STEM Teaching and Learning Progressions

Intended Audience: Educators

Purpose of the tool: The process of transitioning to integrated STEM teaching and learning at the organizational, school, and/or classroom level involves a well-thought out plan that is implemented over an extended period of time. Whether students are being introduced to STEM in pre-kindergarten or at the high school level, the skills involved in STEM thinking and learning are developed over time through deliberate instructional choices. This tool provides an overview of how educators can scaffold STEM teaching and learning experiences through a progression from the beginning stages of STEM learning to more complex implementation.

A glossary of terms is provided at the end of this document.

Assessment

Initial and ongoing assessment provides teachers with information that can assist with driving instructional decisions that are best suited for the learning needs of students. Pre-assessment is a type of formative assessment that occurs before a unit of study begins. Whether formal or informal, pre-assessments are never graded, rather purely diagnostic in nature. Formative assessments provide the feedback on student learning that guides teacher and student adjustments during learning. Summative assessment occurs at the end of the learning process. Some examples of summative assessments include tests, projects, demonstrations, presentations, and performance tasks. The purpose of summative assessment is to provide evidence of the degree to which a student has mastered the knowledge, understandings, and skills of the unit/learning experience.

Assessment in STEM – Integrating and including authentic assessments to assess students' STEM learning including performance-based assessments.

What are authentic assessments?
An **authentic assessment** is a form of assessment that demonstrates application of essential knowledge and skills through engagement in real-world tasks. These real-world tasks often include a rubric by which student performance is assessed and evaluated.
Examples: Oral and/or written real-world experiences, projects, exhibitions, experiments, demonstrations, student interactions, and portfolios.

Why use authentic assessment?

- provides direct measures
- captures constructive nature of learning
- integrates teaching, learning and assessment
- provides multiple paths to demonstration
- promotes higher levels of cognitive rigor

This section will assist teachers in the T-TESS Rubric Planning Dimension 1.2 Data and Assessment.

PROGRESSION OF ASSESSMENTS IN STEM TEACHING AND LEARNING

Traditional Selecting a Response Contrived Recall/Recognition Teacher-structured Indirect Evidence	→	Authentic Performing a Task Real-life Construction/Application Student-structured Direct Evidence

STARTING POINT

Pre-assessment(s). Pre-assess students' prior knowledge and skills in regard to STEM competencies such as STEM content knowledge; STEM fluency skills; process skills of inquiry, the engineering design-process, and project/product-based learning (PBL); personal interests; and real-world experiences.

Formative Assessments. Conduct a variety of formative assessments throughout the duration of a STEM unit or lesson. Facilitate on-going assessment of students' STEM knowledge and skills through a variety of informal and formal assessment techniques. Assessments are based on the foundational knowledge and skills that are being developed. Critique and revision are included in this process.

Examples:

- Teachers conduct informal observations of students engaging in partner/small group experiences and utilize other assessments to assess introductory-levels of STEM Fluency Skills.
  - In grades PK-8 the focus is on developing skills related to communication, creativity, collaboration, critical thinking, and resilience.
  - In grades 9 and up include the mastery of PK-8 skills, as well as developing skills related to promptness, time management, adaptability, and innovation.
- Content-based assessments such as a quiz or other assessment formats are used to assess STEM content knowledge. Assessments sometimes include real-world connections and scenarios.
- Student work is analyzed and assessed. Artifacts and outputs might include brainstorming evidence, planning diagrams/models, prototypes, final products, written reports, and presentations for small-scale inquiry or design projects.

DEVELOPING/INTERMEDIATE

Formative Assessments. Conduct a variety of formative assessments. Facilitate on-going assessment of students' STEM knowledge and skills through a variety of informal and formal assessment techniques. Assessments will be based on the intermediate knowledge and skills that are being developed. Critique and revision are included in this process.

Examples:

- Teachers conduct informal and formal observations of students engaging in partner/small group activities or projects and utilize other assessments to assess intermediate-levels of STEM Fluency skills.
- Content-based assessments such as a quiz or other assessment formats are used to assess STEM content knowledge. Assessments include real-world connections and scenarios. Other formats may include introductory forms of authentic, performance-based assessment such as performing a scientific investigation, and/or engaging in a real-world task.
- Student work is analyzed, critiqued, and assessed. Artifacts and outputs might include brainstorming evidence, planning diagrams/models, prototypes, final products, written reports, presentations, for small-scale inquiry, design projects and/or small-scale project/product-based learning (PBL) projects.
- Students self-assess and reflect on their own STEM learning development
- Students conduct peer critiques based on specific STEM fluency skills, and small-scale project criteria.

ADVANCED

Formative Assessments. Conduct a variety of formative assessments. Facilitate on-going assessment of students' STEM knowledge and skills through a variety of informal and formal assessment techniques. Assessments will be based on the more advanced knowledge and skills that have been developed.

Examples:

- At the advanced level, all assessments included at the developing/intermediate stages are also included at this level. However, assessment of knowledge and skills is geared towards a more advanced-level of mastery.
- Larger-scale PBL projects are implemented involving inquiry and engineering design along with other types of student-centered projects are being implemented at this level and assessments align with the tenets of PBL best practices and mastery-level achievement of STEM competencies.
- Authentic critique, assessment, and input from authentic sources is included (e.g. experts from the field).

STARTING POINT

- Students self-assess and reflect on their own STEM learning development
- Students conduct peer critiques based on specific STEM fluency skills and small-scale project criteria.

Summative Assessments. Conduct a variety of summative assessments to assess knowledge and skill development at the conclusion of a STEM unit or lesson.

Examples:

- Content-based assessments such as a test or other assessment formats are used to assess STEM content knowledge. Assessment includes real-world connections and scenarios.

Or

- End-product evaluation of a small-scale STEM project using a rubric. Criteria is based on a basic level of mastery related to STEM competencies being developed including STEM content knowledge, STEM-related process skills, and STEM fluency skills.

DEVELOPING/INTERMEDIATE

Summative Assessments. Conduct a variety of summative assessments to assess knowledge and skill development at the conclusion of a STEM unit or lesson.

Examples:

- Content-based assessments such as a test or other assessment formats are used to assess STEM content knowledge. Assessments include real-world connections and scenarios.

And

- End-product and process evaluation of a larger-scale STEM project are conducted using a rubric. Criteria is based on an intermediate level-of mastery related to STEM competencies that are continuing to be developed including STEM content knowledge, STEM-related process skills, and STEM fluency skills.

ADVANCED

Summative Assessments. Conduct a variety of summative assessments to assess knowledge and skill development at the conclusion of a STEM unit or lesson.

Examples:

- Content-based assessments such as a test or other assessment formats may be included but are not the focus.
- End-product and process evaluation of larger-scale, complex, authentic PBL projects using a rubric. Criteria is based on advanced level of mastery related to STEM competencies that have been and continue to be developed.
- This level of authenticity includes engaging in performance-based tasks in authentic settings and being evaluated by authentic audiences.

Learning Spaces

The learning space is a crucial component of setting the context for learning. The learning space is not only the physical space where learning takes place, but also the environment that supports the learning.

Learning Spaces in STEM are flexible and inclusive spaces that cultivate creativity, communication, critical thinking, and collaboration. Identifying and preparing the most appropriate learning spaces for integrated STEM learning begins with the goals of STEM learning, the nature of the STEM experience, and the needs of the students. Authentic STEM experiences require authentic learning spaces.

Examples of STEM learning spaces:

- classroom
- other areas of the school
- outdoors
- off-campus authentic spaces
- virtual spaces

Why utilize a variety of learning spaces?

- promotes the idea that learning occurs beyond the classroom
- meets the needs of authentic STEM learning and assessment tasks
- promotes connections to authentic real-world settings
- promotes adaptability, a STEM fluency skill.

This section will assist teachers in the T-TESS Rubric Learning Environment Dimension 3.1 Classroom Environment, Routines and Procedures.

PROGRESSION OF UTILIZING AND EXPERIENCING A VARIETY OF LEARNING SPACES FOR STEM TEACHING AND LEARNING

Traditional Static seating/workspace Learning occurs at school School-based collaboration Limited resource possibilities	→	Authentic Flexible seating/workspace Learning occurs anywhere, any time Global collaboration Unlimited resource possibilities

STARTING POINT

Classroom Learning Space

Having a flexible learning space means that the physical aspects of the classroom can be moved and adapted to fit the learning activity and/or learning preferences of students. When engaging in STEM experiences, the space has flexibility for a variety of student groupings, collaboration areas, and has organized area(s) for STEM supplies, materials, and tools that are accessible to students.

Examples:

- Group student desks/tables for collaborative group work
- Provide multiple work areas that students can choose from in the classroom (e.g. floor area, tables, computer area, etc.)
- Specific STEM supplies, materials, and tools are accessible to students during the STEM activities in which they will be used.

Other Areas in the School

Expose students to a variety of other learning areas in the school, by having students engage in small learning trips, tours, or participating in small learning tasks in those areas. Set the behavioral and learning expectations for each area. Collaboration and planning among teachers/staff may be necessary to utilize certain spaces.

Examples:

Stage, cafeteria, gymnasium, hallways, library/media center, makerspace, science lab, other classrooms, etc.

DEVELOPING/INTERMEDIATE

Classroom Learning Space

As integrated STEM experiences become more enveloped in classroom learning, the learning spaces will need to be adapted to fit the needs of the learning.

Examples:

- If possible, invest in desks/tables on wheels or alternative seating/workspace furniture that enhances the STEM learning experience and provides students with a variety of choices (e.g. bean bag chairs for collaboration, standing desks, work tables, collaborative whiteboards, etc.)
- As students become more familiar with STEM supplies, materials, and tools students are provided with more consistent access to these items.

Other Areas in the School

Now that students are aware of other learning areas, engage students in larger learning tasks in those areas. Continue to communicate and enforce the behavioral and learning expectations for each area. Collaboration and planning among teachers/staff may be necessary to utilize certain spaces.

Examples:

- Students utilize the library/media center and specialist for resource information related to STEM experiences and projects.
- Students use the open spaces in the school such as the gymnasium or cafeteria for STEM experiences requiring larger spaces.

ADVANCED

Classroom Learning Space

At the advanced level, students are involved in the organization of the classroom space. They have experienced a variety of seating and workspace arrangements and have an understanding of which spaces work best for them and the STEM work at hand.

Examples:

- Students assist in the design, development, and organization of the classroom space

Other Areas in the School

Students are now comfortable with learning in other areas of the school and know the expectations for behavior and learning in these areas. More complex STEM experiences can be implemented in these areas. Collaboration and planning among teachers/staff may be necessary to utilize certain spaces.

Examples:

- Students design and implement a music, dance, theater, or visual arts production in the theater engaging in sound design, lighting design, costume design, prop development, marketing, and performance aspects, etc.
- Students conduct a long-term science experiment in the science lab.
- Students design and host a STEM-night for families and the community in the gymnasium.

STARTING POINT	DEVELOPING/INTERMEDIATE	ADVANCED

STARTING POINT

Outdoors

Expose students to outdoor learning by engaging students a variety of learning experiences in the outdoor spaces around the school.

Examples:

- Students engage in collaborative work sessions outdoors
- Students make authentic observations of phenomena happening outside
- Students use the outdoor space to do activities needing large open spaces.
- Students engage in small-scale design projects based on the outdoor areas of the school.

Off-campus Authentic Spaces

Expose students to off-campus authentic spaces to engage in real-world experiences.

Examples:

- Tours of community/industry organizations
- STEM-based field trips
- Learning experiences at informal education sites (e.g. museum, amusement park, metro parks, conservation center, sports organizations, etc.)
- Students utilize their own home spaces for authentic learning tasks, activities, or projects.

DEVELOPING/INTERMEDIATE

Outdoors

Continue to facilitate learning in the outdoor spaces around the school, as well as expose students to outdoor learning in the community, local parks, or local conservation areas.

Examples:

- Students engage in on-going scientific inquiry investigations or citizen science projects in the outdoor spaces around the school.
- Students walk to the local park which has a pond to obtain their own water samples and test water quality, and later observe microorganisms.

Off-campus Authentic Spaces

Continue to engage students real-world learning experiences.

Examples:

- Include all starting-point experiences
- Short-term shadowing experiences
- Volunteer/service opportunities

ADVANCED

Outdoors

Students are now comfortable with outdoor learning spaces and are familiar with particular areas. Students begin to utilize the outdoor spaces for their own inquiry, engineering design, or PBL projects.

- Students design and develop an outdoor classroom for the school.
- Students develop an irrigation system for the local community garden.
- Students work with the local parks system to develop a plan for eradicating an invasive species.

Off-campus Authentic Spaces

Students engage in authentic STEM learning experiences in authentic spaces.

Examples:

- Off-campus internships in STEM-related fields and site locations
- Students present research findings or engineering solutions/prototypes to authentic audiences (e.g. university faculty, industry partners, city officials, etc.)

STARTING POINT

Virtual Spaces

Learning can take place in virtual environments as well as physical environments. Current day digital technology has provided a variety of online platforms and tools for learning. Technology devices, tools, software/apps, and programming should be used to enhance the learning experience, not take the place of the teacher or the interactive classroom context. At the starting-point, teachers may be engaging in their own professional development related to integrating technology into the classroom, learning about a variety of technology tools for teaching and learning, and implementing a few tools at a basic level. Inclusion of virtual learning is dependent upon student and teacher access to technology.

Examples:

- Students utilize available media/video resources for learning content
- Students engage in available games and simulations for learning content knowledge and skills
- Students use available virtual reality/augmented reality apps and devices for learning (e.g. Google expeditions)
- Students and teachers utilize a variety of online collaboration platforms for working on individual and/or group projects
- Students and teachers may engage in social media for learning, collaborating and communicating
- Students use basic creative technology tools for communicating their learning (e.g. slideshow presentation)
- Students engage in basic-level computational thinking and activities using technology
- Students and teachers learn and implement appropriate and safe digital citizenship practices

DEVELOPING/INTERMEDIATE

Virtual Spaces

Technology is always evolving. As new technology resources become available, both teachers and students not only build upon the knowledge and skills that they have developed, they work to apply those skills. At this level, students not only use technology tools for learning content and skill, they begin to utilize technology to design, create, and communicate their learning.

Examples:

- Include all starting point examples
- Students use more-advanced creative technology tools to apply or communicate their learning (e.g. interactive posters, media capturing and editing tool/software, 3D printers, etc.)
- Students engage in learning with others outside of the school community such as video conferencing with real-world experts, and interacting with students in another community, state, or country
- Teachers create their own media/video resources, learning games, simulations, apps, videos, virtual field trips, etc. for students to use and interact with.
- Students engage in intermediate-level computation thinking and activities and/or projects using technology.

ADVANCED

Virtual Spaces

Students are now knowledgeable about and comfortable with using a variety of technology learning tools. Not only are students users of the technology, they become the creators and facilitators of their own virtual learning environments.

Examples:

- Include all starting point and developing/intermediate examples
- Students and teachers collaborate on large-scale research/design projects with others across virtual conferencing and collaboration platforms
- Students engage in advanced-level computational thinking and projects using technology.
- Students utilize technology tools for designing and building prototypes for engineering design projects (e.g. 3D printing.
- Students engage in creating their own media/video resources, learning games, simulations, apps, videos, virtual field trips and social media platforms.

Skill Fluency

Each content area includes associated skills along with content area knowledge that are developed through a variety of learning experiences.

STEM skill fluency refers to having the skills associated with STEM teaching, learning, and the STEM workforce. In grades PK-8 the focus is on developing skills related to communication, creativity, collaboration, critical thinking, and resilience. In grades 9 and up include the mastery of PK-8 skills, as well as developing skills related to promptness, time management, adaptability, and innovation.

Why include STEM fluency skills development in teaching and learning practices?

- supports higher-order thinking and cognitive rigor
- prepares students to be college and career ready

View the STEM Skills Fluency Rubric for more information about specific developmental progressions for each STEM skill.

PROGRESSION OF INTEGRATING STEM FLUENCY SKILLS INTO STEM TEACHING AND LEARNING

Content-focused learning goals Content-focused assessments Low-level cognitive tasks Classroom ready	→	Inclusion of STEM fluency skills in learning goals Authentic, performance-based assessments High-level cognitive tasks College and career ready

STARTING POINT

Pre-assessment(s).

Pre-assess students' STEM fluency skills using a variety of assessment types. Example assessments might include student self-assessment, teacher observation of group work discussion and collaboration, and other group dynamics, individual and group work outputs/ artifacts. View the STEM Skills Fluency Rubric for more information about specific developmental progressions for each STEM skill.

Instruction and Assessment:

Learning experiences and tasks are deliberately designed to introduce and include specific STEM skills to meet the skill level of students based on the pre-assessments.

Examples:

- Students engage in collaborative teamwork experiences during lessons and other activities to deliberately introduce collaboration and communication skills.
- Teachers use deep questioning techniques to promote critical thinking.
- Students use their creativity and critical thinking to develop a solution to a problem.
- Students communicate their learning in a variety of ways (verbally, written form, graphic representation, pictorial representation, physical models, mathematical models, etc.)
- Students reflect upon their opportunities for growth or failures and are encouraged/guided to improve upon their work or ideas in order to develop skills of resilience.
- Expectations are set for promptness in regard to assignment due dates, timeliness to class, and other actions.

DEVELOPING/INTERMEDIATE

Students exhibit an intermediate-level of mastery of STEM fluency skills appropriate for the grade-level. View the STEM Skills Fluency Rubric for more information about specific developmental progressions for each STEM skill.

Instruction and Assessment:

Learning experiences and tasks are deliberately designed to develop students' STEM fluency skills. As STEM fluency skills are developed, students are better equipped to handle the demands of more complex STEM learning.

Examples:

- Include starting-point level experiences to continue developing STEM fluency skills

...and

- Students engage in individual and team-based inquiry investigations.
- Students engage in both individual and collaborative team work to develop a design solution to a design problem. Students are required to communicate verbally during group work time as well as use an interactive document for brainstorming and planning. Students design and develop creative solutions/ prototypes and test their designs. Designs are improved based on test result analysis. Final designs are presented/shared with others.
- Students explore real-world challenges and problems through project/product-based learning experiences or design-based challenges. Through participation in deep and meaningful projects, students gain knowledge and practice are able to practice a variety of STEM fluency skills.

ADVANCED

Students exhibit an advanced-level of mastery of all STEM fluency skills and are well prepared for college and career environments. View the STEM Skills Fluency Rubric for more information about specific developmental progressions for each STEM skill.

Instruction and Assessment:

Learning experiences and tasks are designed to utilize student's developing and advanced-level skills. Students continue to practice the utilization and application of skills in learning, as well as transfer skills to other aspects of their life.

Example:

- Students engage in inquiry, design tasks, and project-based learning experiences and design-based challenges that utilize the STEM fluency skills students have mastered or are still developing. Students also exhibit mastery of skills beyond STEM learning situations such as other classes, extra-curricular activities, work experiences, or in other aspects of the students' lives.

STARTING POINT	DEVELOPING/INTERMEDIATE	ADVANCED
• Students engage in a variety of learning activity types, learning spaces, and student groupings to develop skills of adaptability. Multiple methods of assessment are used to assess on-going development of STEM fluency skills, such as: • Teacher observation/documentation • Student portfolios – project work • Student reflection/self-assessment • Peer critique/evaluation • Performance tasks/rubrics Assessment results are communicated to students via a variety of feedback techniques to promote on-going improvement and metacognition.		

Cognitive Rigor

Cognitive rigor is an ordering of cognitive skills measured by the depth and extent students are challenged and engaged to demonstrate and communicate their knowledge and thinking. It also measures the depth and complexity of student learning experiences.

Cognitive rigor in STEM: STEM teaching and learning includes a variety of experiences across a range of cognitive rigor levels. However, higher-levels of cognitive rigor are attained through engagement in inquiry, the engineering desig¬¬¬n process, and project/product-based learning experiences. Higher-level cognitive tasks include but are not limited to designing, connecting, synthesizing, applying concepts, critiquing, analyzing, creating, constructing, formulating, and hypothesizing.

Why include higher-levels of cognitive rigor in teaching and learning?

- promotes meaning-making
- provides students with the skills to become innovative producers of goods, services, and ideas
- prepares students to be college and career ready

This section is based on Hess' Cognitive Rigor Matrix and synthesized information from a document created by CORE (Consortium on Reaching Excellence in Education.

This section will assist teachers in the T-TESS Rubric Planning Dimension 1.4 Activities and T-TESS Rubric Instruction Dimension 2.3 Communication.

PROGRESSION OF INTEGRATING STEM FLUENCY SKILLS INTO STEM TEACHING AND LEARNING

Low-level cognitive tasks Mindless thinking Low-level questioning Recognition Knowledge attainment	→	High-level cognitive tasks Critical thinking Deep questioning Creation and communication Knowledge extension

STARTING POINT

Teacher's role:

- ask questions to direct or focus attention
- show and tell
- demonstrate
- provides example
- examine
- lead
- break-down
- define

Students engage in low-level cognitive tasks.

- Students recognize, respond, remember, memorize, restate, absorb, describe, demonstrate, follow directions, apply routine processes, definitions, and procedures.

DEVELOPING/INTERMEDIATE

Teacher's role:

- include starting point instructional strategies
- ask questions to differentiate, infer, or check conceptual understanding
- ask questions to probe reasoning and underlying thinking
- ask open-ended questions
- model
- organize
- explore possible options or connections
- provides examples and nonexamples
- provides criteria and examples for making judgements and supporting claims
- act as a resource and coach
- encourage multiple approaches and solutions
- determine when/where depth and exploration is most appropriate

Students engage in low and intermediate-level cognitive tasks.

- Students recognize, response, remember, memorize, restate, absorb, describe, demonstrate, follow directions, apply routine processes, definitions, and procedures.
- Students uncover and select relevant and credible supporting evidence for analyses, critiques, debates, claims, and judgments; plan, initiate questions, dispute, argue, test ideas and solutions, sustain inquiry into topics or deeper problems, apply to the real-world.

ADVANCED

Teacher's role:

- include starting point and intermediate instructional strategies
- ask questions to extend thinking and broaden perspectives
- facilitate teaming, collaboration, and self-evaluation

Students engage in low, intermediate, and advanced-level cognitive tasks

- Students recognize, response, remember, memorize, restate, absorb, describe, demonstrate, follow directions, apply routine processes, definitions, and procedures.
- Students uncover and select relevant and credible supporting evidence for analyses, critiques, debates, claims, and judgments; plan, initiate questions, dispute, argue, test ideas and solutions, sustain inquiry into topics or deeper problems, apply to the real-world.
- Students design, take-risks, research, synthesize multiple resources, collaborate, plan, organize, modify, and create concrete tangible products.

Student-centered Learning and Instruction

Student-centered learning is an approach to learning in which the learning environment has learner responsibility and activity at the core, opposed to emphasis on instructor control. Students construct knowledge rather than passively receive it. Power is transitioned from the instructor to the learner, treating the learner as a co-creator in the teaching and learning process. Students are included in decisions about how and what they learn and how that learning is assessed, and they respect and accommodate individual differences in others' backgrounds, interests, abilities, and experiences. Additionally, learners find the learning process more meaningful when topics are relevant to their lives, needs, and interests, and when they are actively engaged in creating, understanding, and connecting to knowledge.

Student-centered instruction in STEM

Student-centered instruction is an important component of inquiry learning, design thinking, project/product-based learning, and design-based challenges.

<u>Students…</u>

- are active participants in their own learning.
- make decisions about what and how they will learn.
- construct new knowledge and skills by building on current knowledge and skills.
- understand expectations and are encouraged to use self-assessment measures.
- monitor their own learning to develop strategies for learning.
- work in collaboration with other learners.
- produce work that demonstrates authentic learning.

<u>Teachers…</u>

- recognize and accommodate different learning modalities.
- provide structure without being overly directive.
- listen to and respect each learner's point of view.
- encourage and facilitate learners' shared decision-making.
- help learners work through difficulties by asking open-ended questions to help them arrive at conclusions or solutions that are satisfactory to them.

Why transition to student-centered instruction?

- inclusive for all students
- strong potential for increased learner motivation and empowerment
- strong potential for increased academic achievement

This section will assist teachers in the T-TESS Rubric Instruction Dimension 2.3 Communication and T-TESS Rubric Instruction Dimension 2.4 Differentiation.

PROGRESSION OF INTEGRATING AND TRANSITIONING TO MORE STUDENT-CENTERED INSTRUCTION

Teacher-centered	→	Student-centered
Teacher voice and choice Teacher and content-driven Differentiation for specific students Close-ended questioning Tasks with one right answer/solution Failure is considered a weakness Compliant learners Fixed mind-set	→	Student voice and choice Considers student interests Differentiation for all students Open-ended questioning Tasks with multiple answers/solutions Failure is considered a learning tool Empowered learners Growth mind-set

STARTING POINT

Instructional Examples

- Whole-class instruction
- Teachers are responsible for driving the learning process.
- Instructional time is confined to a specific time frame based on a curriculum timeline.
- Teachers take into consideration student interests and culture when designing lessons.
- Assessment is mostly teacher-created.
- Teachers can help learners set goals for themselves and can offer self-directed activities through which students can build both their self-confidence and learning skills.
- Teachers differentiate learning for specific student needs.

DEVELOPING/INTERMEDIATE

Instructional Examples

- Individual and small-group guided inquiry, based on teacher chosen topics.
- Shared power- both teachers and students drive the learning process. Teachers take into consideration student input.
- Teachers encourage students to discover how they learn best and can apply different strategies suitable for each student.
- Teachers model or demonstrate how to approach learning tasks and encourage learners to learn from and with each other.
- Teachers guide and assist students with organizing content, generating examples, posing and answering questions, and solving problems
- Students learn how to self-assess their own work and their learning process.
- Teachers consider and include instructional strategies to meet the needs of many students.

ADVANCED

Instructional Examples

- Individual and small-group inquiry, and design/PBL projects based on student interest and choice.
- Shared power-students drive the learning process, while the teacher takes on a facilitator role.
- Students take on the responsibility for organizing content, generating examples, posing and answering questions, and solving problems. The teacher does more design work, constructing real-life, authentic tasks that encourage learner involvement and participation.
- Assessment includes both teacher-developed and student self-assessment. Student work portfolios are commonly used for assessment.
- Instructional strategies are consistently employed to meet the needs of all students.

Sustained Learning

Sustained learning refers to on-going engagement in a learning experience, topic, or project for an extended amount of time. The duration is not limited to a certain amount of time, but may refer to several hours, several days, several weeks, or longer.

Sustained learning in STEM

Sustained learning is an important aspect of inquiry, engineering design, and project/product-based learning. More complex STEM learning experiences often require students to engage in a more complex series of related activities and processes. When first introduced to STEM teaching and learning, students may have underdeveloped skills associated with self-motivation, perseverance, and grit that are needed to actively engage in longer-term activities. This can affect a student's ability to stay on task and motivated over an extended period of time. Through scaffolded exposure to and engagement in learning activities that require a variety of focused and sustained learning timeframes, students will better be able to adapt to and transition between short-term and long-term STEM experiences. Students that can successfully engage in sustained learning are often more resilient and hardworking and are willing to continue on in the face of difficulties, obstacles or even failures.

Why engage students in sustained learning?

- provides time for deeper and more complex learning experiences
- develops STEM fluency skills

This section will assist teachers in the T-TESS Rubric Instruction Dimension 2.1 Achieving Expectations.

PROGRESSION OF DEVELOPING STUDENT ENGAGEMENT AND PERSEVERANCE IN SUSTAINED STEM LEARNING ACTIVITIES

Separate learning tasks
Short-term learning experiences
Short-attention span
Impatience

→

Connected learning tasks
Long-term learning experiences
Grit – sustained interest and effort
Patience

STARTING POINT	DEVELOPING/INTERMEDIATE	ADVANCED
Students engage in short-term STEM activities and learning experiences. These experiences may last a class period, a few hours, or a few days. **Examples:** • STEM-based integrated lessons and/or activities • Introductory teacher-led or guided short-term design-tasks • Introductory teacher-led or guided short-term inquiry tasks • Students engage in self-assessment and reflection related to perseverance and grit throughout sustained learning activities.	Students engage in several short-term STEM activities and learning experiences as well as one or more longer-term activities or projects. These experiences may last a class period, a few hours, a few days, or a few weeks. **Examples:** • STEM-based integrated lessons and/or activities • Inquiry investigations (e.g. research projects or science experiments) • Introductory project/product-based learning (PBL) activities. • Students engage in self-assessment and reflection related to perseverance and grit throughout sustained learning activities.	Students consistently engage in a variety of short-term and long-term STEM activities, experiences and projects. Complex learning tasks are student-centered and authentic. These experiences may last anywhere from a class period to several months. **Examples:** • Includes developing/intermediate examples • Longer-term project/product-based learning (PBL) projects • Students engage in self-assessment and reflection related to perseverance and grit throughout sustained learning activities.

Integrated Teaching and Learning

The term integration is an overarching term that has a variety of meanings and may be associated with terms such as multidisciplinary, interdisciplinary, cross-disciplinary, or transdisciplinary. Although these approaches have their own unique format and framework, an overarching commonality is the idea that disciplinary concepts and skills are linked.

Integrated STEM Teaching and Learning

When science, technology, engineering, and mathematics disciplines combine to form STEM, a common approach is to promote STEM as an integrated concept that removes boundaries between disciplines and focuses on the connections between disciplines. Inquiry, design thinking, project/product-based learning, and design-based challenges require the use of a variety of skills and can include multiple disciplinary content topics including both STEM and non-STEM disciplines.

Why integrate STEM content?

- provides a more complex real-world perspective of an idea, topic, or process
- requires synthesis, application, and transfer of knowledge and skill within or between disciplines which require higher-levels of cognitive rigor

This section will assist teachers in the T-TESS Rubric Instruction Dimension 2.2 Content Knowledge and Expertise.

PROGRESSION OF DEVELOPING STUDENT ENGAGEMENT AND PERSEVERANCE IN SUSTAINED STEM LEARNING ACTIVITIES

Disciplinary content is separated
Knowledge/skill is confined within a discipline
Teacher autonomy

→

Disciplinary content is connected
Knowledge/skill is transferred across disciplines
Teacher collaboration

STARTING POINT

Lessons and experiences are often based in one disciplinary content. Introductory levels of multidisciplinary integration or interdisciplinary integration may occur. Teacher collaboration and planning is minimal.

Multidisciplinary integration refers to instruction in which core concepts and skills are being taught separately in each discipline but housed within a common theme, topic, or problem. This theme, topic, or problem may be examined from multiple disciplinary perspectives, but no effort is taken to connect these perspectives to one another.

Interdisciplinary integration also examines a theme, topic, or problem from multiple perspectives, however there is an effort to integrate perspectives into a unified or coherent framework. It is a way to incorporate and link a topic or subject across different classes and therefore may require teachers to collaborate in developing a lesson/project/unit together.

Examples:

A theme of ocean currents and the world is agreed upon by teachers. Based on the theme, a teacher would develop a PBL or design challenge for their content area.

During science block/class students use quantifiable data to determine the factors that contribute to the changing patterns and influence of the Gulf Stream. Students analyze the data to determine the relationship between water temperature, amount of living organisms and type of living organisms present.

- A STEM/Engineering project might include designing, constructing, and evaluating a buoy or remotely operated vehicle (ROV) that can collect specified data within a marine environment. Students use a variety of resources to collaborate with mentors and technical experts. Design a buoy or ROV that could measure the water temperature and document marine life presence.

DEVELOPING/INTERMEDIATE

Intermediate levels of multidisciplinary integration and interdisciplinary integration occur. Introductory levels of cross-disciplinary integration occur. Teacher collaboration and planning is more complex.

Cross-disciplinary integration introduces closely linked concepts and skills from two or more disciplines with the aim of deepening understanding and skills. Content/skill of one discipline is studied through the lens of another discipline.

Example:

A project/product-based Learning (PBL) project in which student use their new knowledge about marine ecology and human impacts on the ocean to create and propose a management plan for a Marine Protected Area (Adapted from National Geographic Resource Library Unit: Marine Ecology, Human Impacts, & Conservation, 2019)

Students investigate the interconnectedness of the ocean and Earth's physical and human systems through videos, discussions, writing, and mapping. They make personal connections to their own lives and are introduced to the concept of Marine Protected Areas (MPAs).

Students then explore major marine ecosystems by locating them on maps. Students use marine examples to learn about energy transfer through food chains and food webs. They discuss how food webs can illustrate the health and resilience of an ecosystem.

Students analyze a variety of videos to make observations about species, populations, and communities of organisms and discuss their symbiotic relationships.

- A design-based project might include designing and constructing a hypothetical marine ecosystem and describing the adaptive, trophic, and symbiotic relationships between the biotic and abiotic components of the ecosystem.

ADVANCED

Advanced levels of integration occur. Transdisciplinary integration also occurs at this level. Teacher collaboration and planning is complex.

A transdisciplinary integration approach unifies knowledge and skills from two or more disciplines resulting in a new holistic approach. This type of integration transcends traditional disciplinary boundaries leading to new teaching and learning innovations that go beyond the mixing of content knowledge and skill.

Example:

A student identifies a problem in which fertilizers are being swept into the ocean during flooding.

- Students utilize multiple lenses to analyze solutions. A solution for a marine biologist might be to restrict the use of fertilizers within a certain area near the coast. This solution from the perspective of a farmer might be unrealistic because they need a big yield to support the demand for food. From the perspective of an environmentalist, restricting fertilizers might cause a decrease in growth causing more land erosion which could lead to additional problems. This type of approach is transdisciplinary because it shows the complex integration of not only content but integration of perspectives.
- The STEM/Engineering design challenge would be to develop a process or product that meets the needs of all of these different stakeholders.

STARTING POINT

During social studies block/class, students Use historic maps, journals, ships' logs or other records to investigate the influence of ocean currents on the voyages of European explorers in the 1400s and 1500s.

- A STEM/Engineering project might include using technology available in the 1400-1500s to design a process that European explorers could have used to determine where the ocean currents were located.

During English Language Arts block/class, students read an authentic journal entry or ship's record from the October 1492 journey of Christopher Columbus and compare the journal to a non-fiction account of the same October journey.

- A STEM/Engineering project might include developing a process of preserving paper-based documents (e.g. records) to withstand the elements of an ocean environment and preservation over time.

During math block/class, students make inferences about the velocity of two different sections of the Gulf Stream current based on the degree variation of the visual overlap from the numerical data collected on the currents.

- A STEM/Engineering project might include designing, constructing, and evaluating a buoy or remotely operated vehicle (ROV) that can collect specified data within a marine environment. Students use a variety of resources to collaborate with mentors and technical experts. Design a buoy or ROV that could measure the velocity of two different sections of the gulf stream.

DEVELOPING/INTERMEDIATE

Students are introduced to the idea that humans have enormous impacts on marine ecosystems and resources, and explore the stakeholders involved. Students build on their knowledge of individual impacts on the ocean to see how the whole system can react to threats and changes. They identify and examine ways in which human actions throw marine ecosystems out of balance, explore the concept of how impacts can build, and review their understandings of ecosystem dynamics.

- A STEM/Engineering project might include developing solutions to these problems.

Students explore issues related to fisheries sustainability and simulate fish monitoring methods commonly used by scientists and resource managers.

- A STEM/Engineering project might include developing solutions to these issues based on the data collected.

Students explore Marine Protected Areas on an interactive map and compare and contrast three case studies. They learn how the MPA classification system works in the United States, apply that system to example scenarios, and create case studies of their own. Students read a case study and debate the pros and cons of a Marine Protected Area (MPA) in the region.

- A STEM/Engineering project might include selecting a Marine Protected Area and design, develop and present a management plan for it based on the needs of the area.

ADVANCED

Authentic assessment is a form of assessment that demonstrates application of essential knowledge and skills through engagement in real-world tasks. These real-world tasks often include a rubric by which student performance is assessed and evaluated.

Cognitive rigor is an ordering of cognitive skills measured by the depth and extent students are challenged and engaged to demonstrate and communicate their knowledge and thinking. It also measures the depth and complexity of student learning experiences.

Engineering Design Process is a process associated with STEM learning whereby students use an iterative process of asking questions, brainstorming, planning, creating/building and testing design ideas or solutions, and improving designs.

Formative assessment provides the feedback on student learning that guides teacher and student adjustments during learning.

Inquiry-based learning is an approach to learning that emphasizes the student's role in the learning process. Rather than the teacher telling students what they need to know, students are encouraged to explore the material, ask questions, and share ideas. Instead of memorizing facts and material, students learn by doing. This allows them to build knowledge through exploration, experience, and discussion.

Integration is an overarching term that has a variety of meanings and may be associated with terms such as multidisciplinary, interdisciplinary, cross-disciplinary, or transdisciplinary. Although these approaches have their own unique format and framework, an overarching commonality is the idea that disciplinary concepts and skills are linked.

Performance-based tasks are meaningful activities or assessments that engage students in performing or demonstrating their knowledge, understanding, and proficiency. These tasks involve pertinent concepts and skills, multiple layers of complexity, multiple entry points, and multiple solutions or strategies.

Pre-assessment is a type of formative assessment that occurs before a unit of study begins. Whether formal or informal, pre-assessments are never graded, rather purely diagnostic in nature.

Project/product-based learning (PBL) is a learning experience involving active participation in a project over an extended period of time that engages students in solving a real-world problem or answering a complex question. Students demonstrate their knowledge and skills by developing authentic products or solutions. As a result, students develop deep content knowledge as well as critical thinking, creativity, and communication skills in the context of doing an authentic, meaningful project.

STEM skills fluency refers to having the skills associated with STEM teaching, learning, and the STEM workforce (see STEM Fluency Rubric). In grades PK-8 the focus is on developing skills related to **communication**, **creativity**, **collaboration**, **critical thinking**, and **resilience**. In grades 9 and up include the mastery of PK-8 skills, as well as developing skills related to **promptness**, **time management**, **adaptability**, and **innovation**.

Student-centered learning is an approach to learning in which the learning environment has learner responsibility and activity at the core, opposed to emphasis on instructor control. Students construct knowledge rather than passively receive it. Power is transitioned from the instructor to the learner, treating the learner as a co-creator in the teaching and learning process. Students are included in decisions about how and what they learn and how that learning is assessed, and they respect and accommodate individual differences in others' backgrounds, interests, abilities, and experiences.

Summative assessment occurs at the end of the learning process. Some examples of summative assessments include tests, projects, demonstrations, presentations, and performance tasks. The purpose of summative assessment is to provide evidence of the degree to which a student has mastered the knowledge, understandings, and skills of the unit/learning experience.

Sustained Learning refers to on-going engagement in a learning activity, topic, or project for an extended amount of time. The duration is not limited to a certain amount of time, but may refer to several hours, several days, several weeks, or longer.