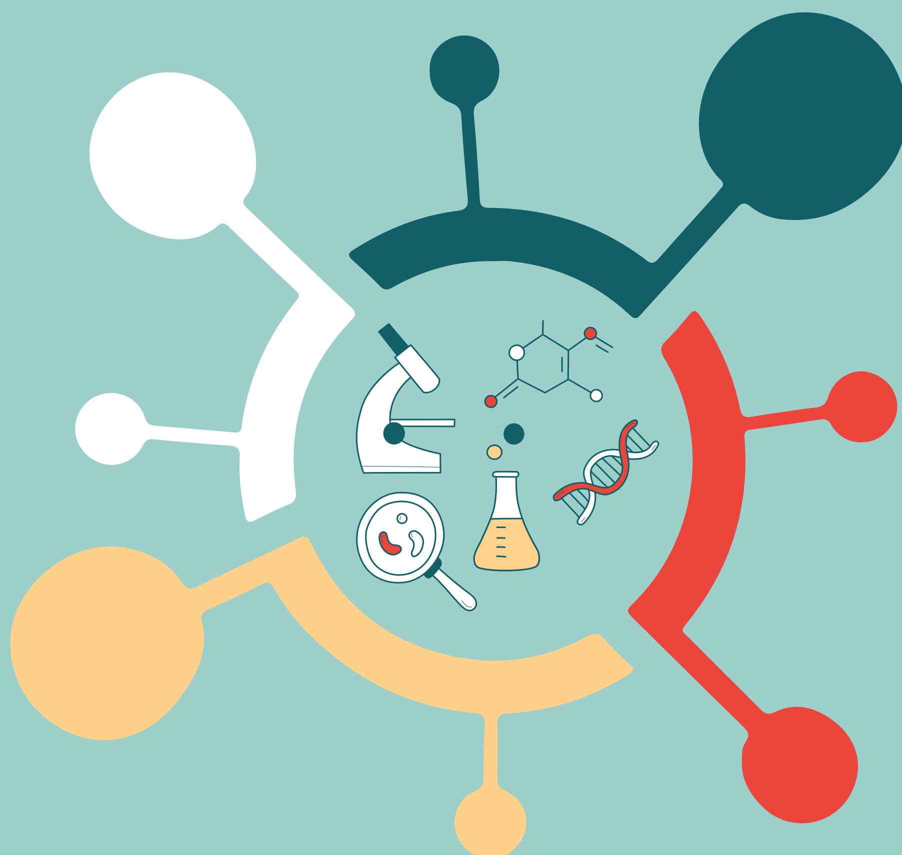
FORT WORTH ISD

SCIENCE

INSTRUCTIONAL FRAMEWORK



2023-2024

MATH/SCIENCE DEPARTMENT

FORT WORTH ISD LEARNING & LEADING, SERVICE NETWORK 2

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Fort Worth
INDEPENDENT SCHOOL DISTRICT

SCIENCE INSTRUCTIONAL FRAMEWORK

The Fort Worth ISD Science Instructional Framework provides research-based guidance for the planning, instruction, assessment, and professional learning of teachers to implement a culturally responsive, relevant, and rigorous curriculum for all students. The Fort Worth ISD Science Department provides science teachers, principals, and district administrators with professional learning and curriculum resources to support shifting to research-based, student-focused teaching and assessment practices to meet the needs of all learners. Fort Worth ISD science teachers improve science achievement by planning for and implementing relevant and rigorous lessons that promote the learning of science concepts through the practices of science to develop scientifically informed, ethical, and responsible citizens.

CALL TO ACTION

Fort Worth ISD educators will intentionally support and shift to student-focused instructional and assessment practices to build students' conceptual understanding of science concepts through the doing and practicing of science in order to develop inquisitive, collaborative learners prepared to engage the world as scientifically informed, ethical, and responsible citizens.

GUIDING PRINCIPLES

The mission of the Fort Worth ISD Science Department is to provide a rigorous, differentiated, and relevant science curriculum with standards-aligned resources and assessments that gives instructional support to all campuses through a renewed focus on teacher knowledge and best practices in the development, alignment, and implementation of relevant learning experiences through the practicing of science. The ultimate goal of this mission is to ensure all students meet current grade-level, state science standards.

1. All students will develop a deep, conceptual understanding of science concepts by engaging in science and engineering practices through multidimensional, student-focused lessons in order to become scientifically informed, ethical, and responsible citizens.
2. Asset-minded educators will encourage a growth mindset for students while providing culturally responsive, multidimensional science instruction and assessment that integrates science content standards, science and engineering practices, recurring themes and concepts, and the nature of science, to contextualize literacy, mathematics, technology, and 21st Century Skills.
3. Daily science teaching practices will require students to collaboratively construct their own conceptual understandings by engaging in science and engineering practices to make sense of relevant, real-world phenomena through productive scientific discourse.
4. Educators will use multidimensional performance tasks and formative assessment feedback loops to inform instructional decisions to increase student voice, choice, engagement, and conceptual understanding.
5. Professional learning will promote teachers' science pedagogical knowledge and self-efficacy in shifting to effective, multidimensional, student-focused, phenomena-driven, research-based science instruction and assessment to meet the needs of all students.
6. Professional learning in science will provide district leaders, administrators, and instructional support teams with the knowledge necessary to support the shifts required for effective science instruction.

A MULTIDIMENSIONAL APPROACH TO SCIENCE INSTRUCTION AND ASSESSMENT

The Fort Worth ISD Science Framework takes a culturally responsive, multidimensional approach to science instruction and assessment **(Figure 1)**. When these multiple dimensions are intentionally planned for and incorporated into science instruction and assessment, students move from being receivers of knowledge to active constructors of knowledge increasing educational excellence for all and moving students toward becoming scientifically informed, ethical, and responsible citizens who can advocate for justice-centered solutions to societal challenges.[1]

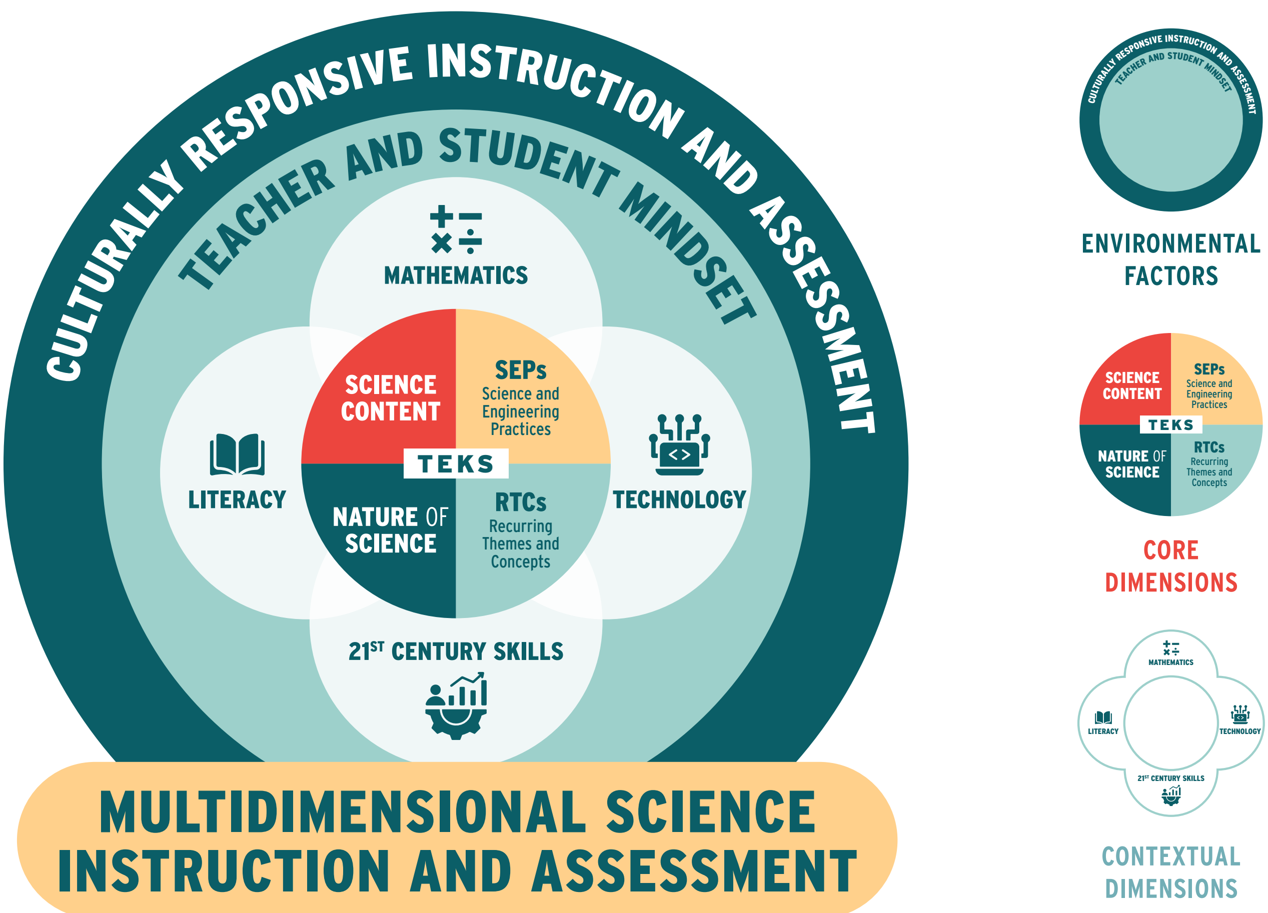


Figure 1. A Multidimensional Approach to Science Instruction and Assessment.[2]

ENVIRONMENTAL FACTORS

Multidimensional science instruction and assessment are framed by culturally responsive instruction and assessment, asset-minded teachers, and growth-minded students. Without these environmental factors, it is difficult for all students to engage in meaningful learning.

ENVIRONMENTAL FACTOR 1

CULTURALLY RESPONSIVE SCIENCE INSTRUCTION AND ASSESSMENT

Developing scientifically informed, ethical, and responsible citizens begins with framing multidimensional science instruction and assessment within culturally responsive teaching practices and recognizing the rightful presence of all students in the science classroom. A Framework for K-12 Science Education[3] proposes instructional shifts that are intended to meet the needs of all students. As educators, we must recognize the influence we have over students and our ability to act as change agents. In doing so, teachers can aid in the reversal of existing inequities in education. Historically, our society has failed to provide engaging, meaningful, and rigorous science education for students from underserved communities.[4] Students from these communities have experienced science instruction as disconnected from their interests, lives, and communities. Culturally responsive science teaching requires teachers to create spaces where all students are given a voice and the opportunity to engage in relevant, challenging learning. This type of teaching recognizes students' rightful presence in the classroom.[5] It also holds high and rigorous expectations for ALL students, not just high-achieving students. With culturally responsive teaching there is an enhanced potential to raise the academic level of all students.

Science instruction can provide and support all students in realizing that science is for everyone. It also emphasizes that all students have the right to be part of science, do science, and have the opportunity to be scientists. Creating a culturally responsive classroom environment requires teachers to design instruction and assessments that recognizes students' rightful presence and brings students' whole lives to the classroom. To erase potential inequities, teachers can incorporate pedagogies of community ethnography (PCE)[6] (see Supporting Document). By incorporating these pedagogies and moving students to consider how historically underserved populations are disproportionately impacted by pressing societal challenges, we heighten the potential to develop students as scientifically informed, ethical, and responsible citizens. These students can learn that injustices can be addressed through justice-centered science and engineering solutions.[7]

ENVIRONMENTAL FACTOR 2

TEACHER AND STUDENT MINDSET

Research indicates the teacher-student relationship is one of the greatest predictors of student achievement.[8] Stronger teacher-student relationships are developed when the teacher has strong listening skills, empathy, mutual respect, caring, and positive regard for students.[8] Many of these skills are often possessed by teachers who hold an asset mindset for their students and avoid a deficit mindset.[9] A typical teacher with a deficit mindset views students as not smart enough, not capable enough, or not able to master a rigorous curriculum. Thus, a deficit-minded teacher avoids designing challenging learning opportunities for students and often perceives what students bring to the classroom as liabilities instead of assets.[9] At times, teachers with a deficit mindset may feel they are, "doing students a favor", by not exposing them to more challenging learning opportunities.

In contrast, an asset-minded teacher recognizes the diverse perspectives their students have to offer and finds ways to scaffold those strengths or assets with learning opportunities and instructional connections in the classroom. These teachers set high expectations for students and design rigorous instruction for all students. They do not accept mediocre performance from students and they work to create a culturally responsive curriculum and classroom environment that promotes students holding a growth mindset for themselves. Students who hold a growth mindset for themselves in a subject area believe that their talents can be developed through hard work, strategic work, mentoring, or coaching.[10] Those with a fixed mindset believe their talents are innate gifts they are born with and that they cannot be changed.[10] A fixed mindset often promotes more cheating. There are multiple approaches and strategies teachers can take to promote a supportive, asset-minded, growth-minded classroom environment for students. Creating this type of environment is likely to enhance learning and create a safe space where all students can learn.

Table 1. Asset vs. Deficit Approaches

	DEFICIT MINDSET	ASSET MINDSET
The goal is...	mastery via learning about.	mastery via figuring out.
Instruction is described as...	teacher-centered and objective-focused.	student-centered and question-focused.
The teacher emphasizes...	weakness and needs of students.	possibility and strengths of students.
Students are...	externally driven.	internally driven.
Assessments of learning are...	less like the real world.	more like the real world.

CORE DIMENSIONS

Within a culturally responsive classroom, there are multiple dimensions of science education that must be planned for and incorporated into instruction and assessment: science content, science and engineering practices, recurring themes and concepts, and the nature of science. These dimensions should be embedded into every science lesson and multiple dimensions should be incorporated into assessments as well.

CORE DIMENSION 1

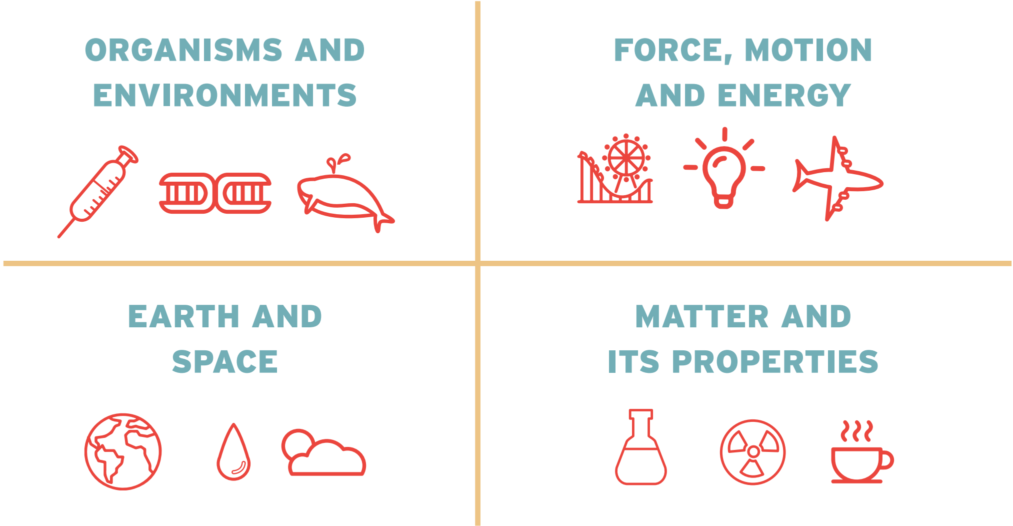
SCIENCE CONTENT

To develop into scientifically informed, ethical, and responsible citizens, students need to know science content. Doing so allows students to unpack community issues and make informed choices. It also allows students to engage fully in the practicing of science and engineering. Science content is traditionally divided into three categories – life science, physical science, and earth science – and is often presented as a series of discrete facts. Contemporary standards focus on disciplinary core ideas[3] that apply to multiple disciplines or are key concepts for one discipline. In Texas, the essential knowledge and skills are divided into four content areas:

1. Matter and its properties
2. Force, Motion, and Energy
3. Earth and Space
4. Organisms and Environments

The TEKS identify science concepts for students to use in the investigation of relevant and challenging phenomena and problems, relate to student cultures, interests, and communities, and are vertically articulated across multiple grades with increasing depth.

Figure 2: Link to TEKS Vertical Alignment K-12 (https://bit.ly/TEKSVerticalAlignment)



CORE DIMENSION 2

SCIENCE AND ENGINEERING PRACTICES (SEPs)

Practicing science and engaging in engineering practices are how we develop new scientific knowledge. This is exemplified in the National Academy of Sciences' definition of science as the "use of evidence to construct testable explanations and predictions of natural phenomena, as well as the knowledge generated through this process." Historically, the scientific method has been used as the approach to teach the skills and practices of science.[11] However, there is no single scientific method that follows a set series of steps.[11] Rather, the development of new scientific knowledge is often messy, involves creativity, curiosity, accidents, and serendipity.[12] In previous iterations of the TEKS, these were referred to as process skills. To support educators in the teaching of science, modern standards identify science and engineering practices to engage students in the doing of science for the understanding of science.

SCIENCE AND ENGINEERING PRACTICES (SEPs)

1. Asking questions (for science) and defining problems (for engineering)	**2.** Developing and using models	**3.** Planning and carrying out investigations	**4.** Analyzing and interpreting data
5. Using mathematics and computational thinking	**6.** Constructing explanations (for science) and designing solutions (for engineering)	**7.** Engaging in argument from evidence	**8.** Obtaining, evaluating, and communicating information

Figure 3. The Science and Engineering Practices (SEPs) as identified by Texas' essential knowledge and skills for science.

CORE DIMENSION 3

RECURRING THEMES AND CONCEPTS (RTCs)

In science, there are recurring themes and concepts that make connections between disciplines and are lenses that can support scientists and engineers in the doing and making sense of science. These lenses allow us to approach the investigation and understanding of phenomena in different ways. For example, students might start by the examination of a phenomenon by observing and looking for patterns. Then students may look to define the system and create a system model to better understand the features of the phenomenon and how it interacts. As part of defining the system, students may take an energy and matter lens to examine how energy transfers and matter flows through the phenomenon system or how the structure affects the function or malfunction of the phenomenon system. Taking on a different lens allows students to develop a different perspective and understanding of the phenomenon. It also supports them in understanding different aspects of phenomena.

These themes and concepts are also different from science and engineering content in that they are crosscutting and relate to a multitude of science concepts and investigations. For example, energy is an amount that can be calculated from the transfers between and among systems as engineers design more efficient engines, scientists from various fields work with engineers to improve the efficiency of solar panels, and biologists determine how much food is needed to sustain bacterial colonies.

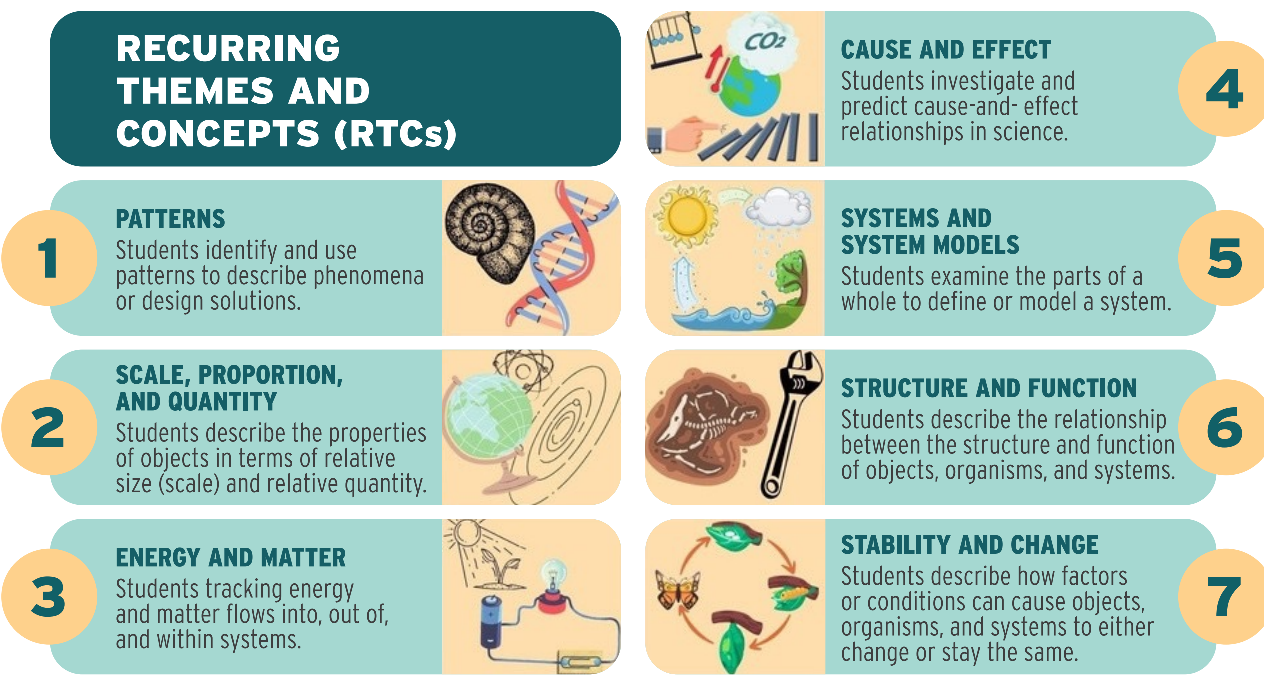


Figure 4. Recurring Themes and Concepts as identified in Texas.

CORE DIMENSION 4

NATURE OF SCIENCE

Science is not simply a set of facts, but rather science is a path to understanding our world. It is a way of learning about and explaining the natural world and how the world works. The nature of science identifies the knowledge and values that are intrinsic to science.[3] In Texas, these basic understandings of the nature of science fall under broader categories **(Figure 5)** and are closely linked to science and engineering practices and with recurring themes and concepts.[3] There are multiple approaches to embedding the nature of science into the classroom (e.g., historical case studies, contemporary case studies, decontextualized activities). Regardless of the approach, decades of research indicate instruction must be explicit and reflective for students to understand nature of science ideas.[11, 13]

Figure 5. Nature of Science categories and their relationship to science and engineering and practices and recurring themes and concepts.

RELATED TO SEPs
SCIENCE AND ENGINEERING PRACTICES

Scientific investigations use a variety of methods.

Scientific knowledge is based on empirical evidence.

Scientific knowledge is open to revision in light of new evidence.

Scientific models, laws, mechanisms, and theories explain natural phenomena.

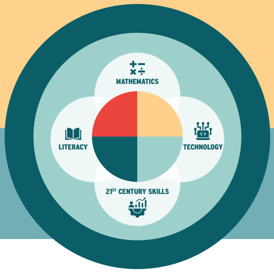
RELATED TO RTCs
RECURRING THEMES AND CONCEPTS

Science is a way of knowing.

Scientific knowledge assumes order and consistency in natural systems.

Science is a human endeavor.

Science addresses questions about the natural and material world.



CONTEXTUAL DIMENSIONS

Within a culturally responsive classroom, the core dimensions of science education are supported by the contextual dimensions of literacy, mathematics, technology, and 21st Century Skills. Integrating these contextual dimensions supports the teaching and assessment of science, but may not happen in every lesson.

CONTEXTUAL DIMENSION 1
LITERACY

Science also provides an excellent context to support and enhance literacy knowledge and practices. As science is a human endeavor and is often social - an activity that people engage in together - discourse is a necessary component of scientific work as are reading and writing. There are several distinctive features of literacy in science that place specific disciplinary demands on students:

- Science texts are typically concept and idea dense.
- Letters and numbers have unique meanings in science (e.g., H_2O). Numbers may be uninterpretable without unit labels.
- Many technical words contain Latin or Greek roots that not only reveal meaning but help to enable scientific classifications.
- Science often requires descriptions of procedures and testing of hypotheses.
- Science frequently presents many visual representations (e.g., charts, figures, graphs, drawings, models) of an idea that must be interpreted.
- Science requires the ability to analyze procedures, like lab experiments.

To address the unique features of literacy in science, teachers need to support students in making meaning of every word and symbol, engaging in close reading and rereading, focusing on the order of procedures, conducting investigations and recording observations, critiquing the procedures used by others in investigations, detecting and correcting errors, analyzing keywords and word parts for identification and classification purposes, dividing attention across multiple representations of content, and using scientific and mathematical text features to make meaning.

Literacy, mathematics, and science practices can be integrated to support students in understanding how the disciplines are interconnected and leveraged to support students in understanding common language across the disciplines **(Figure 6)**.

CONTEXTUAL DIMENSION 2
MATHEMATICS

Science relies on quantitative data, explanations, and models; thus, mathematics is an essential component of the work and practices of science. This is further exemplified by the overlap that exists between mathematics and science practices **(Figure 6)**. Science also provides a context for students to develop a conceptual understanding of how mathematical ideas can be represented, connected, and illustrated. Mathematical procedural fluency, strategic competence, adaptive reasoning, and the productive disposition we hope to see in regard to math can also be developed through the application of mathematics in scientific contexts, and through the practices of science and engineering.

CONTEXTUAL DIMENSION 3

TECHNOLOGY AND OVERLAP IN COMMON MATH, LANGUAGE ARTS, AND SCIENCE PRACTICES

In the 21st century, scientists must be able to appropriately use, evaluate, and create information, media, and technology. Technologies can be used to support the investigation, exploration, creativity, and collaboration of scientists and engineers. In science specifically, technology is used as a tool to support the doing of science.[3] We see an increasing need to acknowledge the readily available technology, the increasing access to technology, and to utilize and instruct on the technologies available as tools for learning and doing science. In this regard, we have seen modifications to Bloom's Taxonomy and acknowledge the need to consider how explorations, investigations, and activities with digital tools may align with more traditional versions of the taxonomy (see Supporting Document).[14]

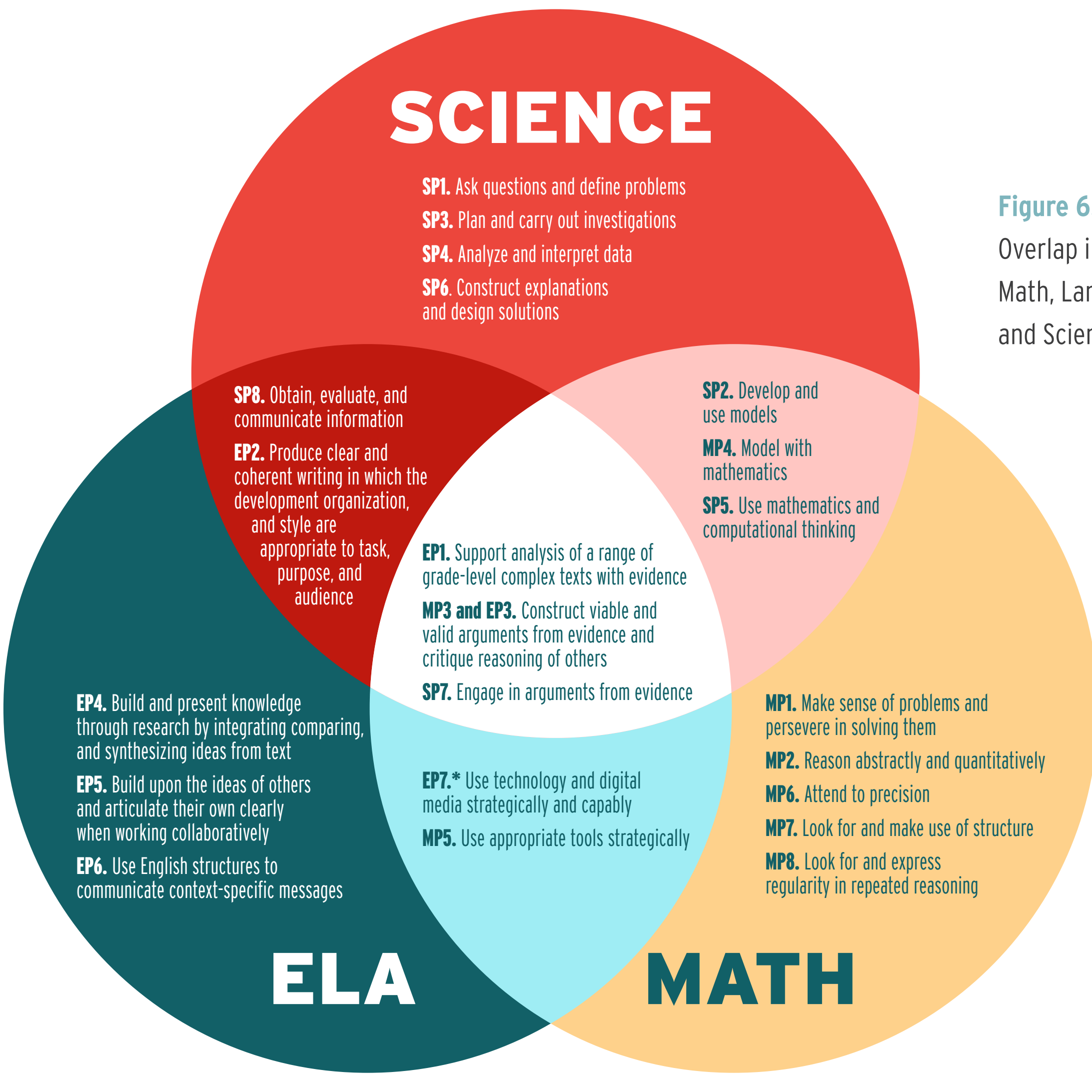
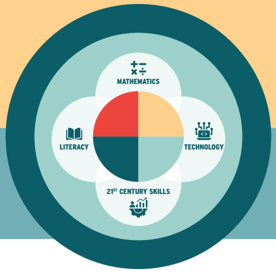


Figure 6.
Overlap in Common Math, Language Arts, and Science Practices[15]



CONTEXTUAL DIMENSION 4

21st CENTURY SKILLS

Students need a variety of skills to succeed in learning and in life. Many careers are dependent on the development of the right set of skills to be successful. Traditionally, schools have focused on the specific skills of reading, writing, and arithmetic. However, with a changing world and labor market, other skills, sometimes called 21st Century Skills, have been identified as necessary for being successful in learning, life, and careers. The Partnership for 21st Century Learning (P21) developed a popular framework for describing the skills, knowledge, and literacies students need to be successful in work and life.[16] Built on the development of conceptual understanding in key subject areas, including science, this framework suggests students need to develop 21st Century skills in three areas:

- **LEARNING AND INNOVATION SKILLS**
  Collaboration, critical thinking, creativity, and communication
- **INFORMATION, MEDIA, AND TECHNOLOGY SKILLS**
  Information literacy, media literacy, and Information, Communications, Technology (ITC) literacy
- **LIFE AND CAREER SKILLS**
  Flexibility and adaptability, initiative and self-direction, social and cross-cultural skills, productivity and accountability, and leadership and responsibility

Accounting for and including instruction around 21st Century Skills provides opportunities for our students to grow into the scientifically responsible, ethical, and informed citizens our society needs.

SUMMARY

Together, the environmental factors, core dimensions, and contextual dimensions work together to inform the design and implementation of instruction. Traditionally, science education has been about the learning and regurgitation of facts. The modern goal for science education is for students to learn science by practicing science. In doing so, students will engage with the science and engineering practices and understand the recurring themes and concepts and the nature of science. It will enable students to gain a deep conceptual understanding of the science content knowledge and become scientifically informed, ethical, and responsible citizens. Attaining this goal necessitates a culturally responsive, asset-minded approach to teaching that encourages students to see their rightful presence in science and to hold a growth mindset for themselves **(Figure 1)**. It also requires contextualization of the science within literacy, mathematics, technology, and 21st Century Skills so students are prepared not only to be scientifically informed, ethical, and responsible citizens, but also to be prepared for the increasing needs of industry in our country and to be College, Career, and Military Ready.

SHIFTS IN PRACTICE

In a traditional classroom, you often see students sitting in rows, or groups taking guided notes. A teacher lectures or leads students through a series of slides that are designed to help them learn vocabulary, ideas, and facts they need to know to perform well on a standardized end-of-course test **(Figure 7)**. The teacher is viewed and acts as the "sage on the stage," and the students are viewed as the receivers of knowledge. Teachers often use an Initiate-Respond-Evaluate (IRE) model for questioning and students raise their hands, or popsicle sticks are used, to provide an answer. After students "receive" this scientific knowledge, they work to confirm it through lab investigations. These labs and lessons are often designed to be completed in one 45-60 minute class period. A series of these lessons addressed concepts related to one science topic which made up a unit of study. Research, however, tells us that in this traditional classroom, science did not make sense to many students. Science did not seem relevant and students did not understand the purpose of what they were learning.[3]

In order to obtain the vision of a culturally responsive, multidimensional, collaborative science classroom environment, where students are constructing knowledge, the teacher is a facilitator of learning who uses formative assessment to drive instruction and multidimensional performance tasks to assess learning and inform grades. Thus, shifts away from traditional instructional and assessment practices in these areas are needed to attain this vision. We want to move from students being receivers of knowledge to making sense of rich, relevant phenomena and designing solutions to problems. We want teachers to move from being deliverers of knowledge to facilitators of sensemaking.

To accomplish the vision of multidimensional science instruction and assessment Fort Worth ISD Science teachers must make these shifts in teaching practices and administrators must work to support teachers as they make these shifts **(Figure 8)**.

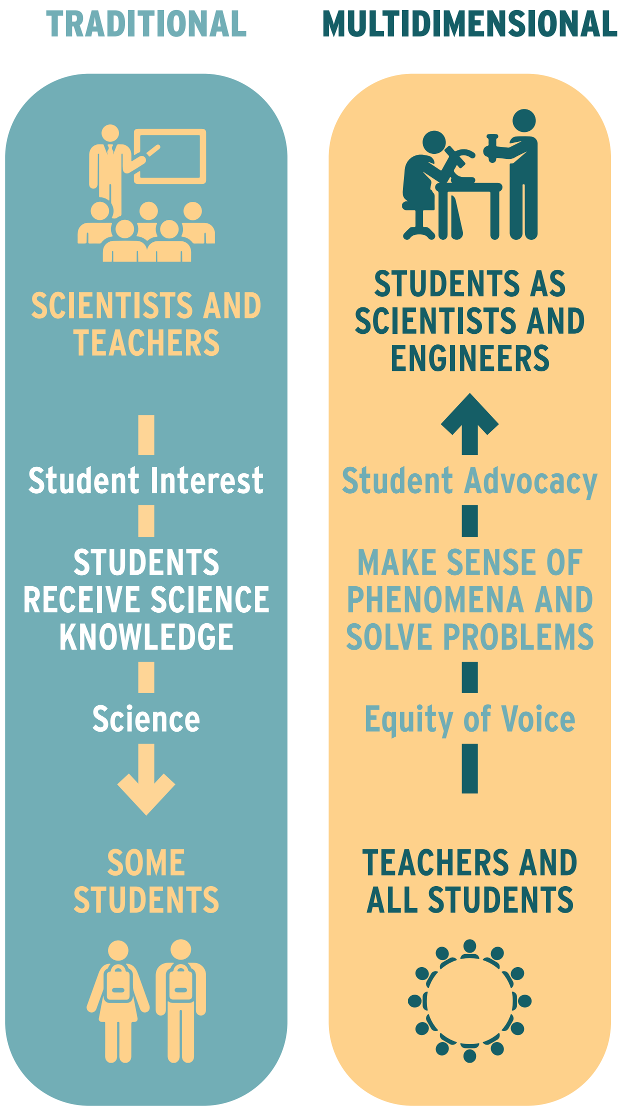


Figure 7. Traditional vs. Multidimensional Classroom.[1]

SHIFTS IN PRACTICE

UNIT AND LESSON STRUCTURE

The Fort Worth ISD Science Instructional Framework expects all teachers and instructional teams to participate in Unit-by-Unit planning and delivery that begins with planning, teaching, assessing, and reflecting, on the following research-based components for every grade-level and course-based Unit:

- Standards alignment, both horizontally and vertically
- Prior knowledge activities and prompts
- Utilization of science and engineering practices to learn science concepts and understand the nature of science through the lens of a recurring theme or concept in the context of a phenomenon or question
- Balanced use of student focused whole group and small group productive science discourse
- Integration of mathematics and literacy
- Appropriate use of tools and technology
- Embeds opportunities for 21st century skill development

Teachers and instructional teams are expected to reflect on student performance and progress throughout a unit to adjust instruction in real time, and at the end of the unit to inform instruction during the next unit and for future years. Students will not experience a gradual release model of instruction with this unit and lesson structure. Teaching lessons and units in this way will result in every day of instruction looking different for students, with a focus on connecting ideas over time rather than teaching individual skills or facts. The Fort Worth ISD Science Instructional Framework supports and expects all teachers to create lessons that are driven by student questions, exploration, and investigation of relevant, engaging phenomena and problems, create opportunities for productive scientific discourse, and push students to be the constructors of their own knowledge.

SUPPORTING SHIFTS IN INSTRUCTION AND ASSESSMENT

The Fort Worth ISD Science Department will provide professional learning in science to district leaders, administrators, instructional support teams, and teachers to support the shifts in instruction and assessment needed to create collaborative, culturally responsive multidimensional science classrooms. Professional learning will have a renewed focus on providing teachers with the content and pedagogical knowledge they need to deliver rigorous, differentiated, and relevant science curriculum. Teachers will be supported in designing and implementing multidimensional formative and performance task assessments.

As teachers do the hard work of shifting their instruction and assessment, support from district leaders, administrators, and instructional support teams will be critical. Professional learning for these stakeholders will support their understanding of the Fort Worth ISD Science Instructional Framework, what multidimensional science instruction and assessment looks like in the classroom, and how best to support teachers with implementing effective science instruction.

SHIFTS IN PRACTICE

Figure 8. Shifts in teaching practices needed for the vision of multidimensional science instruction and assessment to be accomplished.

COLLABORATIVE CLASSROOM ENVIRONMENT

- Establishes norms and expectations for how the community interacts
- Develops and encourages authentic connections with and among students
- Uses a warm, inviting, curious tone to welcome students to take risks and share their thinking openly and freely
- Gives students choices as often as possible
- Encourages students to collaboratively construct their own knowledge by engaging in messy, complex, and sometimes uncomfortable sensemaking
- Focuses on supporting ideas with evidence rather than right answers
- Acknowledges the challenges and discomfort of multidimensional science learning

STUDENTS CONSTRUCTING KNOWLEDGE

- Develops students to be agents of their own learning
- Designs lessons drive by students' questions and problems
- Structures learning so students use science and engineering practices and recurring themes and concepts to make sense of a phenomenon or problem
- Provides vocabulary after students have experiences and opportunities to make sense of the content

MULTIDIMENSIONAL FORMATIVE ASSESSMENT & PERFORMANCE TASKS

- Designs assessments or tasks that require students to show evidence of learning using multiple dimensions and assess student learning along a continuum
- Creates assessment that assess not only learning but also student voice and choice
- Defines the goal of an assessment
- Designs tools and tasks that align with the goal(s) of the assessment
- Utilizes both formal and informal formative assessment loops to inform and modify instruction
- Develops multidimensional performance tasks that ask students to apply science content, recurring themes and concepts, and the nature of science by doing science

TEACHERS AS FACILITATORS

- Student Focused
- Guides explorations and investigations of relevant, real- world phenomena and problems
- Plans student-focused lessons that require practicing science and engineering and student sensemaking
- Plans Phenomena-Based Lessons
- Engages students in phenomena to provide a meaningful, relevant context for learning
- Place-based phenomena learning can create more equity in learning for students
- Anchoring phenomena are used to drive units of learning
- Engages in Productive Science Discourse
- Embeds opportunities for exploratory and explanatory discourse throughout a unit as appropriate
- Creates spaces for productive science discourse by keeping conversations evidence-based, making thinking visible, not stopping at one, separating ideas from individuals, and exploring ideas with words, actions, images, and symbols
- Facilitates conversations where teachers appropriately employ discourse moves that include: time to think, probing, pressing, re-voicing, peer-to-peer talk, and putting ideas on hold
- Supports the classroom community in building science ideas and knowledge together

GRADING

- Adopts an asset mindset for grading student work
- Encourages all stakeholders to view grades as a snapshot of student understanding as a simple indicator of one moment in time along a continuum
- Develops clearly stated learning goals and criteria to assess student learning and communicates those expectations to students
- Utilizes grades to support students in reflecting on where they are along a continuum of learning
- Provides high quality feedback that offers guidance and direction for learning and elicits cognitive responses rather than emotional responses

SUGGESTED CITATION:

Whitworth, B. A., Hilbert, J., Trotter, G., & Williams, R. (2023). Fort Worth Independent School District Science Instructional Framework. FWISD: Fort Worth, TX.

REFERENCES

1 Lee, O., Shelton, T. & Grapin, S. (2022, December 12). *Future approaches in STEM education.* NSTA Blog. Retrieved February 8, 2023, from: https://www.nsta.org/blog/future-approaches-stem-education

2 Whitworth, B. A. (2023). A multidimensional approach to science education.

3 National Research Council (2012). *A Framework for K-12 Science Education: Practices, Crosscutting Concepts, and Core Ideas.* Washington, DC: The National Academy Press.

4 Bang, M., Brown, B., Calabrese Barton, A., Rosebery, A. S., & Warren, B. (2017). Toward more equitable learning in science. *Helping students make sense of the world using next generation science and engineering practices*, 33-58.

5 Calabrese Barton, A., & Tan, E. (2020). Beyond equity as inclusion: A framework of "rightful presence" for guiding justice-oriented studies in teaching and learning. *Educational researcher*, 49(6), 433-440.

6 Schenkel, K., Bliesener, S., Barton, A. C., & Tan, E. (2020). Community ethnography. *Science Scope*, 43(7), 56-67.

7 Lee, O., Shelton, T., & Soriano, K. (2022, June 17). *Contemporary approaches in science education with all students.* NSTA Blog. Retrieved February 18, 2023, from: https://www.nsta.org/blog/contemporary-approaches-science-education-all-students

8 Hattie, J. (2008). *Visible learning: A synthesis of over 800 meta-analyses relating to achievement.* London: Routledge.

9 Milner IV, H. R. (2012). Beyond a test score: Explaining opportunity gaps in educational practice. *Journal of Black Studies*, 43(6), 693-718.

10 Dweck, C. S., & Yeager, D. S. (2019). Mindsets: A view from two eras. Perspectives on Psychological Science. https://doi.org/10.1177/1745691618804166

11 Lederman, N. G., & Lederman, J. S. (2014). Research on teaching and learning of nature of science. In *Handbook of research on science education, volume II* (pp. 614-634). Routledge.

12 Scotchmoor, J., Thanukos, A., & Potter, S. (2009). Improving the public understanding of science: New initiatives. *American Journal of Botany*, 96(10), 1760-1766.

13 Duschl, R. (2000). Making the Nature of Science Explicit. In R. Millar, J. Leech & J. Osborne (Eds.), *Improving Science Education: The Contribution of Research.* Philadelphia, PA: Open University Press.

14 Fracuts Learning. (2017). *Bloom's Digital Taxonomy.* Retrieved February 27, 2023, from: https://www.fractuslearning.com/blooms-taxonomy-digital-print-table

15 Cheuk, T. (2013). Overlap of ELA, Math, and Science standards. *Understanding Language Initiative.* Stanford University. Retrieved February 15, 2023, from: https://sites.google.com/view/tinacheuk/impact

16 Battelle for Kids. (2019). *Framework for 21st century learning.* Retrieved February 18, 2023, from: https://static.battelleforkids.org/documents/p21/P21_Framework_Brief.pdf