DTAMS Assessment Instrument Information
(Diagnostic Teacher Assessments in Mathematics and Science)

This document provides an overview of DTAMS assessments developed by the University of Louisville, Center for Research in Mathematics and Science Teacher Development, to assess middle school science teachers' content knowledge. Separate assessments are available in three science content areas: physical science, earth/space science, and life science. All assessments are designed to be used as pre/post measures of content knowledge.

Summary of development process

Teams of researchers analyzed a number of standards documents and research literature to synthesize the science content (detailed below) middle school teachers should know. Five types of knowledge (detailed below) were also identified. This provided a 2-dimensional chart within which questions were generated to ensure both breadth of coverage (content) and depth of coverage (knowledge type).

Teams of practicing science teachers, science teacher educators, and scientists generated questions intended to simultaneously target a particular content area and a particular knowledge type. Questions were targeted to be balanced across both dimensions.

Questions for each content area were sent out to approximately 40 external reviewers composed from the same three groups. These external reviewers categorized questions into a content category and a knowledge type as well as rated the appropriateness of each question and provided any other suggestions for improving the questions.

Based on reviewer feedback, questions were selected, revised, and assembled into a field test. Parallel questions were generated to produce 6 versions of each content area field test. Tests are designed to be completed by test takers within an hour – each is composed of 20 multiple choice and 5 open response questions.

Below are brief descriptions of each knowledge type and each content category and subcategory for all 3 science assessments. Sample assessment items are provided at the end of this document.

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KNOWLEDGE TYPE DESCRIPTIONS

Declarative Knowledge (DEC): This is knowledge of definitions and facts. It includes memorized statements of concepts, rules, and laws—"knowing that." Although they may or may not understand the basis of the concepts or how to apply them to solve problems, teachers with this knowledge can

- perform skills by rote.
- apply rules.
- give definitions.
- recall facts.

Scientific Inquiry and Procedures (INQ): This is knowledge of scientific procedures and approaches—"knowing how to do science." Teachers with knowledge of the elements of scientific inquiry can

- identify questions for scientific inquiry.
- design and conduct scientific investigations and experiments.
- use appropriate tools, instruments, and techniques to gather, analyze, and interpret data.
- develop descriptions, explanations, predictions, and models using experimental evidence.
- think critically and logically to relate evidence and explanations.
- recognize and analyze alternative explanations and predictions.
- communicate scientific procedures and explanations.
- use mathematics in all aspects of scientific inquiry.

Schematic Knowledge (SCH): Schematic knowledge represents a deep understanding of science concepts, laws, theories, principles, and rules—"knowing and understanding why." Teachers with this knowledge

- understand connections and relationships among scientific phenomena.
- understand the reasons for scientific rules and laws.
- can explain the basis for concepts and understandings.
- discern the nature of relationships.
- can compare and contrast properties and characteristics of scientific concepts.
- can explain natural phenomena within the limits of current scientific knowledge.
- know that many phenomena have not yet been explained and that scientific knowledge is always evolving.

Pedagogical Content Knowledge (PED): This knowledge represents strategic knowledge for science teaching—"knowing when, where, and how to best teach science." For these assessments, we are concentrating on the use of pedagogical content knowledge in the correction of student misconceptions about science. Teachers with this knowledge can satisfy two criteria:

1. Recognize the students' misconceptions, and
2. Describe the most effective ways to teach particular scientific concepts--the most powerful analogies, illustrations, examples, explanations, experiments, and demonstrations.

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Science, Technology, and Society Knowledge (STS):
STS addresses the interactions of science with technology and human society, including technology, personal applications, influences of society and government, and the history of science and technology. STS knowledge is represented in situations where human needs are a primary purpose for the application of science. Teachers with knowledge of STS can

- identify and utilize scientific principles and concepts incorporated into **devices and processes** designed to change the world for human purposes and to meet human needs.

- design, use and evaluate **technology**.

- understand the reciprocal influences of human society and technology on each other, including **ethical and environmental** considerations.

- understand the importance **of historical contexts** for the development of science and various technologies.

CONTENT SUBCATEGORIES – PHYSICAL SCIENCE

Note: The BOLD words are the abbreviated label used for each subcategory on the score report returned to the field test coordinator.

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1. **Matter** - Properties and changes of properties in matter

   a. physical properties (e.g. density, boiling point, solubility), mixtures, physical vs. chemical change

   b. chemical reactions, compounds, conservation of mass, chemical families

   c. elements & atomic structure

   d. states of matter, kinetic theory, and gas laws

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2. **Motion and Forces**

   a. position and direction of motion, speed & velocity, graphical representation of motion

   b. force & acceleration (includes friction, weight, f = ma, gravity), addition of forces, balanced & unbalanced forces, momentum and impulse (includes action-reaction)

   c. Newton's first law of motion (inertia)

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3. **Energy**

   a. energy as ability to do work/change, mechanical energy, kinetic and potential energy, simple machines, systems & conservation of energy

   b. waves, sound, light (refraction, absorption, scattering & reflection), color and vision, electromagnetic spectrum, and sunlight

   c. static electricity, electric current &circuits, magnetism, electromagnetism

   d. thermodynamics, heat, temperature, and temperature scales

   e. chemical energy, nuclear energy (radioactivity, fusion, fission)

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CONTENT SUBCATEGORIES – LIFE SCIENCE

Note: The BOLD words are the abbreviated label used for each subcategory on the score report returned to the field test coordinator.

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1. **Structure/Function** of Living Systems

   a. complimentary nature of structure and function, increase in complexity: cell-tissue-organ

   b. cells

   c. animal organ systems

   d. plant organ systems

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2. **Internal Regulation** and Behavior

   a. organisms convert energy (photosynthesis, respiration, metabolism)

   b. homeostasis; behavior from cellular to organ levels

   c. cellular communication (hormones), immune system, and disease fighting

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3. Reproduction and **Heredity, Diversity** and Adaptation of Organisms

   a. plant and animal reproduction (sexual & asexual)

   b. genetics

   c. fitness and survival (nature vs. nurture), adaptations, evolution (change over time), extinction

   d. taxonomy

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4. **Interdependence** of Organisms (Ecology, Populations)

   a. organisms obtain and use resources (consumers, producers, parasitism, mutualism, etc.)

   b. cycling of nature

   c. populations/ biomes/ ecosystems

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CONTENT SUBCATEGORIES – EARTH/SPACE SCIENCE

Note: The BOLD words are the abbreviated label used for each subcategory on the score report returned to the field test coordinator.

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1. **Atmosphere, Hydrosphere**

    a. atmosphere composition & properties

    b. weather/weather hazards/cloud formation

    c. climate, oceans & water cycle

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2. **Lithosphere**

    a. rock/mineral/soil properties

    b. rock/mineral cycle & processes (weathering, erosion, glaciers)

    c. movements of plates/ earthquakes/volcanoes & Earth's layers

    d. history of the Earth: geologic time/ uniformitarianism fossils as evidence

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3. **Space** – Earth in the Solar System

    a. solar system

    b. phases, motion and eclipses

    c. sun as energy and reason for seasons

    d. gravity and tides

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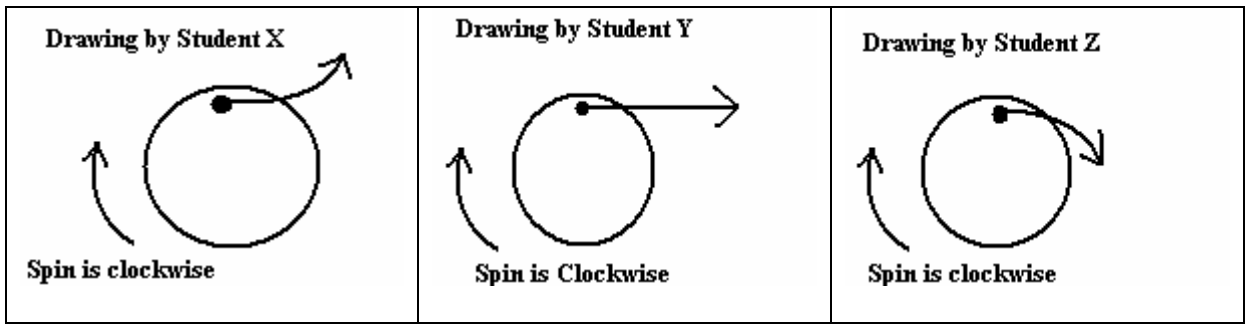
SAMPLE ASSESSMENT QUESTIONS

NOTE: These are assessment questions that did not make the cut from the external reviewers' feedback and are therefore not on our assessments. Thus they may not fit into the categories indicated – the suggested categorization is included to help the reader better understand the intended operationalization of the definitions above.

PHYSICAL SCIENCE SAMPLE ITEMS

1. (*content subcategory 1d, knowledge type STS*)
   A pressure cooker is a stovetop device designed with a lid that locks on the pot so that the pressure inside the pot can build up higher than one atmosphere during cooking. A pressure cooker can be used to cook foods faster than boiling water in an open pot because
   a. water boils at a higher temperature when the pressure is higher.
   b. the food stays completely submerged in the pot with a locked lid.
   c. the higher pressure forces the boiling water more quickly into the interior of the food.
   d. no water escapes the pot as steam, leaving more water remaining in the pot to cook the food.

2. (*content subcategory 2c, knowledge type PED*)
   You ask three students what would happen to a marble released on a spinning surface, such as a merry-go-round. Each draws a different picture, represented by the diagrams below. (The merry-go-round is spinning in a clockwise direction. The point of release of the marble is indicated by a black dot. The path taken by the marble after leaving the merry-go-round is shown by an arrow.) Explain which student (X, Y, or Z) has drawn the most correct picture, and detail what you would say and/or do to correct the other two students' misconceptions.



3. (*content subcategory 3d, knowledge type SCH*)
Without the input of external work, heat always moves from hotter regions to colder regions because
   a. the temperature contained in the hotter region flows down the temperature gradient towards the colder region.
   b. the hotter regions are less dense, causing them to rise up and spread out over the colder region until the two are evenly mixed.
   c. the faster-moving molecules in the hotter region will collide with those in the colder region and transfer energy to the slower molecules.
   d. the lower energy of the colder regions generates a low pressure which causes the hotter regions to flow toward the colder regions and mix until they become uniform.

4. (*content subcategory 2b, knowledge type DEC*)
If a constant net force greater than zero is applied to a ball, what would you observe?
   a. Not much, because a "net" force is always weak.
   b. The ball will go at a constant speed in a straight line.
   c. The ball speeds up, slows down, or changes direction.
   d. The ball will eventually explode or disintegrate.

5. (*content subcategory 1d, knowledge type INQ)*
During an experiment, a student was looking at a piece of ice which slowly changed into a liquid in front of her eyes. This student wrote in her journal that the ice is melting and changing into a liquid. Her statement is
   a. an inference.
   b. an observation.
   c. a conclusion.
   d. a hypothesis.

6. (*content subcategory 3c, knowledge type PED*)
After a lab that involved magnetism and compasses, a student writes that a magnet can't function on the Moon because there are no magnetic poles on the Moon as there are on Earth. Identify this student's misconception and describe an appropriate strategy to counteract this misconception.