SCIENCE CURRICULUM

State of Illinois
SCIENCE GOALS 11-12-13
Preschool through Grade 12

Catholic Schools
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education

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RATIONALE FOR THE STUDY OF SCIENCE

Science is all around us. It is part of our lives, our homes, our schools, our communities; it is an integral part of the modern world in which we live. Science helps us to understand and monitor our planet, our solar system, the universe. It helps us to make sense of the natural world — that which we see all around us.

Technology is all around us as well. We use technology in our kitchens, our cars, our schools, and in our professional endeavors. Technology is a process and a tool used to solve the problems and challenges of society; innovations in technology continue to enter our lives and interact with them in complex yet dynamic ways.

Literacy in Science and Technology is vital to being an informed citizen. Knowledgeable citizens understand and appreciate societal needs, new discoveries, and the rapid pace of change; they make thoughtful decisions, as individuals and communities, about the roles that Science and Technology play in society.

Current issues in biotechnology, quality of life, genetic engineering, food production, disease transmission and treatment, use of natural resources, level of health risk and natural disasters, space exploration, and even national security depend on an educated citizenry.

Studying Science cultivates the imagination, creativity and the analytical skills needed to be successful problem-solvers. Such skills are highly valued in understanding life issues that have multiple constraints, challenges, and variables. Understanding science enables good stewardship of the many gifts with which God has graced us.

All students in the schools of the Archdiocese need the opportunity to engage in learning that fosters mastery of the valued and accepted science goals as outlined in the State of Illinois Science Standards.

Therefore, the Office of Catholic Schools committed to create a tool to assist teachers, students, and parents as each contributes to the important work of continued learning about science.

Through a contractual agreement with the *Biological Sciences Curriculum Study* (BSCS) and the assistance of elementary, middle school and high school teachers who served as design team and responders, the Office of Catholic Schools believes that such a tool has been created.

This tool — the Science Curriculum — has been researched and designed to provide consistency, coherence, and rigor in the content and process of the teaching of Science throughout the schools of the Archdiocese.

It is expected that each school will integrate the standards and goals of the Science Curriculum in the delivery of science content, concepts, and skills.

EXPECTATIONS FOR MASTERY OF SCIENCE STANDARDS

All students will:

- Show evidence of proficiency in the basic knowledge and skills of science.
- Recognize and investigate problems and formulate and propose solutions supported by reason and evidence.
- Think logically, critically, analytically, and ethically.
- Express and interpret ideas orally, and in writing, using correct terminology.
- Apply learning skills and techniques to real-world situations; identify and solve problems within the situation.
- Integrate learning into their everyday lives; engage in learning activities, use imagination and creativity, willingly take risks, and demonstrate confidence in their skills.
- Learn and contribute productively as individuals and as members of groups.
- Utilize appropriate instruments, electronic equipment, and networks to access information, process ideas, and communicate learning.
- Recognize and apply connections of important information and ideas within and among learning disciplines.
- Demonstrate an understanding and practice of the Catholic social teachings.

All teachers will:

- Differentiate instruction to meet the diverse needs present in the student population.
- Use a variety of materials, resources, and assessments appropriate to student age, development, and the teaching and learning process.
- Provide varied learning situations such as flexible grouping, cooperative groups, and peer leadership.
- Use appropriate instruments, electronic equipment, and networks to support and integrate teaching and learning.
- Collaborate with colleagues at all levels to ensure the continuum of learning.
- Participate in ongoing professional development.
- Be skilled and certified in their discipline.
- Access appropriate communication venues to inform parents of the goals, objectives, and outcomes of the school's curricula in general and their child's progress in particular.
- Model and nurture Catholic values and beliefs.
- Use the published Archdiocesan curriculum.

All Administrators will:

- Monitor and regularly assess the written and taught curriculum.
- Monitor instruction and evaluation through regular classroom observation and the review of lesson plans.
- Provide appropriate professional and instructional resources, including technology, for all teachers.
- Design and monitor appropriate communication venues to inform parents of the goals, objectives, and outcomes of the school's curricula in general and their child's progress in particular.
- Create an environment permeated with the Gospel spirit of love and joy.
- Model and nurture Catholic values and beliefs.

All Parents/Guardians will:

- Understand and embrace their role(s) as primary educator.
- Encourage and exemplify the reality of lifelong learning.
- Access all opportunities for communication with school personnel appropriately and adequately.
- Partner with school personnel in a spirit of trust and collaboration.
- Be actively involved within the school community.
- Model and nurture Catholic values and beliefs.

The Office of Catholic Schools will:

- Provide the vision for a coherent, rigorous science curriculum.
- Initiate, develop, and publish curricula in collaboration with experts in the field, administrators, and teachers.
- Offer professional development opportunities and disseminate information regarding other available opportunities and resources for teachers and administrators.
- Encourage regular articulation among educators at all levels.
- Act as liaison with national and state departments of education regarding curricular standards and expectations for student learning.

INTRODUCTION TO THE SCIENCE CURRICULUM

The Science Curriculum of the Archdiocese of Chicago provides Catholic schools and teachers with a blueprint or road map for student learning in science and technology from preschool through grade 12. The goals and science standards align closely with the Illinois Learning Standards for Science.

Benefits to Schools

This science curriculum and supporting materials will help schools:

1. Use all Illinois Learning Standards for Science (ILS) in a user-friendly, effective way at each grade level.

2. Sequence science concepts and skills for the three Illinois State Learning Goals for Science without undue repetition from grade to grade.

3. Prioritize the significance of science concepts and skills at each grade level, identifying what is critical to understand and master at the grade, significant to develop, and useful to work on if time allows.

4. Use sample assessments to help teachers evaluate the desired learning of each learning standard/outcome.

5. Make connections with other subject areas, including Catholic identity and core values.

6. Support effective communication among teachers at the same grade level, as well as within a grade-level band, in sequencing and reinforcing learning, developing student assessments, and working together to design and use teaching materials.

7. Collaborate with other Catholic schools in developing effective assessments and learning activities at each grade level.

Understanding the Science Curriculum

The following points will help schools and parents understand and be able to use the Science Curriculum:

- The Science Curriculum consists of two sections that guide learning from preschool through grade 12. The first is the **Science Standards Framework**. This framework organizes science benchmarks by content area from early elementary grades through high school so that teachers, students, and parents can see "big ideas" in fields of science and technology. The Science Standards Framework is foundational for the second part of the Science Curriculum, the **Grade-Level Alignment**.

- The Science Standards Framework is based on the Illinois State goals and standards for science, Goals 11, 12, and 13. This framework then organizes science benchmarks by grade-level band (e.g., early elementary, late elementary, middle school). Subheadings indicate areas of student learning in a standard. For example, key areas in the life sciences (Goal 12, Standards A and B) include the following:
  - Structure and function of organisms
  - Behavior of organisms
  - Reproduction and heredity
  - Biologic evolution and change with time
  - Populations, interdependence, and ecosystems
  - Matter and energy in ecosystems
  - Diversity and adaptation of organisms

- The Grade-Level Alignment (1) distributes science benchmarks by grade level as learning standards and outcomes, (2) gives priority to benchmarks so as to focus on major concepts and ideas in science, (3) shows sample assessments per benchmark, and (4) illustrates connections to subjects other than science. Together, the Science Standards Framework and the Grade-Level Alignment articulate a

progression of concepts, principles, and skills from preschool through grade 12 that will promote literacy in science and technology for all students.

- The Science Standards Framework and Grade-Level Alignment are available to schools in three formats: (1) printed form, (2) on CD, and (3) on the Archdiocesan Web site (www.archchicago.org/schools). These can be downloaded as a Word document or a PDF file.

- For each goal, the Grade-Level Alignment identifies the learning standard (outcome) in the first column. Each learning standard is also a benchmark in the Science Standards Framework. These learning standards are sorted by importance into three categories: (1) *critical to understand and master* at the grade level, (2) *significant to develop*, and (3) *useful to work on*. If there are no learning standards in one of these categories at a particular grade level, that category does not appear.

- The benchmark level of priority is also shown in the Science Standards Framework and has an "L" level (i.e., L1, critical to understand and master; L2, significant to develop; L3, useful to work on).

  A key theme in science education is that enduring understandings develop from proficiency in both knowledge of concepts and abilities in basic skills (e.g., Wiggins and McTighe, 1998). Moreover, identifying the priority of benchmarks helps teachers to focus on major concepts and principles. These two ideas are illustrated in Figure 1. This helps to center the Science Curriculum so that it does not become "a mile wide and an inch deep" (e.g., Schmidt et al., 2001).

- Each learning standard has a number for reference. The first digit indicates grade level (P, K, 1, 2, 3, and so on) and is followed by a period. The second digit represents the Illinois State goal (11, 12, 13), and is followed by a period. The third digit represents the number of the outcome per goal at a particular grade level. For example, learning standard 1.12.03 refers to grade 1, Goal 12, learning standard 3.

- For benchmarks that are not critical to understand (i.e., L2 or L3), the number or letter in parentheses after the learning standard in the Grade-Level Alignment indicates with which goal and learning standard the benchmark correlates. For example, consider:

  7.12.09 Describe simple patterns in the periodic table of elements that relate to the physical properties of matter (e.g., solids, gases; metals, nonmetals) (12C)

  The term (12C) indicates that this outcome for grade 7 helps students meet the Illinois Learning Standard C in state Goal 12: "Know and apply concepts that describe properties of matter and energy and the kinds of interactions between matter and energy." Teachers should focus first on the learning standard (i.e., benchmark), and not necessarily on the standard (12C). The reference to 12C is included so that schools may demonstrate easily to accreditation review teams that the Science Curriculum includes all the relevant ILS at each grade level. This code is also helpful for reviewing alignment with standardized testing in relation to ILS.

- For each learning standard, the Science Curriculum provides a sample assessment to show how students might demonstrate an understanding of the learning standard. Teachers can use these assessments, modify them, or use them as examples to develop other appropriate assessments.

- Sample assessments are illustrated with a constructed response format (i.e., academic prompt), but teachers can use an assessment method that is appropriate for their classes.

- For each learning standard (benchmark), example connections are also illustrated to other subject areas, real-life experiences, and/or Catholic identity and core values. These connections help spark teacher creativity in teaching science. The connections help link science to other subject areas and to student experiences outside of school, such as in their families and communities. These connections will also emphasize the Gospel values at the core of Catholic schools.

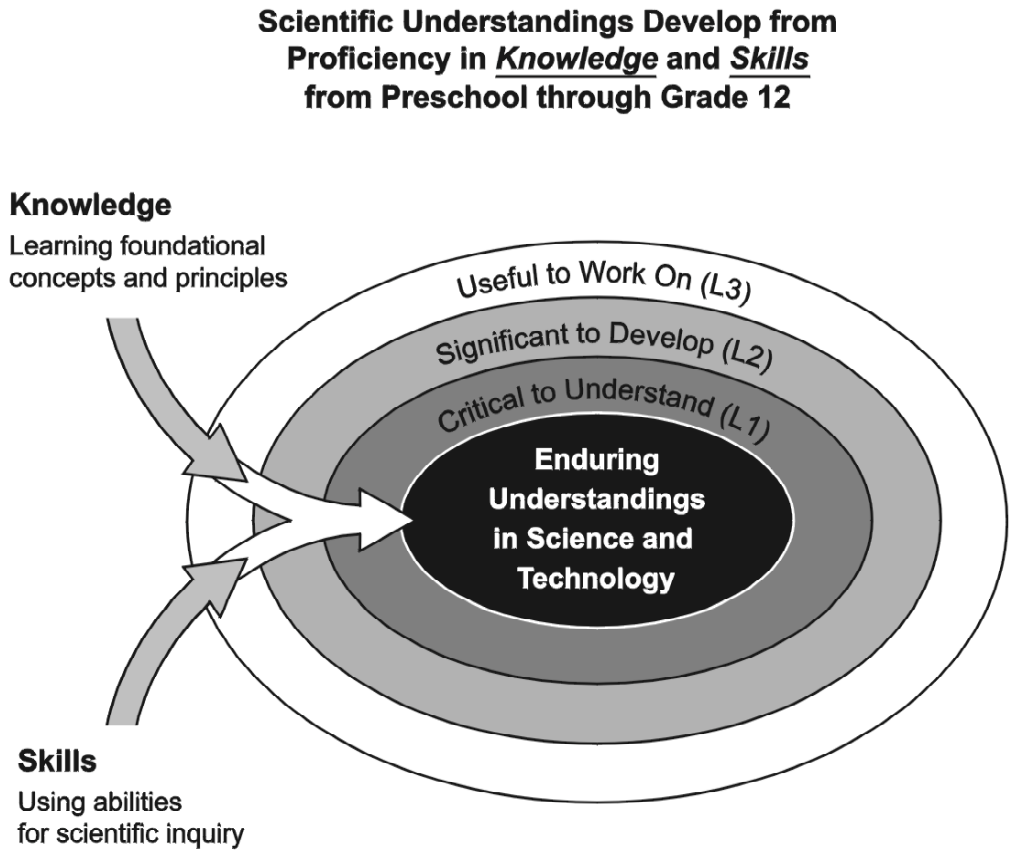

Figure 1: Enduring understandings in science and technology come from both knowledge of principles or concepts and skills in scientific inquiry. In the Archdiocese Science Curriculum, learning standards (benchmarks) that are critical to understand and master (L1) are most closely linked with developing enduring understandings for students in science and technology.

USING THE SCIENCE CURRICULUM IN YOUR SCHOOL

The following guidelines will help teachers use the Science Curriculum in planning science instruction at their schools. Several parts of the curriculum will help teachers and students achieve the learning objectives.

- The Science Standards Framework parallels the Illinois Learning Standards for Science (ILS). The science framework is guided by the three Illinois science goals (Goals 11, 12, 13), with several science standards per goal (e.g., Standards A and B in life sciences). Each goal contains a rationale for why each science goal is important.

- The Science Standards Framework guides three different facets of student learning: curriculum, instruction, and assessment (Figure 2). These 3 facets reflect what students should learn, how students are taught the content, and how teachers will assess student understandings, respectively. Each field displays overlap with neighboring fields, and is not taken in isolation. Participating in professional development with colleagues will enhance the abilities of teachers to understanding how these areas contribute to student learning.

- The Science Standards Framework shows the benchmarks by grade band as in the ILS. These bands are early elementary (preschool to grade 2), late elementary (grades 3 to 5), middle school or junior high school (grades 6 to 8), early high school (grades 9 to 10), and late high school (grades 11 to 12). A benchmark must be covered in a student's education by the completion of the grade band.

  For example, Standard A of Goal 12 (12A) shows that students need to be able to "identify similar structures in organisms that have different purposes for different animals." Depending on their instructional materials, students may achieve this benchmark by grade 3, but they must complete it by the end of grade 5.

Science Framework Guides Three Key Areas of Student Learning

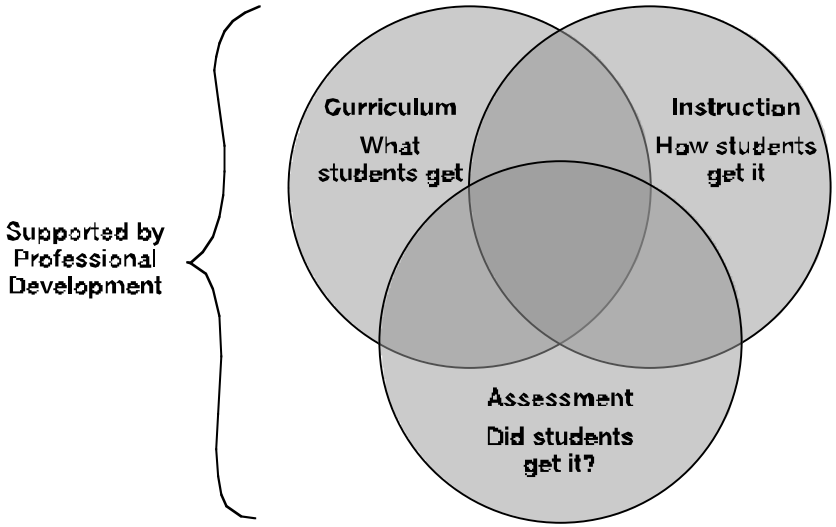

Figure 2: Diagram showing how the Archdiocese Science Framework supports facets of the science curriculum, instruction, and assessment. Using the science framework in all these three areas is supported by professional development with colleagues.

- In the Science Standards Framework, subheadings connect areas of learning from preschool to grade 12. Obviously, not all concepts can articulate seamlessly across these 14 years, so not all cells are filled in and emphases may change. Similar adjustments in emphasis based on grade-level appropriateness would also be found in subjects such as math (e.g., trigonometry or calculus is not a fruitful subject until high school). Other benchmarks, such as in Goal 11, do carry across all grades. This emphasizes content or skills in science that must be cultivated throughout the child's entire education.

- A key part of the Science Curriculum is the Grade-Level Alignment for ILS Goals 11, 12, and 13. Depending on instructional materials or programs per school (e.g., textbooks, science kits, modules at primary levels), different schools might address the benchmark at different grade levels. **The key point is that schools should hold a dialogue per grade-level band (e.g., teachers for grades 3 to 5) to confirm that the benchmarks are completed by the end of that grade band.**

  To illustrate, consider middle school science. Some schools offer a sequence of earth sciences (grade 6), physical sciences (grade 7), then life sciences (grade 8). In contrast, other schools include a sampling of earth, physical, and life sciences each year from grades 6 to 8. To accommodate differences in sequencing, the Archdiocese Science Curriculum organizes key benchmarks by content area, along with levels of priority.

- For high school, Goal 12 learning standards are distributed among four fields: biology, earth and space sciences, chemistry, and physics. In contrast, Goal 11 benchmarks, which highlight the abilities of scientific inquiry, and Goal 13 benchmarks, which detail science, technology, and society, should be applied in each of the four subject areas above. Again, staff dialogue is essential to identify which courses are best able to meet given benchmarks, especially for Goals 11 and 13.

- Teachers can refer to the sample assessments as examples of how students can demonstrate their understanding of the science concept of the learning standard. Teachers may choose to use the sample assessments given and/or they may design their own, following the model. During instruction, teachers will also use other assignments and assessments to gauge student progress on the learning standard.

- Teachers can refer to the connections to help them plan science instruction in ways that integrate science with other subjects they teach, or with school events, service projects, and student experiences.

Using "Backwards Design" for Classroom Instruction

The Archdiocese Science Curriculum supports instructional planning through a "backward design" process (e.g., Wiggins and McTighe, 1998). In this model, teachers plan instruction iteratively by asking and answering three questions in this order:

1. **What is the intended learning?**
   Learning Standard: What should students know, understand, and be able to do? State this as observable behavior using an active verb. These are in the Science Standards Framework, and Grade-Level Alignment.

2. **What serves as evidence of student learning?**
   Assessment: How will students demonstrate that they have acquired and can use the knowledge, skills, and understandings in the learning standard?

3. **How will I prepare students to show evidence of their learning?**
   Strategies: What teaching and learning activities, resources, field trips, and so on will help me teach the knowledge, skills, and understandings in the outcomes so that students can give evidence of the learning asked for in the assessments that I am using?

The Archdiocese Science Curriculum provides distinct guidance for steps 1 and 2 above. This is in the form of learning standards, sample assessments, and connections to other subject areas. For step 3, teachers and teams of teachers will develop strategies as they progress through and teach specific knowledge and skills during the year.

Science and Technology in a Curriculum

Often, the words "science" and "technology" are used together, interchangeably, or with little distinction. In contrast, the Archdiocese Science Curriculum draws key distinctions between science and tech-

nology and the roles of each in society. Each field is vital to understanding our physical world in a comprehensive way and to solving human problems in the world. Science and technology give us different, yet complementary, understandings and skills as citizens.

To illustrate, science originates in questions about the natural world, while technology stems from problems and challenges for humans in their environment. This is shown in Figure 3 (Bybee et al., 1989). Those who engage in science glean information by applying inquiry and by proposing and testing explanations about the natural world. In contrast, those using technology apply problem-solving strategies and propose solutions to human challenges.

For example, Goal 11 clearly distinguishes between developing abilities of scientific inquiry (Standard A) and the processes of technological design (Standard B) (e.g., see also NRC, 1996). For students, the approaches are complementary. These understandings will equip students with the analytical and communication skills that will extend to professional endeavors beyond the sciences (e.g., NSB, 2004)

The Archdiocese Science Curriculum also includes a standard - Goal 11, Standard C - that will complement and strengthen students' work in the science and technology standards. This standard indicates that students shall use their skills in areas such as mathematics and language arts (writing, reading) to convey their understandings in science. This emphasizes that science does not merely consist of knowing facts and accurately repeating those facts. Rather, students must develop abilities to communicate effectively their understandings by several means. This helps teachers assess their true levels of understandings. These abilities will also help students be successful in other academic areas.

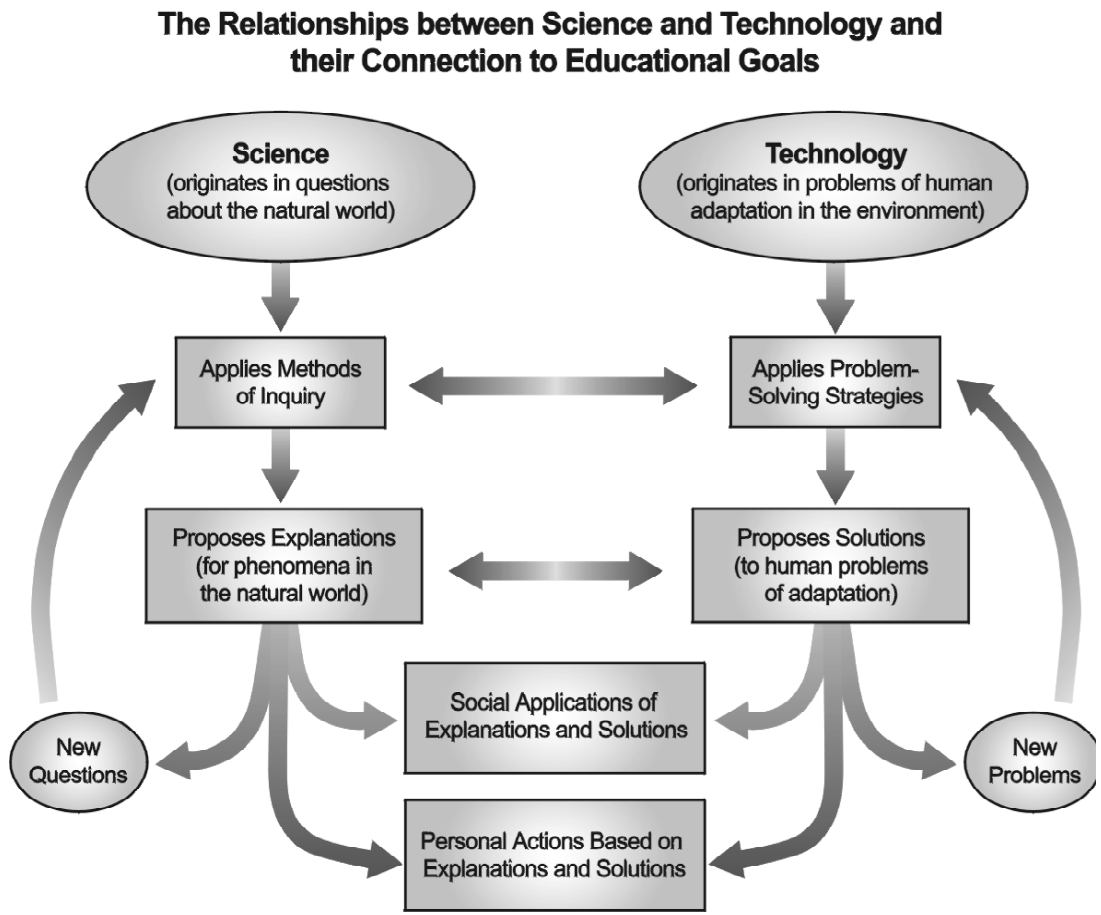

Figure 3: This diagram shows distinctions between science and technology in the Archdiocese Science Curriculum (adapted from Bybee et al., 1989). Science focuses on explaining the natural world, whereas technology centers on solutions to human problems. Both science and technology join to solve problems of society.

STATE OF ILLINOIS GOALS IN SCIENCE

STATE GOALS 11-13

State Goal 11: Understand the processes of scientific inquiry and technological design to investigate questions, conduct experiments, and solve problems.

State Goal 12: Understand fundamental concepts, principles, and interconnections of the life, physical, and earth and space sciences.

State Goal 13: Understand the relationships among science, technology, and society in historical and contemporary contexts.

LEARNING STANDARDS IN SCIENCE

STATE GOALS 11-13

STATE GOAL 11 Understand the processes of scientific inquiry and technological design to investigate questions, conduct experiments, and solve problems.

Learning Standard A: Know and apply the concepts, principles, and processes of scientific inquiry.
Learning Standard B: Know and apply the concepts, principles, and processes of technological design.
Learning Standard C: Use skills and abilities in math, writing, and dialogue (e.g., speaking, listening) to convey findings and understandings in the sciences.

STATE GOAL 12: Understand fundamental concepts, principles, and interconnections of the life, physical, and earth and space sciences.

Learning Standard A: Know and apply concepts that explain how living things function, adapt, and change over time.
Learning Standard B: Know and apply concepts that describe how living things interact with each other and with their environments.
Learning Standard C: Know and apply concepts that describe properties of matter and energy and the kinds of interactions between matter and energy.
Learning Standard D: Know and apply concepts of force and motion and the principles that explain them.
Learning Standard E: Know and apply concepts that describe the changing features and processes of Earth and its resources.
Learning Standard F: Know and apply concepts that explain the composition and structure of solar systems, galaxies, the universe, and Earth's place in these.

STATE GOAL 13: Understand the relationships among science, technology, and society in historical and contemporary contexts.

Learning Standard A: Know and apply the practices and understandings of science and technology, and how these relate to the history and nature of science.
Learning Standard B: Know and apply concepts that describe the interaction among science, technology and society.