ACT Science

ACT Science Assessment and NGSS

- Science education and state standards -- 3D
- ACT's model of Science
- ACT clusters compared to old IL blueprint
- Reports for students and schools

Components of NGSS/NRC Framework 3-Dimensional Learning and Assessment: an outgrowth of science education reform

- Shift from NSES mid 1990s with science practices as a separate but equal partner to content knowledge
- Fully integrating the three strands to engage in scientific sense making or problem solving in engineering

How we implement in teaching and assessment

Crosscutting Concepts

- *Patterns*
- *Cause and Effect*
- *Scale, Proportion, and Quantity*
- *Systems and System Models*
- *Energy and Matter*
- *Structure and Function*
- *Stability and Change*

Making sense of phenomena

Evaluating and solving real world problems

Scientific phenomena or scenario

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*
- *Constructing Explanations and Designing Solutions*
- *Engaging in Argument from Evidence*
- *Obtaining, Evaluating and Communicating Information*

Disciplinary Core Ideas

- Physical Science
- Life Science
- Earth & Space Science
- Engineering, Technology, & the Application of Science

Science & Engineering Practices	Disciplinary Core Ideas	Performance Expectations
❶ Asking questions (for science) and defining problems (for engineering) ❷ Developing and using models ❸ Planning and carrying out investigations Planning and carrying out investigations to answer questions or test solutions to problems in 6–8 builds on K–5 experiences and progresses to include investigations that use multiple variables and provide evidence to support explanations or design 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. ❹ Analyzing and interpreting data ❺ Using mathematics and computational thinking ❻ Constructing explanations (for science) and designing solutions (for engineering) ❼ Engaging in argument from evidence ❽ Obtaining, evaluating, and communicating information	Forces and Motion: - The motion of an object is determined by the sum of the forces acting on it; if the total force on the object is not zero, its motion will change. - The greater the mass of the object, the greater the force needed to achieve the same change in motion. - For any given object, a larger force causes a larger change in motion.	MS-PS2-2 *Students who demonstrate understanding can:* Plan an investigation to provide evidence that the change in an object's motion depends on the sum of the forces on the object and the mass of the object. Clarification Statement: Emphasis is on balanced (Newton's First Law) and unbalanced forces in a system, qualitative comparisons of forces, mass and changes in motion (Newton's Second Law), frame of reference, and specification of units. Assessment Boundary: Assessment is limited to forces and changes in motion in one-dimension in an inertial reference frame and to change in one variable at a time. Assessment does not include the use of trigonometry.

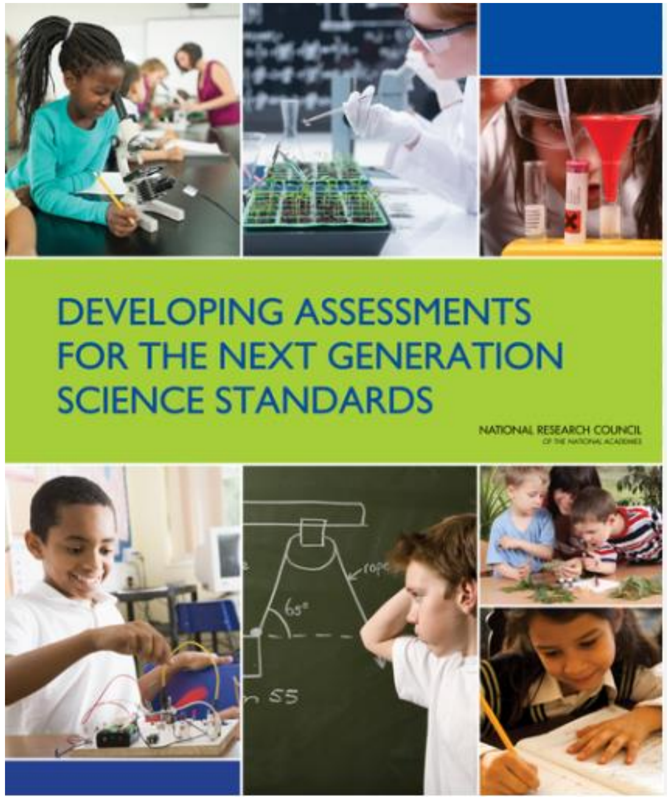
Crosscutting Concepts: Stability and Change

- Explanations of stability and change in natural or designed systems can be constructed by examining the changes over time and forces at different scales.

Example of a Performance Expectation

A specific combination of a SEP, CCC, and DCI as THE WAY to TEACH and ASSESS

How to assess these aspirational standards – Conclusions from NRC



- **Assessment tasks will generally need to contain multiple components (e.g., a set of interrelated questions**).
- **It may be useful to focus on individual practices, core ideas, or crosscutting concepts in the various components of an assessment task, but, together, the components need to support inferences about students' three-dimensional science learning** (2-1)
- **It will not be feasible to assess all of the performance expectations** (2-3)
- **Effective evaluation of three-dimensional science learning requires more than a one-to-one mapping between the NGSS performance expectations and assessment tasks** (2-4)
- **Reasonable testing time and cost**.(p 145)
- **Focus on selected aspects of the NGSS** (reflected as particular performance expectations or **some other logical grouping structure**). (7-2)

See Gorin and Mislevy (2013) for summary of challenges of assessing NGSS

ACT Design Tradeoffs for Science and NGSS

- Time consideration vs breadth of content sampling
- Time consideration, omit rate, and cost of CR or Composite Items
  - Paper and Pencil vs Computer based Testing
- Predicting college and career readiness vs covering all state standards
- Access to opportunity to learn
- Differential course taking patterns by region and academic ability
- Passage and item set together measure all three dimensions although some items measure only 2 dimensions (SEP and CCC)

Example 2-dimensional item (SEP & CCC) in a Physics context

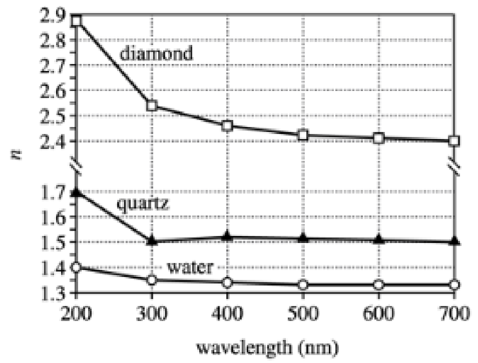
By measuring the angle of deviation, *d*, the value of *n* can be calculated. Table 1 and Figure 2 show values of *d* and of *n*, respectively, for each of 3 prisms at each of 6 wavelengths.

Table 1

Wavelength (nm*)	*d* (degrees) for a prism composed of:		
	diamond	quartz	water†
200	39.99	14.07	8.06
300	32.50	10.26	7.09
400	30.64	10.65	6.89
500	29.92	10.51	6.81
600	29.61	10.38	6.75
700	29.35	10.34	6.73

*nanometers
†a thin-walled glass prism filled with water

Figure 2



One of the values of *d* listed in Table 1 is in error. As a result, the corresponding value of *n* in Figure 2 is in error.

Based on the trends in those data, the error is for which prism and which value of *d*?

A. Quartz; 10.26°

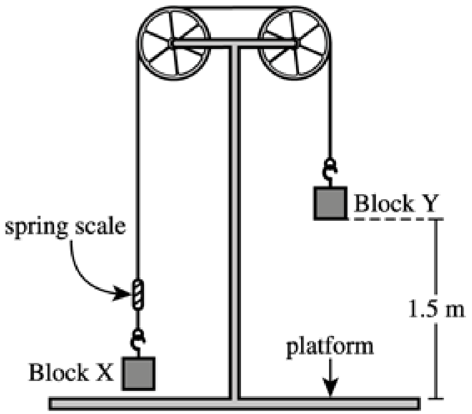
B. Quartz; 10.51°

C. Water; 7.09°

D. Water; 8.06°

The *Atwood machine* shown in Figure 1 was used as part of 2 studies on objects moving with constant acceleration.

Figure 1



Study 1

In each of 10 trials, the following procedure was performed:

1. A string was passed over 2 pulleys. The string had a ring on each end and a *spring scale* (a device that can measure forces) near one end.
2. Block X, having a mass m_X, was hooked onto the left ring. Block Y, having a mass m_Y, was hooked onto the right ring.
3. Block X was pulled down and held in place so that Block Y was 1.5 m above the platform.
4. With all objects starting at rest, Block X was released, and both F (the force on the string) and t (the time required for Block Y to fall to the platform) were measured.

(Note: All objects other than the 2 blocks had negligible mass. The string was not stretchable.)

Table 1 shows the results, with F in newtons (N) and t in seconds (s).

Table 1

Trial	m_X (kg)	m_Y (kg)	F (N)	t (s)
1	0.2	0.2	1.96	—
2	0.2	0.4	2.61	0.96
3	0.2	0.6	2.94	0.78
4	0.2	0.8	3.14	0.71
5	0.4	0.4	3.92	—
6	0.4	0.6	4.70	1.24
7	0.4	0.8	5.23	0.96
8	0.6	0.6	5.88	—
9	0.6	0.8	6.72	1.46
10	0.8	0.8	7.84	—

Note: A dash indicates that Block Y did not fall.

Suppose that in Step 3, Block X had been pulled down and held in place so that Block Y was 100 *centimeters* (NOT meters) above the platform. Would the values of t recorded in Study 1 more likely have been greater than or less than those shown in Table 1?

A. Greater, because Block Y would have fallen a longer distance.

B. Greater, because Block Y would have fallen a shorter distance.

C. Less, because Block Y would have fallen a longer distance.

D. Less, because Block Y would have fallen a shorter distance.

Challenge of large domain and short testing time

- 8 SEP, 7 CCC, and dozens of DCI
- Emphasizing those standards that most strongly tie to college and career readiness provides a stronger indicator while maintaining a *shorter testing time*
- ACT National Curriculum Survey (2012, 2016, 2020) research shows that Post Secondary Educators state science practices are more strongly tied to college and career readiness than is content mastery
- ACT Readiness Reports consistently show strong correlation to ACT Science score to college outcomes
- **Many standards overlap**, which makes sense for instruction, but for assessment, results in repetition in domain sampling

Examples of how Science & Engineering Practices inherently overlap

Asking Questions & Defining Problems: Ask questions that arise from examining models…to determine relationships, including quantitative relationships, between independent and dependent variables…clarify and refine a model…evaluate questions that challenge …the interpretation of a data set…the development of a process or system…

Obtaining, Evaluating, & Communicating Information: Students evaluate the validity and reliability of claims, methods…Critically read scientific literature…to obtain scientific and technical information…Compare, integrate, and evaluate sources of information…to address a scientific question…evaluate scientific and technical information…Communicate scientific and technical information…graphically

Analyzing & Interpreting Data: …comparison of data sets for… use of models to generate and analyze data. Analyze data using…models…make valid and reliable scientific claims…when analyzing and interpreting data…examine consistency of measurements and observations…Evaluate the impact of new data on a working explanation or model…or characteristics of system…

Developing & Using Models: …develop models to predict and show relationships…between systems and their components…Evaluate merits …Design a test…based on evidence…predict the relationships between systems……generate data to support explanations, predict phenomena…

Planning & Carrying Out Investigations: …provide evidence for…mathematical…and empirical models: …plan an investigation…to produce data that can serve as evidence to build and revise models, support explanations…Consider possible…effects…collect, record, analyze, and evaluate data…collect data about a complex model of a proposed process or system

Constructing Explanations & Designing Solutions: …create explanations that are supported by multiple …sources of evidence…Make quantitative …claims regarding the relationship …Construct and revise an explanation based …evidence …including …investigations, model …provide an explanation of …effects …link evidence to the claim and to assess the extent to which the reasoning and data support the explanation.

Engaging In Argument From Evidence: …use appropriate and sufficient evidence and scientific reasoning to defend and critique claims and explanations…Compare and evaluate competing arguments…in light of…new evidence …determine the merits of arguments…Construct, use, and present…arguments or counter-arguments based on data and evidence.

Using Mathematics & Computational Thinking: …analyze, represent, and model data…Use mathematical…representations…to describe and support claims and explanations.

Examples of how Crosscutting Concepts inherently overlap with Science and Engineering Practices:

Patterns: …patterns in systems at different scales…evidence for causality in supporting their explanations…explanations used at one scale may not be useful or need revision using a different scale, thus requiring improved investigations and experiments. …use mathematical representations to identify and analyze patterns…

Developing & Using Models: …develop models to predict and show relationships…between systems and their components…Evaluate merits …Design a test…based on evidence…predict the relationships between systems……generate data to support explanations, predict phenomena…

Analyzing & Interpreting Data: …comparison of data sets for… use of models to generate and analyze data. Analyze data using…models…make valid and reliable scientific claims…when analyzing and interpreting data…examine consistency of measurements and observations…Evaluate the impact of new data on a working explanation or model…or characteristics of system…

Scale, Proportion, & Quantity: …dependent on the scale…recognize patterns…understand how a model at one scale relates to a model at another scale…use algebraic thinking to examine scientific data and predict the effect of a change in one variable on another…

Systems and System Models: Students investigate or analyze…use models …systems at different scales…use models…to predict the behavior of a system…

Cause & Effect: …suggest cause and effect relationships to explain and predict behaviors …propose causal relationships… smaller scale…recognize changes in systems…

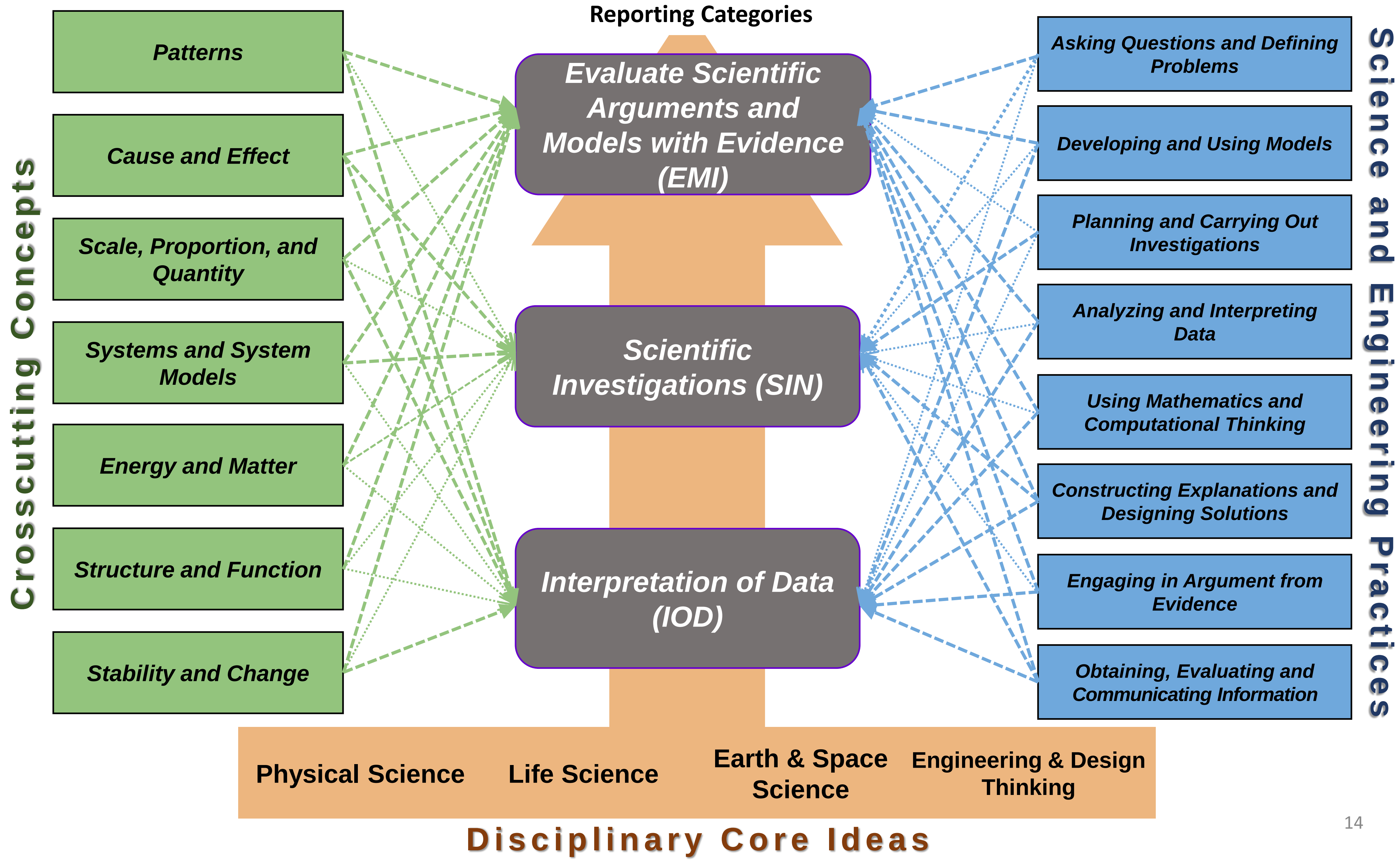
Constructing Explanations & Designing Solutions: …create explanations that are supported by multiple …sources of evidence…Make quantitative …claims regarding the relationship …Construct and revise an explanation based …evidence …including …investigations, model …provide an explanation of …effects …link evidence to the claim and to assess the extent to which the reasoning and data support the explanation.

Focus on Some Other Logical Structure of the Three Dimensions (Recommendation 7-2)

The “logical structure” on which ACT Science is based reflects the **natural redundancy across the 3 NGSS dimensions**, the **research on college and career readiness for science**, and the **necessary design trade-offs** to meet the practical requirements for large-scale summative assessment.

Three overarching domains of science skills and knowledge for which students receive performance indicators and that make up the construct of ACT Science . They are:

- **Interpretation of Data (IOD):** Students manipulate/analyze scientific data presented in tables, graphs, and diagrams (recognize trends in data, translate data into graphs, interpolate and extrapolate, mathematical reasoning)
- **Scientific Investigation (SIN):** Students understand experimental tools, procedures, and design (methods, tools, variables, controls) and compare, extend, modify experiments (e .g ., predict the results of additional trials).
- **Evaluation of Scientific Arguments and Models with Evidence (EMI):** Students judge the validity of scientific information and formulate conclusions and predictions based on that information (e.g., determine which explanation for a scientific phenomenon is supported by new findings).


Reporting Categories
Patterns
Cause and Effect
Scale, Proportion, and Quantity
Systems and System Models
Energy and Matter
Structure and Function
Stability and Change
Crosscutting Concepts
Evaluate Scientific Arguments and Models with Evidence (EMI)
Scientific Investigations (SIN)
Interpretation of Data (IOD)
Asking Questions and Defining Problems
Developing and Using Models
Planning and Carrying Out Investigations
Analyzing and Interpreting Data
Using Mathematics and Computational Thinking
Constructing Explanations and Designing Solutions
Engaging in Argument from Evidence
Obtaining, Evaluating and Communicating Information
Science and Engineering Practices
Physical Science
Life Science
Earth & Space Science
Engineering & Design Thinking
Disciplinary Core Ideas

How has ACT's approach worked with other states who have science standards based on NGSS

States Using the ACT Science Test Under ESSA for Accountability: Assessment Peer Review Status				
State	**ACT Used to Measure Achievement in:**			**ESSA Peer Review Status and Links to Decision Letters**
	ELA	**Math**	**Science**	
Alabama	X	X	X	Substantially Meets Requirements
Montana	X	X		Substantially Meets Requirements
			X	Submitted December 2023 – Decision Pending
Nebraska	X	X	X	**Substantially Meets Requirements**
Wisconsin	X	X	X	**Fully Meets Requirements**

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Comparison Illinois Current Science Blueprints to ACT

CURRENT Illinois HS Test		
Content Discipline	Clusters (operational scenarios)	Items
Life Science	4	24 MC/TE + 1CR
Earth and Space Science	4	24 MC/TE + 1 CR
Physical	4	24 MC/TE + 1 CR
TOTALS	12	72 MC/TE + 3 CR (91 points)

ACT Science Test		
Content Discipline	Clusters (operational scenarios)	Items
Life Science	2	11-14 MC
Chemistry	1-2	5-14 MC
Physics	1-2	5-14 MC
Earth and Space Science	1-2	5-14 MC
TOTALS	6	40

- MC – Multiple Choice
- TE – Tech Enhanced
- CR – Constructed Response

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The ISA does not currently cluster SEP into subreporting categories of related skills (although the 2017 recommendations did look at some possibilities)

Primary ACT reporting category by SEP		
SIN	**EMI**	**IOD**
SEP 1: Asking Questions and Defining Problems (SIN)	SEP 6: Constructing Explanations and Designing Solutions (EMI)	SEP 4: Analyzing and Interpreting Data (IOD)
SEP 3: Planning and Carrying Out Investigation (SIN)	SEP 7: Engaging in Argument from Evidence (EMI)	SEP 5: Using Mathematical and Computational Thinking (IOD)
	SEP 8: Obtaining, Evaluating, and Communication of Information (EMI)	
	SEP 2: Developing and Using Models (EMI)	

https://www.isbe.net/Documents/ISA-Report.pdf

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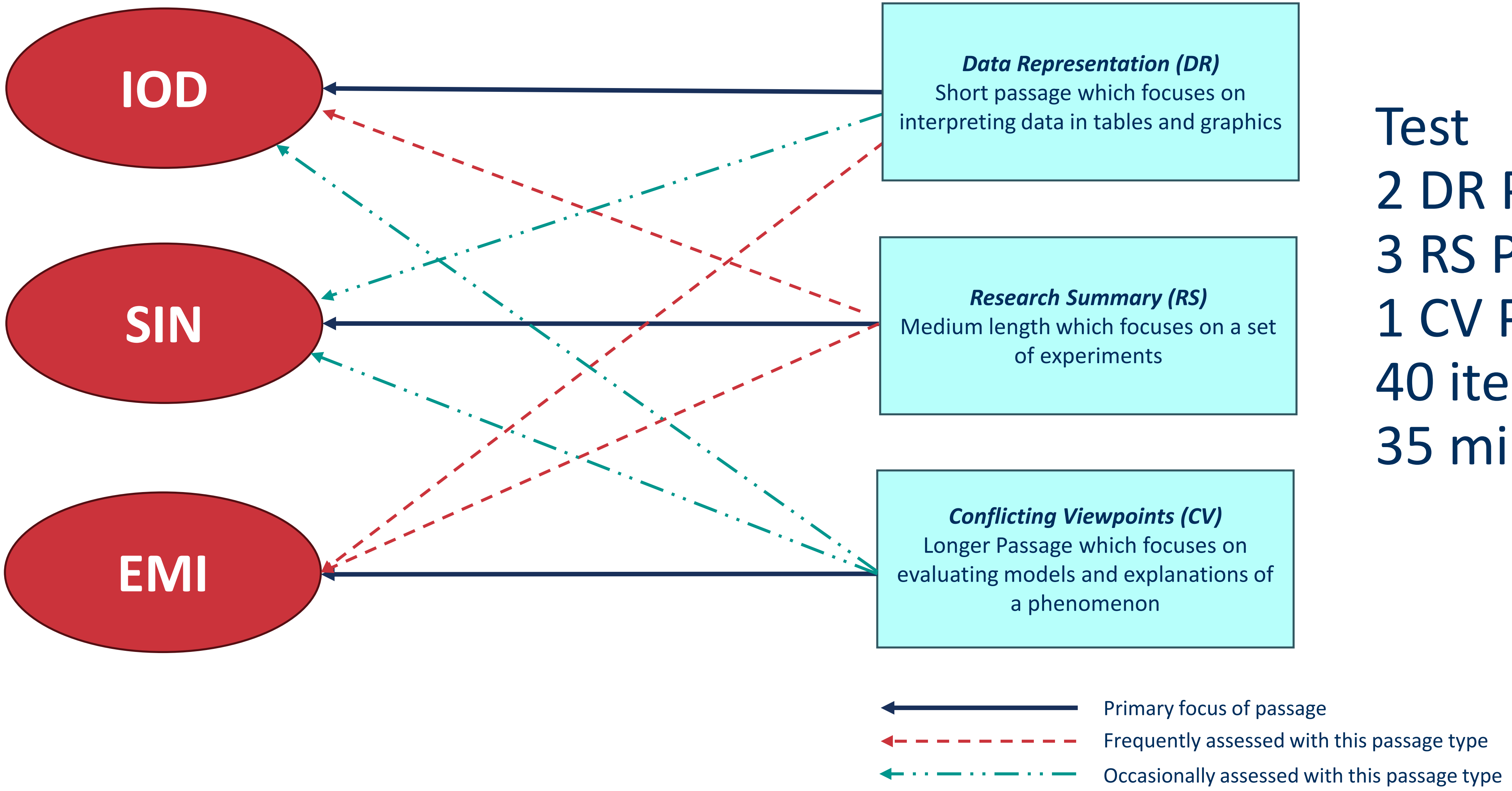
Targeted Reporting Categories by Passage Type



Test
2 DR Passages
3 RS Passages
1 CV Passage
40 items
35 minutes

Reports for students and schools

ANN C TAYLOR
7852 W 46TH ST APT 4
WHEAT RIDGE, CO, 80033

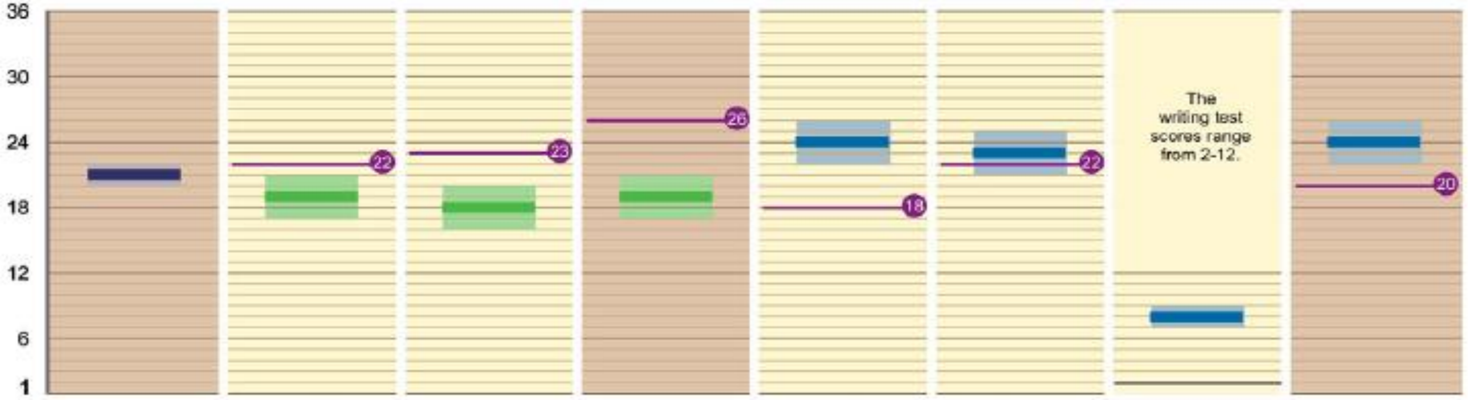
ACT ID: 201293212
GRADUATION YEAR: 2023

DOB: SEPTEMBER 01, 2004
GENDER: FEMALE

TEST DATE: APRIL 2022
HIGH SCHOOL CODE: 061-450
WHEAT RIDGE SENIOR HIGH SCHOOL

The ACT® High School Report

SUPER SCORE							
22	21 Oct 2020	20 Oct 2020	21	24 Apr 2021	23 Apr 2021	8 Apr 2021	24
21 COMPOSITE	19 MATH	18 SCIENCE	19 STEM	24 ENGLISH	23 READING	8 WRITING	24 ELA



Student Score
Score
Score Range

ACT College Readiness Benchmarks
Readiness Benchmark
If the student's score is at or above the Benchmark, he or she will likely be ready for first-year college courses in the corresponding subject area. There is currently no Benchmark for writing.

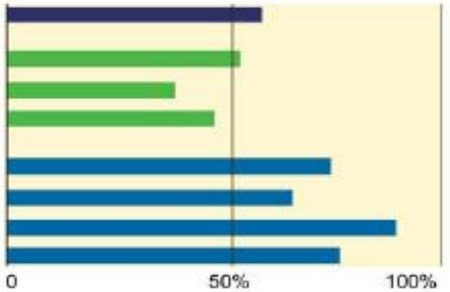
Student's Score Range
Test scores are estimates of the student's educational development. Think of true achievement on this test as being within a range that extends about one standard error of measurement, or about 1 point for the Composite and writing scores, and 2 points for STEM, ELA, and the other test scores, above and below the student's score.

Ranking Results

The student's ranks tell you the approximate percentages of recent high school graduates in the US and your state who took the ACT® test and received scores that are the same as or lower than the student's scores. For example, a rank of 56 for the student's Composite score means 56% of students earned that Composite score or below.

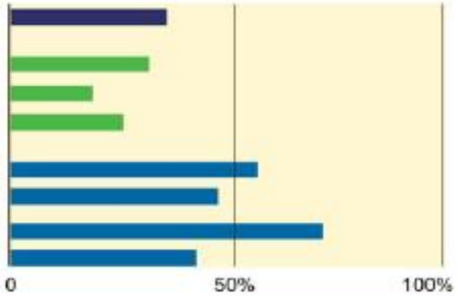
US Rank

Composite	59%
Math	54%
Science	39%
STEM	48%
English	75%
Reading	66%
Writing	90%
ELA	77%



State Rank

Composite	36%
Math	32%
Science	19%
STEM	26%
English	57%
Reading	48%
Writing	72%
ELA	43%



Detailed Results

ACT Readiness Range

MATH 19		
Preparing for Higher Math	15 of 35	43%
• Number & Quantity	3 of 5	60%
• Algebra	4 of 8	50%
• Functions	2 of 8	25%
• Geometry	4 of 8	50%
• Statistics & Probability	2 of 6	33%
Integrating Essential Skills	11 of 25	44%
Modeling	12 of 21	57%

SCIENCE 18		
Interpretation of Data	10 of 18	56%
Scientific Investigation	2 of 10	20%
Evaluation of Models, Inferences & Experimental Results	4 of 12	33%

ACT Composite Score: ACT Math, Science, English, and Reading test scores and the Composite score range from 1 to 36. For each test, we converted the student's number of correct answers into a score within that range. The student's Composite

ACT Readiness Range

ENGLISH 24		
Production of Writing	17 of 23	74%
Knowledge of Language	10 of 12	83%
Conventions of Standard English	29 of 40	73%

READING 23		
Key Ideas & Details	17 of 24	71%
Craft & Structure	5 of 10	50%
Integration of Knowledge & Ideas	5 of 6	83%

Understanding Complex Texts — Below | Proficient | Above

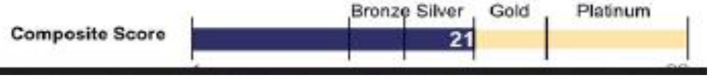
Understanding Complex Texts: This indicator lets you know if you are understanding the central meaning of complex texts at a level that is needed to succeed in college courses with high reading demand.

WRITING 8

If the student took the writing test, the essay was scored on a scale of 1 to 6 by two raters in each of

Progress Toward the ACT National Career Readiness Certificate®

This indicator provides an estimate of the ACT National Career Readiness Certificate (ACT NCRC®) that students with this ACT Composite score are likely to obtain. The ACT NCRC is an assessment-based credential that documents foundational work skills important for job success across industries and occupations.



Composite and Content Area Scores reported longitudinally

ACT Online Reporting by Data Interaction

Help | BW

Summary View: The ACT State Contract, Spring

Showing students who are College Reportable

Options | Save | Download | Table | Chart | Transpose

Group	Year	Admin	Composite		Math	Science	STEM	English	Reading	Writing	ELA
			Valid Number	Mean Score	Mean Score	Mean Score	Mean Score	Mean Score	Mean Score	Mean Score	Mean Score
Stormshire State Organization	2020-2021	Spring	14073	17.9	17.8	18.3	18.3	16.6	18.5	6.1	17.1
Stormshire State Organization	2019-2020	Spring	13974	17.7	17.7	18.2	18.2	16.2	18.1	5.9	16.4
Stormshire State Organization	2018-2019	Spring	17774	17.4	17.5	17.7	17.8	15.9	18.0	5.9	16.1
Silverpine High School	2020-2021	Spring	2712	17.9	17.7	18.1	18.2	16.5	18.6	6.1	17.1
Silverpine High School	2019-2020	Spring	2807	17.7	17.7	18.1	18.1	16.2	18.1	5.9	16.4
Silverpine High School	2018-2019	Spring	3548	17.3	17.3	17.7	17.8	15.8	17.9	5.8	16.0

Reporting Category Score Report

Percentage of students that meet the benchmark (score ≥ 23) (% Met) for each Reporting Category.

ACT Online Reporting by Data Interaction

Help Recent BW

Summary View: The ACT State Contract, Spring

Showing students who are College Reportable

Options Save Download Table Chart Transpose

			Composite	Science					
				Interpretation of Data-Readiness		Scientific Investigation-Readiness		Evaluation of Models/Inferences-Readiness	
Group	Year	Admin	Valid Number	% Met	% Not Met	% Met	% Not Met	% Met	% Not Met
Stormshire State Organization	2020-2021	Spring	14073	22	78	25	75	22	78
Stormshire State Organization	2019-2020	Spring	13974	24	76	20	80	23	77
Stormshire State Organization	2018-2019	Spring	17774	22	78	22	78	20	80
Silverpine High School	2020-2021	Spring	2712	21	79	23	77	21	79
Silverpine High School	2019-2020	Spring	2807	23	77	19	81	22	78
Silverpine High School	2018-2019	Spring	3548	22	78	21	79	20	80

Score Ranges – Identify percentage of students in each score band to better use targeted supports

Summary View: The ACT State Contract, Spring

Showing students who are College Reportable

Options Save Download Table Chart Transpose

			Composite	Science						
				CCRS (01 to 12)	CCRS (13 to 15)	CCRS (16 to 19)	CCRS (20 to 23)	CCRS (24 to 27)	CCRS (28 to 32)	CCRS (33 to 36)
Group	Year	Admin	Valid Number	%	%	%	%	%	%	%
Stormshire State Organization	2020-2021	Spring	14073	13	19	30	22	12	3	1
Stormshire State Organization	2019-2020	Spring	13974	13	20	30	21	10	4	1
Stormshire State Organization	2018-2019	Spring	17774	16	19	32	18	10	3	1
Silverpine High School	2020-2021	Spring	2712	13	21	28	22	11	4	1
Silverpine High School	2019-2020	Spring	2807	14	20	31	21	10	4	1
Silverpine High School	2018-2019	Spring	3548	16	20	32	18	10	3	1

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Every student gets an opportunity to take a test used by the vast majority of post-secondary institutions as critical tool in college admissions decisions, and the ACT Science Test:

- assumes students bring basic science content knowledge (think *Disciplinary Core Ideas*), but *only* from introductory courses, so largely **curricula/course sequence neutral**
- focuses on practices and crosscutting concepts, which should accompany any content sequence
- focuses on the science knowledge, skills, and practices that research shows are most indicative of college and career readiness
- is linked to free teacher resources that tie to College and Career Readiness Skills

Questions