POSITION STATEMENTS

Assessment

Assessment refers to the processes used to measure student progress and achievement by identifying patterns of qualitative and quantitative learning driven by instruction and feedback. Assessments provide evidence of students' prior knowledge, thinking, or learning in order to evaluate what students understand and how they are thinking at a given point in time for the purpose of promoting student learning. Consequently, science instruction should be informed by assessment, and instructional strategies should be adjusted based on feedback to meet the individual needs of all students. Assessment is aligned with curriculum and instruction and supports conceptual understanding with a focus on competency. Because no single assessment method provides a complete picture of what a student knows and can do, a variety of assessment methods is imperative. Ongoing formative assessments provide diagnostic feedback to teachers and students before, during, and after instruction. Formative assessment information should be used as feedback to modify teaching and learning activities. Summative assessments are used in classrooms, schools, and districts to determine student achievement at the end of a unit, course, or time period. Designers of assessments should consider the diverse backgrounds and different learning styles of students when planning for academic success in the classroom. Assessment tasks must integrate the three dimensions of science and engineering practices, crosscutting concepts, and disciplinary core ideas and provide opportunities for students to demonstrate conceptual understanding of science phenomena during inquiry. The primary goal of assessment is to measure with accuracy and validity what a student knows and can do and what a student still needs to learn based on Alabama's College- and Career-Readiness Standards.

Classroom Environment

Effective science classroom environments are those in which teachers and students work collaboratively. These student-centered environments shift the focus from the teacher to the learner, providing opportunities for creative scientific exploration and engineering design that allow students to connect the classroom to the outside world. Thus, stimulating the learner's interest in science through investigation encourages a lifelong pursuit for exploration and knowledge. The science classroom is any place where scientific inquiry occurs, whether it is the traditional laboratory or classroom, a playground, a science museum, an amusement park, a forest, or a beach. In the student-centered classroom, emphasis is placed upon active and cooperative learning environments where students work together to manipulate variables, make observations, and use prior knowledge to construct reasonable explanations while solving problems under conditions that assure both positive interdependence and individual accountability. Teachers guide and facilitate investigations by immersing students in scientific practices using inquiry, correct and appropriate manipulative techniques, and safe and humane laboratory practices. Students may be observed engaging in interpreting scientific data collected to construct and evaluate evidence-based arguments of phenomena during scientific inquiry or engaging in argument from evidence acquired during research of a phenomenon. Quality science instruction emphasizes critical thinking and investigative processes that reveal consistencies, relationships, and patterns. The classroom should be flexible, yet structured, intellectually challenging, positive and nonthreatening, stimulating, and adaptable to a variety of learning styles.

Cultural Diversity

Cultural diversity is an asset in the classroom. Educators should actively encourage students of various backgrounds to share their experiences in relation to science. Recognizing multicultural diversity in the classroom as a valuable resource contributes in positive ways to collaboration and participation in science learning.

Science and engineering are collaborative social processes that take place in the context of culturally valued knowledge and practices. Throughout history, diverse groups of people from different cultures and races have contributed to the body of scientific knowledge. This knowledge has resulted in remarkable technological advances that benefit all mankind. Today's global scientific community can be enhanced by the diverse perspectives represented by all nations, groups, and races. From a global perspective, engineering offers opportunities for innovation and creativity at the K-12 level. Engineering is a field that is critical to innovation, and exposure to engineering activities such as robotics and invention competitions can spark interest in the study of the science, technology, engineering, and mathematics (STEM) fields. This opportunity is particularly important for students who traditionally have not recognized science as relevant to their lives or future because of the lack of emphasis within the culture.

All students, regardless of gender, ethnicity, or cultural background, should have equal access to learning science and engaging in scientific and engineering practices. Strategies utilized for instruction must recognize and respect differences students bring based on their cultures. These standards provide an opportunity for schools to create environments that cultivate and prepare the minds of all students for greater understanding of the scientific enterprise. An increasing number of scientists and engineers are needed in our state and nation to continue technological advancement in many traditional and emerging scientific and engineering careers.

Instructional Model

Effective instruction results from deliberate and focused instructional design. This involves a shift in focus to the desired learning from which appropriate strategies will follow. As teachers shift the focus from teaching to student learning, they begin to spend most of the time considering what the learner needs in order to accomplish the learning goals instead of what the teacher will do and which materials the teacher will use. Effective instruction ensures that students are actively engaged in the learning process, have opportunities for interaction with the environment, and have time for reflection upon learning. The instructional setting must allow students time for developing the reasoning and critical-thinking skills necessary for constructing meaning and acquiring scientific knowledge. In this setting, teachers facilitate the learning process by guiding students, providing students with a focus, challenging students to excel, and encouraging and supporting student learning at all levels of inquiry. Before quality instruction can occur, there must be a plan for what teachers want students to learn. One process for planning includes the following three steps.

1. Identify desired outcomes found in the standards.
2. Determine acceptable evidence of student learning by designing evaluation activities.
3. Develop activities and learning experiences that will engage all students in exploring, explaining, and expanding their understanding of the scientific and engineering practices, crosscutting concepts, and disciplinary core ideas in the standards.

Members of the Alabama State Science Course of Study Committee and Task Force support the use of inquiry-based instructional models such as the following Five E + IA Instructional Model.* This model complements the three-step planning process described on the preceding page.

Five E + IA Instructional Model

Engage

Student interest is stimulated and connections are made to prior knowledge and between past and present experiences. Student thinking is focused on learning outcomes as they become mentally engaged in the practices, crosscutting concepts, and core ideas of the unit or lesson.

Explore

Students investigate initial ideas and solutions in a context within which they can identify. Using investigation, research, discourse, text, and media, students actively explore situations and build common experiences that serve as a basis for developing an understanding of the concept within context.

Explain

Students are provided the opportunity to collaborate, communicate, and construct meaning from their experiences based on an analysis of the exploration. This phase emphasizes the importance of students developing evidence-based explanations founded upon their observations and experiences obtained through investigations. Teachers clarify understanding through definitions, labels, and explanations for abilities, concepts, practices, and skills.

Elaborate

Students reflect upon, expand, and apply conceptual understanding of scientific concepts to new and unfamiliar situations in order to cultivate a broader and deeper understanding of concepts through new experiences within new contexts and situations.

Evaluate

Students are assessed on understanding of scientific concepts. Assessment provides opportunities for teachers to evaluate understanding of concepts and practices identified in the standards. This phase helps teachers know if students are learning in order for appropriate next steps to occur.

Intervene or **A**ccelerate

When some students do not learn the first time, intervention strategies may be implemented to further explain and elaborate upon concepts to a greater extent in order to clarify understanding. Students who have demonstrated proficiency may be able to enrich or accelerate learning through more challenging, engaging, and exploratory experiences.

*Adapted from Zuiker, Steven J., and J. Reid Whitaker (in preparation). "A Case Study of the STEMscopes 5E+I/A Inquiry Model." *Journal of Science Education and Technology*.

Interdisciplinary Connections

Academic rigor, critical-thinking skills, and vertically aligned learning progressions are common elements among Alabama's core academic standards. Diverse texts and media should be infused to create a rich science learning environment where students use real-world experiences and historical facts and events to discuss and create hypotheses and explain theories. Being able to read, write, and understand various media and texts in context are important skills to develop for both in and out of the classroom. Students write, speak, and create multimedia presentations based upon laboratory experiences and knowledge they obtained from published resources. The scientific and engineering practices allow students to utilize reading and writing skills (Appendix A). What is learned in English language arts classes is also learned and practiced in science when students construct explanations from evidence; engage in argument from evidence through debate to defend a claim; or obtain, evaluate, and communicate information from media, texts, and specifically through case studies. In both mathematics and science classes, students use computational thinking and mathematical representations to comprehend and communicate scientific findings. Students learn to develop and use models derived from data analyzed statistically to explain or describe phenomena. The creative element of science is found not only in discovery and invention, but is also realized in the artistic, scientific, and engineering designs developed by students. Science comes alive as students explore the natural world through the use of the five senses and produce sketches as a response to the observed environment while others write fiction and nonfiction to describe surroundings. At the same time, students may discover artifacts and native specimens which lead to discussions of history and geography of the area. High school students studying the disciplinary core idea, Heredity: Inheritance and Variation of Traits, may learn in science and world history about the important role hemophilia has played in Europe's history and communicate their findings orally or through writing. Students should also be able to develop an understanding of historical figures and events that have helped shape our world in the realm of science. Thus, it is essential for teachers to demonstrate how knowledge is interrelated and model strategies to recognize these connections.

Laboratory Safety

Active hands-on learning increases the potential for injuries or accidents. Safety is a primary concern for everyone in kindergarten through Grade 12, including students, teachers, support personnel, and administrators. For this reason, the National Science Teachers Association (NSTA) and the Alabama State Science Course of Study Committee and Task Force recommend that all science teachers be certified in first aid by the American Red Cross. Professional learning information may be accessed at http://www.redcross.org/take-a-class/certificates-ceus and http://www.redcross.org/take-a-class/program-highlights/cpr-first-aid. Before allowing students to participate in scientific investigations, teachers should recognize any potential for harm in order to prevent possible injuries or accidents or to minimize the impact of injuries or accidents if prevention is not successful.

Safety must be given a priority in the storage, use, and care of equipment, specimens, and materials in the science classroom. It is recommended that science teachers adhere to national regulatory agencies such as the American Chemical Society (ACS) and the Occupational Safety and Health Administration's (OSHA) revised Hazard Communication Standard (HCS), now aligned with the Globally Harmonized System (GHS) of Classification and Labeling of Chemicals, as well as local and state regulatory agencies that have established safety guidelines. In addition, teachers must work with the local school and local school system to be certain that science safety guidelines for which they are responsible are implemented.

Teachers must be certain that students receive adequate instruction for participating safely in all science investigations, no matter the location. As part of the safety guidelines, consideration must be given to adequate and safe space for scientific collaboration and investigation. To address this safety issue, professional organizations of science teachers recommend that science laboratory classes not exceed 24 students.

A written science safety plan is an essential part of the school science program. It is suggested that a science safety plan be developed by a team that includes the principal, teachers, school nurse, a fire fighter, and a representative from an insurance agency. Suggestions for developing science safety plans for schools and school systems are available on the Alabama Department of Education Web site at www.alsde.edu. After initial development, an annual review and assessment of the plan should be made to ensure its effectiveness.

Teachers should also be aware of the state safety goggle law found in the *Code of Alabama*, 1975, §16-1-7. This law requires local boards of education to provide American National Standard Institute (ANSI) Z87 or Z87.1 coded safety goggles to every student engaged in science experiments. Teachers are further encouraged to obtain and keep readily available the safety references, *Science and Safety—Making the Connection* for secondary classrooms and the *Science and Safety: It's Elementary!* calendar and flip chart. These publications are available to download free of charge from the Council of State Science Supervisors (CSSS) at http://csss-science.org/safety.shtml.

Nature of Science

Throughout history, humans have attempted to explain the natural world in which they live. Current scientific knowledge and engineering practices are the result of humankind's ongoing pursuit for answers to questions about natural phenomena. All scientists share the assumptions that the universe has order, consistency, and mathematically interpreted patterns. While there is no single pathway to discovering new scientific knowledge, all scientific models, theories, and laws are based on empirical evidence. Specifically, scientific theories can be defined as inferred explanations of observable events or phenomena. Scientific laws are statements of measurable relationships among observable events or phenomena. All scientific knowledge is open to revision in light of new evidence.

All scientific discourse is centered on the common values of logical thinking, open-mindedness, objectivity, skepticism, reliability of research results, and honest reporting of findings. Science is fundamentally a human endeavor constrained by the progressing human capacity, technology, and social and economic contexts.

The 2012 National Research Council (NRC) publication, *A Framework for K-12 Science Education: Practices, Crosscutting Concepts, and Core Ideas,* recognizes the importance of the nature of science by stating what an educated citizen should comprehend about the scientific enterprise. As indicated in the publication, there is strong agreement that students should understand and be able to distinguish among observations, hypotheses, inferences, models, and theories or unsubstantiated claims.

Science, Engineering, Technology, and Society

Advances in science and engineering have profound effects on human society, including agriculture, health care, transportation, and communication. At the same time, economic, political, and cultural factors influence the goals and funding for science and engineering research. The work of science is essential in addressing global issues such as the demand for energy, clean water, and food for Earth's growing population. On the other hand, science and engineering are needed to resolve problems created by human activity that draws on natural resources. A goal of science and engineering education is to equip students with the knowledge, skills, and dispositions that will help them grow into responsible consumers and wise managers of Earth's resources. Students should be able to contribute and engage in society as educated, literate science citizens who make responsible and informed decisions about what is appropriate in situations involving science and technology.

The Alabama State Science Course of Study Committee and Task Force recognize two specific important ideas that relate science, technology, and society. The first is that scientific inquiry, engineering design, and technological development are interdependent. Scientific discoveries allow engineers to perform their work, and engineering accomplishments enable the work of scientists. For example, discoveries of electricity made it possible for engineers to create power grids to illuminate cities and allow for communications. The Hubble Space Telescope and certain light sensors created by engineers expanded our understanding of the universe beyond existing astronomical knowledge. The second important idea is that scientific discoveries and technological decisions affect society and the natural environment. People make decisions that ultimately guide the work of scientists and engineers. The infusion of the engineering, technology, and applications of science domain into the science standards should serve as a vehicle for providing reliable sources of scientific and technological information to be used in the process of decision making.

The Alabama Department of Education supports science, technology, engineering, and mathematics (STEM) education through the Alabama Math, Science, and Technology Initiative (AMSTI), an outcome of the Alabama Mathematics, Science, Technology, and Engineering Coalition (AMSTEC), a network of state business, education, and public policy stakeholders working for systemic change in STEM education. AMSTI, designed by a Blue-Ribbon Committee of business leaders and K-12 and higher education representatives, is committed to the mission of affording all K-12 students with the knowledge and skills needed for college and career readiness in science, engineering, and technology. AMSTI, Alabama Science in Motion, the Southeastern Consortium of Minorities in Engineering (SECME), and Alabama Technology in Motion provide research-based practices for incorporating STEM education into classrooms.

Scientific Writing

Written communication in science is essential for conveying data and results from investigations, explaining evidence and findings from research, and affirming and defending claims and arguments based on evidence and reasoning. College- and career-ready writers should be able to utilize the most current technology and media to create, refine, and collaborate through writing. Writing as indicated in the Literacy Standards for Grades 6-12: History/Social Studies, Science, and Technical Subjects (Appendix A), should be emphasized across the curriculum. Students should be given opportunities to demonstrate writing skills to explain and document results of inquiries of scientific phenomena and concepts. Clear and coherent writing, developmentally appropriate for each grade level and reflecting knowledge and understanding through the use of accurate science academic language, is expected.

Writing activities such as scientific journals and laboratory reports should be introduced in the primary grades. During the middle and high school years, students should expand writing to completion of short or more extended inquiry or research projects using appropriate terminology, available technology, and suitable units of measurements. Students should be transitioning to the use of words and phrases with subject-specific meanings that differ from meanings used in everyday life. Discipline-specific discourse through oral or written language provides ways to communicate science core ideas. In addition, open-ended essays are an excellent way to assess student understanding of scientific concepts, principles and laws, scientific and engineering practices, crosscutting concepts, and disciplinary core ideas. As learning progresses, students should develop more sophisticated methods of gathering information, evaluating sources, citing materials, and reporting findings from research. Students should devote significant time and effort to writing for a range of science tasks, purposes, and audiences.