematical ideas and understandings. The following table summarizes the eight Mathematical Habits of Mind (MHM) and provides examples of questions that teachers might use to support mathematical thinking and student engagement (as called for in the MHM standards).

Summary of the Mathematical Habits of Mind	**Questions to Develop Mathematical Thinking**
MHM1 **Make sense of problems and persevere in solving them.** Mathematically proficient students: » Interpret and make meaning of the problem to find a starting point. » Analyze what is given in order to explain to themselves the meaning of the problem. » Plan a solution pathway instead of jumping to a solution. » Monitor their own progress and change the approach if necessary. » See relationships between various representations. » Relate current situations to concepts or skills previously learned and connect mathematical ideas to one another. » Continually ask themselves, "Does this make sense?" » Can understand various approaches to solutions.	» How would you describe the problems in your own words? » How would you describe what you are trying to find? » What do you notice about _______? » What information is given in the problem? » Describe the relationship between the quantities. » Describe what you have already tried. What might you change? » Talk me through the steps you have used to this point. » What steps in the process are you most confident about? » What are some other strategies you might try? » What are some other problems that are similar to this one? » How might you use one of your previous problems to help you begin? » How else might you [organize, represent, show, etc.] _______?

MHM2 **Reason abstractly and quantitatively.** Mathematically proficient students: » Make sense of quantities, and the relationships between quantities, in problem situations. » Decontextualize (represent a situation symbolically and manipulate the symbols) and contextualize (make meaning of the symbols in a problem) quantitative relationships. » Understand the meaning of quantities and flexibly use operations and their properties. » Create a logical representation of the problem. » Attend to the meaning of quantities, not just how to compute them.	» What do the numbers used in the problem represent? » What is the relationship of the quantities? » How is _______ related to _______? » What is the relationship between _______ and _______? » What does _______ mean to you? (e.g. symbol, quantity, diagram) » What properties might we use to find a solution? » How did you decide that you needed to use _______ in this task? » Could we have used another operation or property to solve this task? Why or why not?
MHM3 **Construct viable arguments and critique the reasoning of others.** Mathematically proficient students: » Analyze problems and use stated mathematical assumptions, definitions, and established results in constructing arguments. » Justify conclusions with mathematical ideas. » Listen to the arguments of others, and ask useful questions to determine if an argument makes sense. » Ask clarifying questions or suggest ideas to improve or revise the argument. » Compare two arguments and determine if the logic is correct or flawed.	» What mathematical evidence would support your solution? » How can we be sure that _______? » How could you prove that _______? » Will it still work if _______? » What were you considering when _______? » How did you decide to try that strategy? » How did you test whether your approach worked? » How did you decide what the problem was asking you to find? (What was unknown?) » Did you try a method that did not work? Why didn't it work? Would it ever work? Why or why not? » What is the same and what is different about _______? » How could you demonstrate a counter-example? » I think it might be clearer if you said _______. Is that what you meant? » Is your method like Shawna's method? If not, how is your method different?
MHM4 **Model with mathematics.** Mathematically proficient students: » Understand this is a way to reason quantitatively and abstractly (able to decontextualize and contextualize). » Apply the mathematics they know to solve everyday problems. » Simplify a complex problem and identify important quantities to look at relationships. » Represent mathematics to describe a situation either with an equation or a diagram, and interpret the results of a mathematical situation. » Reflect on whether the results make sense, possibly improving or revising the model. » Ask themselves, "How can I represent this mathematically?"	» What math drawing or diagram could you make and label to represent the problem? » What are some ways to represent the quantities? » What is an equation or expression that matches the [diagram, number line, chart, table, etc.]? » Where did you see one of the quantities in the task in your equation or expression? » How would it help to create a [diagram, graph, table, etc.]? » What are some ways to visually represent _______? » What formula might apply in this situation?

MHM5 **Use appropriate tools strategically.** Mathematically proficient students: » Use available tools including visual models, recognizing the strengths and limitations of each. » Use estimation and other mathematical knowledge to detect possible errors. » Identify relevant external mathematical resources to pose and solve problems. » Use technological tools to deepen their understanding of mathematics.	» What mathematical tools could we use to visualize and represent the situation? » What information do you have? » What do you know that is not stated in the problem? » What approach would you consider trying first? » What estimate did you make for the solution? » In this situation, would it be helpful to use a [graph, number line, ruler, diagram, calculator, manipulatives, etc.]? » Why was it helpful to use _______? » What can using a _______ show us that _______ may not? » In what situations might it be more informative or helpful to use _________?
MHM6 **Attend to precision.** Mathematically proficient students: » Communicate precisely with others and try to use clear mathematical language when discussing their reasoning. » Understand the meanings of symbols used in mathematics and can label quantities appropriately. » Express numerical answers with a degree of precision appropriate for the problem context. » Calculate efficiently and accurately.	» What mathematical terms apply in this situation? » How did you know your solution was reasonable? » Explain how you might show that your solution answers the problem. » What would be a more efficient strategy? » How are you showing the meaning of the quantities? » What symbols or mathematical notations are important in this problem? » What mathematical language, definitions, properties (and so forth) can you use to explain _______? » Can you say it in a different way? » Can you say it in your own words? And now say it in mathematical words. » How could you test your solution to see if it answers the problem?
MMH7 **Look for and make use of structure.** Mathematically proficient students: » Look for the overall structures and patterns in mathematics and think about how to describe these in words, mathematical symbols, or visual models. » See complicated things as single objects or as being composed of several objects. Compose and decompose conceptually. » Apply general mathematical patterns, rules, or procedures to specific situations.	» What observations can you make about _______? » What do you notice when _______? » What parts of the problem might you [eliminate, simplify, etc.]? » What patterns do you find in _______? » How do you know if something is a pattern? » What ideas that we have learned before were useful in solving this problem? » What are some other problems that are similar to this one? » How does this relate to _______? » In what ways does this problem connect to other mathematical concepts?

MHM8 **Look for and express regularity in repeated reasoning.** Mathematically proficient students: » See repeated calculations and look for generalizations and shortcuts. » See the overall process of the problem and still attend to the details in the problem-solving steps. » Understand the broader application of patterns and see the structure in similar situations. » Continually evaluate the reasonableness of their intermediate results.	» Explain how this strategy works in other situations. » Is this always true, sometimes true, or never true? » How would we prove that _______? » What do you notice about _______? » What is happening in this situation? What would happen if_______? » Is there a mathematical rule for _______? » What predictions or generalizations can this pattern support? » What mathematical consistencies do you notice? » How is this situation like and different from other situations using this operation?

The Mathematical Habits of Mind are developed throughout each grade and, together with the content standards, prescribe that students experience mathematics as a rigorous, coherent, useful, and logical subject. They represent a picture of what it looks like for students to understand and do mathematics in the classroom and should be integrated into every mathematics lesson for all students. Ideally, several Mathematical Habits of Mind will be evident in each lesson as they interact and overlap with each other. The Mathematical Habits of Mind are not a checklist; they are the basis for mathematics instruction and learning. To help students persevere in solving problems (MHM1), teachers need to allow their students to struggle productively, and they must be attentive to the type of feedback they provide to students. Dr. Carol Dweck's research (Dweck, 2006) revealed that feedback offering praise of effort and perseverance seems to engender and reinforce a "growth mindset."[1] In Dweck's estimation, "[g]rowth-minded teachers tell students the truth [about being able to close the learning gap between them and their peers] and then give them the tools to close the gap" (Dweck, 2006).

ACTION STEPS

Choose a Mathematical Habit of Mind on which to focus in your classroom.

- How will you see yourself addressing this Mathematical Habit of Mind in the context of a unit of study?
- Create a list of questions that you might use to support mathematical thinking and student engagement as the unit of study unfolds.
- Be prepared to share your results with your peers, your PLC, or your school team.

According to Dweck, a person with a growth mindset believes that intelligence is something that can be nurtured and gained. When people with this type of mindset do not meet the expected level of performance on a test or an assignment or have difficulty understanding a concept, they work hard at it, believing that if they just try hard enough, they will achieve the desired outcome.

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Making the STEAM Classroom Inclusive for Students with Disabilities

It is widely understood that a one-size-fits-all approach to education does not work. This is particularly the case in the context of STEAM education and students with disabilities. Educators who are rethinking education to intentionally include STEAM should be ensuring nothing limits students from being prepared for what comes next in life, whether it is continuing their education, transitioning to a work environment, or both. It is imperative that we keep this in mind when planning STEAM experiences for students with disabilities.

The possibilities of what can happen when educators challenge the status quo of special education to include STEAM is very exciting. Teachers and administrators play a key role in determining the climate in STEAM environments for students with disabilities. Whether or not an instructor is supportive of all students can make or break the experience.

EDUCATOR TIPS

The following are simple tips educators should follow to ensure equitable access to STEAM experiences for all students.

- Adopt Universal Design for Learning principles, which will make it easier to address the needs of students with and without disabilities and offer the best possible support to the largest number of students.
- Allow the use of graphic organizers and visuals as much as possible.
- Assume competency. Believe that students with disabilities can learn at higher levels and that you can create an environment to help be successful.
- Model persistence, communication, creativity, and collaboration. These qualities are especially useful to students with disabilities who may need support in these areas.
- Build on students' strengths and interests. Leverage their strengths and interests to increase their comfort and excitement about learning
- Explicitly teach self-regulation strategies. STEAM classrooms can often be over-stimulating, with complex distractions. It can become frustrating for some students to maintain attention or motivation. Students with deficits in executive functioning may need practice with self-regulatory strategies including self-monitoring, self-instruction, goal-setting, and self-reinforcement in order to be successful in the STEAM classroom.
- Get to know your students with disabilities. Work together with their special educators and learn as much as you can about students and their strengths and difficulties in order to make reasonable accommodations.

- Make accommodations to the physical learning environment to make resources and learning accessible to all students. The following links provide ideas for making the physical environment and materials accessible to students with low-incidence disabilities.
  - Math resources for the education of deaf and hard of hearing students: *https://deaftec.org/teaching-learning/strategies-for-teaching-math/*
  - Science equipment that are accessible for all students: *https://www.washington.edu/doit/accessible-science-equipment*
  - STEM accommodations for students with blindness: *https://www.washington.edu/doit/what-are-typical-accommodations-students-blindness*
  - Perkins School for the Blind Accessible Science Resources: *https://www.perkinselearning.org/topics/stem*

Student Success Standards

West Virginia College- and Career-Readiness Dispositions and Standards for Student Success
The Middle Level Programming (Grades 6-8) focuses on academic, career, social, and emotional development. Students need support in developing the knowledge, skills, and dispositions to navigate a socially complex environment and the creation of a vision for their future. The WVCCRDSSS support students to achieve school success, establish the foundation for high school, and become globally competent citizens. The standards will be delivered within the programmatic level in a sequence designed by the school leadership team.

6-8 Dispositions

In a developmentally appropriate fashion:
- increase interpersonal and social skills.
- refine learning, study, and work habits.
- consider career and life goals.
- adopt practices that support global citizenship.

Individual Dispositions	Initiative-Interaction	Responsive Interaction
» Participate politely in classroom discussions » Initiate positive habits that contribute to school readiness » Take responsibility for completing homework » Appropriately cope with stressful situations » Use technology when it is contextually appropriate without interruption or offense to others » Participate appropriately for a variety of situations » Exhibit sportsmanship and appropriate audience behavior » Refrain from spreading rumors » Make thoughtful decisions to balance academic and social success » Assume responsibility for personal and academic success » Seek resources as needed to support success	» Initiate and maintain appropriate conversations » Politely excuse oneself from activities and conversations » Introduce oneself and make introductions » Start activity under one's own motivation » Balance speaking and listening » Utilize cooperation and negotiation in group work » Engage in polite conversation with others about individual, social and cultural differences » Give and ask for directions in public » Engage in positive peer groups and activities » Engage in student leadership » Analyze the accuracy of various digital information sources and networks » Employ digital security techniques to protect oneself and others	» Respond appropriately in various situations » Participate appropriately in group collaboration » Help peers when asked » Accept ideas different from one's own » Interact appropriately with adults » Express sympathy and empathy » Follow verbal and written directions » Respond politely to school and public authorities » Resolve conflict peacefully » Deal with embarrassment in non-aggressive ways » Accept praise with humility » Make one's own responsible decisions in peer settings » Resist pressure to engage in inappropriate behavior » Consider the impact of various choices on one's friends and family

The High School Level Programming (Grades 9-12) focuses on academic, career, social and emotional development, and global citizenship. Acquisition of the knowledge, skills, and dispositions described in WVCCRDSSS help students achieve school success and prepare to successfully transition to their post-secondary choices; whether it is direct placement in entry-level jobs, credit-bearing academic college course, industry-recognized certificate, license, or workforce training programs. These standards will be delivered within the programmatic level in a sequence designed by the school leadership team.

9-12 Dispositions

In a developmentally appropriate fashion:

- increase interpersonal and social skills.
- refine learning, study, and work habits.
- consider career and life goals.
- adopt practices that support global citizenship.

Individual Behaviors

- Use class time productively
- Balance school and other activities to meet obligations
- Develop academic and personal goals
- Control emotions
- Identify and manage resources
- Practice and model internet etiquette
- Refrain from inappropriate public displays of affection
- Respect cultural diversity
- Make ethical decisions
- Follow digital laws and rules
- Establish goals for future success

Initiative Interaction

- Express feelings appropriately
- Give compliments
- Express dissatisfaction appropriately
- Respect the space of others
- Stand up for a friend
- Initiate post-secondary planning
- Utilize technology skills to advance attainment of personal and academic goals.
- Advocate for self and others
- Give affirmations to support others
- Express dissatisfaction in appropriate ways
- Exercise civic responsibility through participation in student government activities
- Access personal values and norms
- Act as a responsible role model

Responsive Interaction

- Recognize feelings of others and respond appropriately
- Deal with disappointment in a manner that does not harm
- Respond to complaints
- Use constructive criticism to make improvements
- Complete post-secondary applications
- Address rumors appropriately
- Respond to peer pressure appropriately and use refusal skills when necessary
- De-escalate violent situations (physical and virtual)
- Apply a decision-making process to academic and social issues
- Choose appropriate options to negative peer pressure

Work Skills Interaction

- Maintain focus on work tasks
- Ask for feedback and respond appropriately
- Use negotiation skills
- Interact appropriately with team members
- Act as a responsible and respected presentative of the school
- Encourage positive habits in self and others
- Utilize communication, negotiation, and conflict resolution skills in the workplace
- Advocate for appropriate work conditions
- Utilize social skills to improve customer service
- Formulate a post-secondary plan
- Provide leadership for a school/community service project
- Use technology in an appropriate manner displaying digital citizenship

ACTION STEPS

1. Review the standards that are the focus of the lesson you are teaching; identify the dispositions and standards for student success which are already embedded into the lesson standards.
2. Review the standards that are the focus of the lesson you are teaching; identify the dispositions and standards for student success which may be easily embedded in the lesson standards.
3. Re-vamp the lesson to add any additional dispositions and standards for student success which may enhance the student learning.

Design Thinking

Design thinking is a unique method for learning, collaboration, and problem-solving. While there are many models for this approach, the basic framework is a process that enables teachers and students to embrace challenges and develop the skills necessary to strategize and build innovative solutions. Design thinkers strive to balance what is desirable from a user's point of view with what is feasible with technology and viable from an educator's perspective.

The basic model of Design Thinking includes the following:

- **Empathize**: seeking to understand a group or audience by observing and interviewing.
- **Define**: creating a point of view based on the needs of a group.
- **Ideate**: brainstorm creative solutions. Start broad and go narrow.
- **Prototype**: build a representation of one or more ideas. Think rough draft.
- **Test**: share prototyped idea with group for feedback

The process allows educators to grow wild ideas into real-world solutions!

Who is this solution for? What is this person thinking? What words would you use to describe how they are feeling? Put yourself in their situation. How would you feel?

What is the main problem to be solved? What do these people need? Put a positive spin on the problem. How are you going to help?

Brainstorm as many wild and creative solutions as possible! Write it down. Draw it. Demonstrate it! Use different ways of thinking to get your brain working.

Make and create a solution to the problem. Is your creation a drawing, a model, or a plan? Remember, This is a rough draft, it doesn't have to be perfect.

Test the prototype. Keep in mind the empathy you used when defining the problem for which you were looking for a solution. Does the prototype need modification? Keep going! Work through as many cycles as you need until you find the best solution.

ACTION STEPS

Learn more about Design Thinking by reviewing this article about employing empathy in Design Thinking. *https://www.edutopia.org/blog/teaching-empathy-through-design-thinking-rusul-alrubail*

Visit Design for Change USA and locate a social issue that holds meaning for your students, for example plastic pollution or elder isolation. Watch the video and then preview the Empathy Warm Ups, Design Sprints, and Community Action activities. *https://designforchange.us/*

Review the Introduction to Design Thinking Lesson at Common Sense Media. Note the steps and stages in the lesson.
https://www.commonsense.org/education/lesson-plans/introduction-into-design-thinking

Review the Featured Resources at the Stanford Design School site. *https://dschool.stanford.edu/resources*

Answer these questions:

- Which of the activities in the resources above could I employ in my classroom?
- What standards do I teach will allow me to most easily include a design thinking activity?
- How can I incorporate a transdisciplinary STEAM activity into a design thinking activity?
- How can I assist my students in becoming more empathetic?

West Virginia Standards for Effective Schools

The West Virginia Standards for Effective Schools describe the seven common standards expected of schools to ensure high quality education in engaging learning environments. The research-based standards represent a coherent and aligned framework for continuous improvement which schools can use as a guide for self-assessment, decision-making, professional development, and strategic planning.

Clear and Focused Mission

> *Definition: The school's purpose and approach to support learning for all*

Key Concepts:

- A culture of ownership for student success is pervasive.
- Shared beliefs and values are evident.
- Commitment to a shared vision is present.

Instructional Leadership

> *Definition: Ensuring the effectiveness of instruction leads to student achievement*

Key Concepts:

- Principal ensures implementation of high yield instructional strategies.
- Staff lead and assume responsibility for overall academic success.
- Students are engaged in age-appropriate leadership opportunities.

High Expectations for Success

> *Definition: Purposefully providing a climate in which all students can learn and succeed*

Key Concepts:

- Staff believe in and demonstrate their ability to successfully teach all students.
- Staff believe all students can and will obtain mastery.
- Responses and adjustments occur to assure mastery when some students do not learn, or have already mastered the concept.

Positive and Safe Environment

> *Definition: Orderly, purposeful, and accommodating of all students' needs*

Key Concepts:

- Collaboration and cooperation are pervasive among staff and students.
- Appropriate behavior is expected and supported.
- Student diversity is embraced and respected.

Equitable Opportunities to Learn and Effective Instruction

> *Definition: Sufficient time for meaningful learning is provided to all students*

Key Concepts:

- Instructional time is utilized efficiently and effectively.
- Instructional activities are rigorous and aligned to student interest and State Standards. Feedback is timely, ongoing, and supports individual student growth.

Frequent Monitoring of Student Progress

> *Definition: A variety of data are used as the basis for adjusting the instructional approach*

Key Concepts:

- Formative assessment processes are utilized to measure student performance.
- Student performance is used to guide instructional decisions.
- Teacher monitors student progress toward established instructional goals.

Family and Community Partnerships

> *Definition: Purposeful relationships exist between families, community, and the school*

Key Concepts:

- The school community fosters shared responsibility for student success.
- Community understands and supports the school's mission.
- Partnerships exist between school and community to support academic, social-emotional, and physical needs.

ACTION STEPS

Standard 1: Clear and Focused Mission

> *What can I, the educator, do to support learning for all?*

Considerations for reflection:

- What are my criteria for ensuring all students are included in my school?
- Do I design, teach, coach, and assess appropriate curriculum that is based on student need?
- Is my evidence of student learning gathered from authentic experiences occurring throughout the school day?

Standard 2: Instructional Leadership

> *How do I assume responsibility for overall academic success and ensure students are engaged in age-appropriate leadership opportunities?*

Considerations for reflection:

- How is leadership at my school shared?
- Are decisions made collaboratively through communication between the school administration, staff, students, families, and community?
- Does my school provide student leadership opportunities which develop self-direction and foster a sense of responsibility for improving self, school, and community?

Standard 3: High Expectations for Success

> *How do I promote a culture that promotes and encourages student learning and foster the belief that all students will obtain mastery of State Standards?*

Considerations for reflection:

- How are my expectations of students reflected in my instructional delivery?
- How do I ensure students believe in their own abilities to succeed at school and help them release their inner potential to its fullest capacity?
- Does my school consistently post learning targets and communicate them to students during lessons?
- Does my school utilize a personalized intervention plan based on data?

Standard 4: Positive and Safe Environment

> *Does my classroom have a climate conducive to teaching and learning?*

Considerations for reflection:

- How do I ensure time on task for students?

- How do I intentionally maintain positive teacher-student relationships?
- Does my school have an agreed-upon disciplinary plan in which all staff are committed to consistently follow?
- How is student diversity embraced and respected?

Standard 5: Equitable Opportunities to Learn and Effective Instruction

> *How does my school ensure WV College and Career Readiness Standards are providing a clear direction for the school's instructional program?*

Considerations for reflection:

- How does your classroom environment foster a student-centered climate that encourages student learning conversations?
- How are modifications made to curriculum to meet all students' needs?
- What is the analyzation process to ensure curriculum is aligned to grade-level state standards?
- What is the process for reviewing student work and providing feedback?

Standard 6: Frequent Monitoring of Student Progress

> *How does my school ensure student performance is used to guide instructional decisions?*

Considerations for reflection:

- What is the process for analyzing and monitoring student data and progress?
- How is the formative assessment process utilized in your classroom and how do you adjust lessons and instructional decisions?
- How often do you meet in professional learning communities to discuss best practices and research-based strategies?
- Does the school have a personal commitment to data-driven approaches for improving student performance?

Standard 7: Family and Community Partnerships

> *How do I provide systematic feedback to students and families about student progress?*

Considerations for reflection:

- Do I share data gathered from county required sources?
- How do I plan for and conduct purposeful and positive conferences with students and parents?
- Do I create opportunities for regular communication with school community?
- How are my beliefs about families and their role evident in my classroom?

STEAM Career Exploration

Career Exploration brings awareness of opportunities our students may want to pursue while they develop their academic skills and specialize their fields of study throughout high school. Middle school students should be exploring careers that align to their interests while identifying preliminary courses of action to ensure they're on track to meet the educational requirements of different careers.

Resource	Description	Audience
Roads to Success College Access and Career Development Curriculum	A free research-based curriculum for middle school students to young adults that helps them make the connection between school and their future aspirations.	K-AD
CFWV	Provides free college and career exploration and planning.	6-12
Career Finder	Provides College and Career Exploration and planning (funded by WVDE). Roadtrip Nation® and College Board have partnered to build Career Finder™, a career exploration tool that helps students make informed academic and career decisions based on what truly drives them.	8-12
Pathways to the Future	A collection of resources, tools and people to help students with disabilities, through the journey from youth to adulthood.	6-12
My State. My Life – West Virginia	Provides free exploration and information of the educational and career opportunities available to West Virginia's young people.	6-12

ACTION STEPS

Explore the **websites** above to gain a better understanding of their capacity and ability to bring vital career information to students.

1. What activities are embedded within these websites that are important to students?
2. Identify the components that ensure our students are college and career ready upon graduation from our high schools.
3. Create an activity to help students navigate one of the websites.
4. How does the information within these websites help educators focus on academic, career, social, and emotional development as outlined in the West Virginia College and Career Readiness Dispositions and Standards for Student Success (WVCCRDSSS)?

STEAM Glossary

A

Asynchronous Learning – A general term used to describe forms of education, instruction, and learning that do not occur in the same place or at the same time. The term is most commonly applied to various forms of digital and online learning in which students learn from instruction—such as prerecorded video lessons or game-based learning tasks that students complete on their own—that is not being delivered in person or in real time. Yet asynchronous learning may also encompass a wide variety of instructional interactions, including email exchanges between teachers, online discussion boards, and course-management systems that organize instructional materials and correspondence, among many other possible variations.

It should be noted that the term asynchronous learning is typically applied to teacher-student or peer-to-peer learning interactions that are happening in different locations or at different times, rather than to online learning experiences that do not involve an instructor, colleague, or peer. For example, the popular language-learning software Rosetta Stone is often purchased and used by individuals who want to acquire new language skills, but it is also increasingly used by world-language teachers in schools. When teachers use the software as an instructional tool to enhance language acquisition or diagnose learning weaknesses, this process would typically be considered a form of asynchronous learning. If someone uses the software on their own—i.e., without additional instruction or support from a teacher, and not as an extension of a formal course—it would likely not be considered asynchronous learning.

B

Blended Learning – A combination of different modes of learning. Blended learning is often used to refer specifically to combination courses that use both in-classroom and online distance learning techniques.

C

Coaching – The act of teaching and directing through advice and encouragement. A coach is most traditionally recognized in areas of sports, but motivational and inspirational coaches emerged during the 20th century.

Coding – Coding refers to creating computer programming code. In a more general sense, the word coding is used to refer to assigning a code or classification to something.

Collaboration – The ability to work effectively with diverse teams; be helpful and make necessary compromises to accomplish a common goal.

Collaborative Learning – A term covering many different approaches to education, all of which use joint effort between groups of students, or students and their instructors. Related to cooperative learning, collaborative learning can include group projects and collaborative writing, among other tasks.

Complex Question – An open-ended question that promotes higher-order thinking skills and requires students to synthesize information from multiple sources.

Computational Thinking – A problem solving process that includes (but is not limited to) the following characteristics:

- formulating problems in a way that enables us to use a computer and other tools to help solve them;
- logically organizing and analyzing data;
- representing data through abstractions such as models and simulations.
- automating solutions through algorithmic thinking;
- identifying, analyzing, and implementing possible solutions with the goal of achieving the most efficient combination of steps and resources; and
- generalizing and transferring this problem-solving process to a wide variety of problems.

Computer Science – Computer science is the study of both computer hardware and software design. It encompasses both the study of theoretical algorithms and the practical problems involved in implementing them through computer hardware and software. The study of computer science has many branches, including artificial intelligence, software engineering, programming, and computer graphics. The need for computer science as a discipline has grown as computers become more integrated into our day-to-day lives and technology continues to advance.

Computer Literacy – The terminology and range of skills required to successfully use computers and other devices associated with computers.

Cooperative Learning – A switch from more traditional, curriculum-focused methods of education. Cooperative learning environments support students learning, both as self and within the group.

Creative Thinking or Ideas – The ability or power used to produce original thoughts and ideas based upon reasoning and judgement.

Critical Thinking – The ability to acquire information, analyze and evaluate it, and reach a conclusion or answer by using logic and reasoning skills.

D

Design Thinking – is a process for creative problem solving, with a human-centered core. This ideology encourages users to focus on the people they are creating a solution for, which leads to better products, services, and processes. Design thinking encourages users to pull together what's desirable from a human standpoint with what is economically viable and technologically feasible.

Differentiated Instruction – Differentiated instruction is a teacher's response to learners' needs including respectful tasks, flexible grouping and ongoing assessment. Teachers can differentiate content, process or product based on students' readiness, interests and learning profiles. A process of designing lesson plans that meets the needs of the range of learners; such planning includes learning objectives, grouping practices, teaching methods, varied assignments and varied materials chosen based on student skill levels and learning preferences. Differentiated instruction focuses on instructional strategies, instructional groupings and use of an array of materials.

Digital Citizen – A person who uses technology and the Internet effectively and responsibly.

Digital Etiquette – The conventional rules or personal behaviors pertaining to courteous online practices.

Digital Literacy – the ability to use information and communication technologies to find, evaluate, create, and communicate information, requiring both cognitive and technical skill.

Divergent Thinking – Thinking that moves in diverging directions so as to involve a variety of aspects and which sometime leads to novel ideas and solutions.

E

Education Reform – A movement or plan that brings or attempts to bring an entire change of the system of educational theory and practice across society or community lines.

Educational Technology – Using multimedia technologies or audiovisual aids as a tool to enhance the teaching and learning process.

E-learning – Computer and communications technology facilitated to enhance learning. E-learning can be utilized through home computers, software, television, and mobile technology such as tablets and smart phones. Communications technology uses email, internet access, online discussion forums and team learning systems for students and teachers to communicate.

Electronic Portfolio – Primarily known as a digital or e-portfolio, an electronic portfolio is a portfolio found on electronic media and services in an educational context. It is a record of personal information, primarily including proof of knowledge and capability.

Engagement – How a student does or does not feel toward learning and his or her learning environment.

Evidence – Facts, figures, details, quotations or other sources of data and information that provide support for claims or an analysis that can be evaluated by others; should appear in a form and be derived from a source widely accepted as appropriate to a particular discipline, as in details or quotations from a text in the study of literature and experimental results in the study of science.

Experiential Education – Better known as learning by doing or hands-on learning, experiential education is the process of engaging students actively in an experience with benefits and consequences in an authentic manner. Students discover and experiment in a hands-on environment, allowing them to gather the knowledge personally rather than simply through hearing or reading the experiences of others. Experiential education allows students to develop new attitudes and skills by reflecting on their experiences afterward, which can facilitate new theories and ways of thinking about problems. The process of experimental education highly relates to constructivist learning theory.

H

Higher Order Thinking Skills – Higher order thinking skills include critical, logical, reflective, metacognitive, and creative thinking. They are activated when individuals encounter unfamiliar problems, uncertainties, questions, or dilemmas.

I

Individualized Instruction – The instructional method where instructional materials, media, content and learning pace are solely based on the individual learner's interests and abilities.

Innovation – An improvement of existing technological product, system, or method of doing something.

Inquiry Education – Also known as inquiry method, inquiry education is centered on students. It is a method of education that is focused on asking questions: students that have meaningful questions are encouraged to ask them, especially if they do not have an easy answer. During the questioning time, teachers are encouraged to stay as silent as possible, facilitating more questions rather than giving answers.

Instructional Design – Also referred to as instructional systems design, instructional design is an analytic process of developing instruction and analyzing learning needs. Designers frequently use instructional technology to develop instruction. Design models usually require a specific method that, when followed, transfer skills, attitude, and knowledge to students.

Instructional Leadership – The behaviors and actions of individuals or groups within the educational field, characterized by skill and knowledge in curriculum and instructional methodology. This includes resources to meet a school's mission, one-on-one communication, communication in both small and large groups, and an established clear, articulated vision for the institution.

Instructional Technology – Created as a response to labor shortage problems in the United States during WWII. The need of skilled labor workers to fill factories was a definite need, and instructional technology created a manner of training workers efficiently.

Integrated Curriculum – Content and activities are presented in an interdisciplinary approach connecting STEM subjects together for the benefit of modeling for the teachers how STEM teaching and learning is different from the traditional areas of science, technology engineering and mathematics. Furthermore the activities will be models of those which can be transferred into the classroom and are grade appropriate for the target audience.

Integrated Learning – The theory that describes movement to integration of lessons that will assist students in cross-curricula connections. It is a concept in higher education and is different from the "integrated curriculum" movement in elementary and secondary schools.

L

Lesson Seed – Ideas that can be used to build a lesson. They are designed to generate evidence of student understanding and to give teachers ideas for developing their own activities. Lesson seeds are not meant to be all-inclusive, nor are they substitutes for instruction.

Lifelong Learning – A philosophy that is summed by the concept believing that it is "never too soon or too late for learning." The concept seeks to provide people with opportunities for learning throughout life and in various contexts, whether it be in school, at work, or through recreational activity.

Lifelong Education – Pedagogical form frequently attained through e-learning, continuing education, and correspondence courses. It can also include postgraduate programs for improving skill sets and work retraining. It shares similar goals with internal training at corporations.

M

Makerspace – An area in a school or community where a maker mentality is encouraged. This could be a stand-alone classroom, or it could be a small space integrated into a general classroom. Makerspaces are stocked with tools needed for maker's projects, which can include 3-D printers, shop tools such as a band saw, or low-tech supplies like glue and cardboard.

Mastery Learning – The instructional method that holds the presumption all children are capable of learning, provided they have the appropriate conditions. It is a method in which students that have not advanced to a particular objective will stay in place until they can demonstrate the proficiency to move on.

Mentoring – The transmission of knowledge in a subject area by a more experienced person to an individual who has less experience, through the enabling of a more comprehensive understanding of the subject content, and by providing guidance and support.

Metacognition – Is defined as "cognition about cognition," or "knowing about knowing." It can take many forms; it includes knowledge about when and how to use particular strategies for learning or for problem solving.

Model – A detailed visual, mathematical, or three-dimensional representation in detail of an object or design, often smaller than the original. A model is often used to test ideas, make changes to a design, and to learn more about what would happen to a similar, real object.

O

Outdoor Education (aka adventure education) – Commonly refers to organized learning experiences that occur outdoors, often involving residential or journey-based experiences where students can participate in different challenges including group games, hiking, and canoeing. Outdoor education uses the theories and philosophies put forth in experiential education.

P

Pedagogy – The art and science of teaching, from the Greek paidagogos. The Latin for pedagogy is education, and is much more widely used, though they are interchangeable.

Primary Source – An original or direct source of information characterized as informational text.

Problem Finding – Discovery of problems. Part of the process that also includes problem shaping and solving. Requires insight and intellectual vision, involving creativity application, into finding the missing piece.

Problem Shaping – Revisiting and revising questions to begin or continue the process of finding a solution. Part of a larger process including problem finding and solving. Often involves critical thinking applications.

Problem Solving – A part of thinking, problem solving happens when a system cannot proceed from one state to its desired goal. Part of the process that includes problem finding and shaping.

Problem-Based Learning (PBL) – A concept of active learning, currently being adapted for primary through secondary education. Defining characteristics of PBL include being driven by open-ended problems, collaborative working in small groups, and the use of facilitators rather than teachers.

Procedural Knowledge (aka know-how) – The direct knowledge of how to perform a task. This differs from other forms of knowledge as it can apply to a task directly, rather than propositional knowledge in problem solving.

Process-Oriented Experiences – Activities in which students participate that require thinking, communicating, organizing, interacting, making decisions and solving problems, individually and in groups.

Product – A tangible artifact produced by means of either human or mechanical work, or by biological or chemical processes.

Professional Learning Communities (PLC) – A collegial group of educators who are united in their commitment to student learning. They share a vision, work and learn collaboratively and visit and review other classrooms.

Project Manager – A person who plans and organizes the resources necessary to complete a project.

Prototype – A full-scale working model used to test a design concept by making actual observations and necessary adjustments.
Portfolio – A collection of various samples of a student's work throughout the school year that can include writing samples, examples of math problems, products created from projects, and results of science experiments.

Q

Qualitative – Of, relating to, or involving measurement of quality or kind without extensive mathematical analysis.

Quantitative – Relating to, or expressible in terms of quantity.

R

Researchable Question – A clear and concise question that has a means of which to be answered through investigation. Researchable questions include questions that aid in specifying and prioritizing requirements and/or constraints of a problem or challenge.

Rubric – Refers to a grading or scoring tool. A rubric is a tool that lists the criteria to be met in an assignment. A rubric also describes levels of quality for each of the criteria. These levels of performance may be written as different ratings (e.g., Excellent, Good, and Needs Improvement) or as numerical scores (e.g. 4, 3, 2, 1).

S

Secondary Source – Information on a topic written by someone who did not participate or experience the topic first-hand

Self-directed – Monitoring one's own understanding and learning needs; demonstrating initiative to advance professional skill levels; defining, prioritizing and completing tasks without direct oversight.

Service Learning – The method of combining academic curriculum with meaningful community service. Specifically, service learning integrates instruction and reflection with meaningful community service to teach civic responsibility, facilitate lifelong civic engagement, and enrich learning experiences, in addition to strengthening communities in which service learning occurs.

Simulated Workplace– is the creation of an educational environment that empowers students and changes the culture of a traditional CTE classrooms into student-led companies that emulate the future workplace of its participants. Students are presented with opportunities to master both technical and soft skills and earn industry-recognized credentials while taking on leadership roles that enhance a student's ability to not only acquire but to sustain gainful employment.

Spatial Thinking – Thinking that finds meaning in the shape, size, orientation, location, direction or trajectory, of objects, processes or phenomena, or the relative positions in space of multiple objects, processes or phenomena. Spatial thinking uses the properties of space as a vehicle for structuring problems, for finding answers, and for expressing solutions (National Research Council, 2006).

STEAM – An acronym for the transdisciplinary integration of the five disciplines of Science, Technology, Engineering, the Arts, and Mathematics. STEAM education places a priority on the study of science and math with purposeful integration of technology, the arts, and the engineering design process. STEAM education is an opportunity for students to collaboratively solve engaging and relevant problems using innovation and creativity. The engineering design process allows students to identify problems, design possible solutions, test and evaluate those solutions until the best solution is discovered. STEAM in the classroom engages students in real–world situations and allows students to experience solution– finding for problems that are relevant to the world in which they live.

STEAM Centric – The development or modification of units, lessons, or activities to reflect the definition of STEAM education.

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STEAM Proficient Students – STEAM-proficient students are able to answer complex questions, investigate global issues, and develop solutions for challenges and real–world problems while applying the rigor of science, technology, engineering, the arts, and mathematics content. STEAM proficient students are logical thinkers who are technologically, scientifically, and mathematically literate.

STEAM Team – A group of people with a full set of complementary skills required to complete a task, job, or project. Team members

- operate with a high degree of interdependence,
- share authority and responsibility for self–management,
- are accountable for the collective performance, and
- work toward a common goal and shared reward(s).

Subject Matter Expert – A professional who has acquired knowledge and skills through study and practice over the years, in a particular field or subject, to the extent that his or her opinion may be helpful in fact finding, problem solving, or understanding of a situation.

T

Technical Audiences – Audience consisting of practitioners in the field of engineering, technology, design, business, and other workforce-related disciplines.

Technological Tool –- A device used by humans to complete a task. These tools may include rulers, protractors, computer software, CAD programs, etc.

Technology Literacy – The ability to use, manage, understand and assess technology.

Thematic Units – A unit of study that has lessons focused on a specific topic, sometimes covering all core subject areas. It is often used as an alternative approach to teaching history or social studies chronologically.

Transdisciplinary – In the transdisciplinary approach to integration, teachers organize curriculum around student questions and concerns. Students develop life skills as they apply interdisciplinary and disciplinary skills in a real-life context. Two routes lead to transdisciplinary integration: project-based learning and negotiating the curriculum.

V

Virtual Schools – Accredited schools that teach a full-time (or nearly full-time) course of instruction, primarily or entirely over the Internet, designed to lead to a degree.

W

Work-Based Learning – Education opportunities that reinforce core curriculum subjects through internships, apprenticeships, or other programs that place the student in an authentic work environment.

Michele L. Blatt
West Virginia Superintendent of Schools