This course supports the assessments for DET1. The course covers 1 competency and represents 4 competency units.

Introduction

This course is aligned to the DET1 performance assessment. The same study materials are utilized in the DEC1 objective assessment. If you have previously completed the DEC1 assessment, then you should have already completed the required study activities found in this course. You may wish to review the assignments here, but you are not required to repeat these activities. If you have not yet completed the DEC1 assessment, then please proceed through this course in full.

Overview

Science teaching is composed of two distinct and vital components: what to teach and how to teach. In this course we primarily consider how to teach. However, we will also cover some of the basic foundations of science that are important for all science teachers to understand and that are not always directly covered in science content courses.

The content found in this course is the equivalent of two college level courses and will require a significant time commitment. But, mastering the fundamentals of science pedagogy now will lay the foundation for a career of successful and enjoyable science teaching.

Watch the following video for an introduction to this course:

Competencies

This course provides guidance to help you demonstrate the following 1 competency:

- **Competency 602.6.1: Teaching Methods-Science (Secondary)**
  The graduate understands and provides safe, effective, research-based instruction in science.

Teaching Dispositions Statement

Please review the [Statement of Teaching Dispositions](#).

Course Instructor Assistance

As you prepare to successfully demonstrate competency in this subject, remember that course instructors stand ready to help you reach your educational goals. As subject matter experts, mentors enjoy and take pride in helping students become reflective learners, problem solvers, and critical thinkers. Course instructors are excited to hear from you and eager to work with you.

Successful students report that working with a course instructor is the key to their success. Course instructors are able to share tips on approaches, tools, and skills that can help you apply the content you're studying. They also provide guidance in assessment preparation.
strategies and troubleshoot areas of deficiency. Even if things don’t work out on your first try, course instructors act as a support system to guide you through the revision process. You should expect to work with course instructors for the duration of your coursework, so you are welcome to contact them as soon as you begin. Course instructors are fully committed to your success!

Preparing for Success

The information in this section is provided to detail the resources available for you to use as you complete this course.

Learning Resources
The learning resources listed in this section are required to complete the activities in this course. For many resources, WGU has provided automatic access through the course. However, you may need to manually enroll in or independently acquire other resources. Read the full instructions provided to ensure that you have access to all of your resources in a timely manner.

Automatically Enrolled Learning Resources

You can access the learning resources listed in this section by clicking on the links provided throughout the course. You may be prompted to log in to the WGU student portal to access the resources.

VitalSource E-Texts
The following textbook is available to you as an e-text within this course. You will be directly linked to the specific readings required within the activities that follow. *This e-text is available to you as part of your program tuition and fees, but you may purchase a hard copy at your own expense through a retailer of your choice. If you choose to do so, please use the ISBN listed to ensure that you receive the correct edition.*


Manually Enrolled Resources

[AMNH Seminars (Optional)]

Take a moment to enroll in the learning resources listed in this section. To enroll, navigate to the “Learning Resources” tab, click the “Sections” button, and then click the “Enroll Now” button for each resource. Once your mentor approves your enrollment in the resource, you will receive an e-mail with further access instructions. Contact your mentor if you have questions.
and discussions to connect teachers and future teachers from around the world to cutting-edge research, classroom resources, and each other. Participating in the seminars develops your understanding of the content, models an appropriate teaching technique, and exposes you to an array of resources that can be used in your classroom. While this is an optional learning resource, you are strongly encouraged to take advantage of this opportunity.

The following seminars are related to this course:

- AMNH-WGU FAQ

Each six-week seminar requires about eight hours per week of your time. Review the AMNH Calendar http://www.amnh.org/learn/calendar to determine when the course is offered and consult your mentor to coordinate this seminar with your schedule. Discuss the AMNH-WGU FAQ https://web5.wgu.edu/aap/content/amnh%20wgu%20faq.pdf document with your mentor to better understand how to successfully use the AMNH seminar as a WGU learning resource.

Other Learning Resources

You will use the following learning resources for this course.

National Science Education Standards
From the National Academies Press, purchase a paperback book or download a free PDF version of the following document:


This course utilizes resources located in the WGU Library E-Reserves, with articles available for you to download. For instructions on how to access WGU Library E-Reserves, see the "Accessing WGU Library E-Reserves" page.

The following e-reserve materials will be used in this course:


The Nature of Science

Engaging in authentic science investigations and reflecting on historical examples of science are important methods in the process of developing an accurate picture of the complex nature of science.
The Nature of Science
Science is as much about investigation, humanistic traits, and application as it is about a body of knowledge. You will study the nature of science directly and indirectly by reviewing historical accounts that demonstrate science in action.

This topic addresses the following competency:

- **Competency 602.6.1: Teaching Methods-Science (Secondary)**
  
  The graduate understands and provides safe, effective, research-based instruction in science.

**NSTA's Position on the Nature of Science**

Review the following webpage:

- [National Science Teachers Association](#)

Summarize this statement in three sentences or less.

**Historical Perspective**

Read the following chapter in *Science for All Americans*:

- **chapter 10 ("Historical Perspective")**

Write a paragraph for each of the ten discoveries summarizing the aspects of the nature of science demonstrated. Use examples as often as possible and make sure you include humanistic aspects of science, how science typically advances by building on previous discoveries, how the scientific community operates, and how discoveries change our world view.

**Mathematics in Science**

Read the following chapter in *Science for All Americans*:

- **chapter 2 ("The Nature of Mathematics")**

Review the following page in *Science Instruction in the Middle and Secondary Schools*:

- **page 112 chapter 7 ("The Nature of Science")**

In your notes, describe the importance of mathematics in science.

**Limitations of Scientific Investigation**

Complete the following:

- Develop in your notebook a list of questions that science can and cannot answer.
- Why is it that science cannot answer some questions?
● Show how science is different from technology and from other ways of knowing the world.
● Compare ways of knowing in science and in the arts.
● How are the philosophical tenets of science different from other knowledge areas such as the arts?
● How is the development of knowledge different?

Scientific Methods

Review the following chapter in *Science for All Americans*:

- chapter 10 (“Historical Perspective”)

Consider the following questions as you read In light of what you just read...

- How do scientific theories come about?
- What were the procedures that these scientists used?
- How were those procedures similar to and different from the traditional steps of the scientific method?
- Why is it important that you teach students that there is no single series of steps called the scientific method?

Without your observing, have a friend place some small common object in a paper bag and tape it closed. Without opening the bag, try to determine what the object is. Were you correct? Now list in your notebook the steps that you took to identify the object.

You probably learned about the scientific method in school. Can you remember the steps? While there are traits of the traditionally taught scientific method that are often part of science discoveries, science educators have come to realize that real science does not always follow a scientific method, and when it does, there is no one single correct scientific method.

Try to match the steps you used with the steps of the scientific method. In what ways was it necessary to deviate from the traditional steps of the scientific method?

Examine the following lab report. How does this investigation unfold relative to the steps of investigation you just read about?

- Grade 5 Lab Report

Scientific Investigation Over Time

Download the article "The Concept of Disease: Structure and Change" by Paul Thagard from the e-reserves in the WGU e-library. Read about how the concept of disease changed throughout history.

Write the answers to these questions in your notebook. Does scientific knowledge remain
static? If not, why? What influences change in scientific knowledge? What is meant by conceptual change? What are some examples used by Thagard and researchers mentioned in this article? How can conceptual change theory affect how you teach science and how students learn science?

Find other examples from the history of science that demonstrate how theories have changed. Make a list in your notebook. Can you explain to a colleague what a theory is? How do you feel about the scientific method and the messiness of science?

**Significant Figures in the History of Science**

Conduct an online search to learn about the life and contributions of the following scientists:

- Nicolaus Copernicus
- Aristotle
- Johannes Kepler
- Albert Einstein
- Francis Bacon
- Neils Bohr
- Isaac Newton
- Charles Darwin
- Antoine Laurent Lavoisier
- Alfred Nobel
- Marie Curie
- Edwin Hubble
- Louis Pasteur
- Enrico Fermi
- Galen of Pergamum
- Galileo Galilei

In your notebook arrange the scientists in a timeline.

- What contribution did each make to our understanding of science?
- What personal problems did each struggle to overcome?
- Are there any other scientists you would like to add to this timeline?
- How does knowing about these men and women make them seem more human?
- Is there a lesson here for students of science?

**The Nature of Science**

Read the following chapter in *Science Instruction in the Middle and Secondary Schools*.

- chapter 7 ("The Nature of Science")

Make sure you take the "Myths of Science Quiz" before reading the chapter; take the quiz again after reading the chapter and review your answers with the correct answers listed at the end of the chapter.
Complete the following:

- In your notes, write a definition of science.
- In a short paragraph, describe how you differentiate between what is and is not science.
- Provide accurate definitions or descriptions of key scientific terms discussed in chapter 7.
- Describe important ethical traditions in science including why they are important.
- Describe the importance of the humanistic aspect of science.
- Describe the importance of and balance between open-mindedness and skepticism in science.
- Describe the importance of communicating and defending results in the scientific enterprise.

Read the following chapters in *Science for All Americans*:

- chapter 1 ("The Nature of Science")
- chapter 12 ("Habits of Mind")

*Note: pay attention to the "Values and Attitudes" section of chapter 12.*

In your notes, add to your descriptions of the following:

- what is or is not science
- the important ethical traditions in science
- the important humanistic aspects of science
- the importance of communicating and defending results in the scientific enterprise
- the importance of balance between open-mindedness and skepticism in science

**Science Myths**

Read the following:

- The Principal Elements of the Nature Of Science: Dispelling the Myths

In your notes, add to your descriptions of the following:

- what is or is not science
- the basic beliefs that scientists share
- the key scientific terms in chapter 7

Add to your descriptions of the following:

- the important humanistic aspects of science
- how induction and deduction are used in science, including the problem of induction

**Unifying Concepts**
Important themes reoccur in all science disciplines. Understanding these concepts allows you to understand and communicate science topics more efficiently.

**Unifying Concepts**
The world is complex. In order to study, understand, and explain the natural world we need to rely on common themes that transcend disciplinary boundaries. In this topic, you will review systems and organization, models, constancy and change, and measurement.

This topic addresses the following competency:

- **Competency 602.6.1: Teaching Methods-Science (Secondary)**
  The graduate understands and provides safe, effective, research-based instruction in science.

**Systems**

Read the following chapters in *Science for All Americans*:

- chapter 11 ("Common Themes")

Create or find an example of how a system or subsystem can be used to help solve a science problem. Post your example to the message board.

**Models in Science**

Think about your idea of what science is and how science is conducted. Models are often used to support scientific investigation.

Read the following:

- "Models" in chapter 11 ("Common Themes") of *Science for All Americans*
- "Myth 13" in *The Principal Elements of the Nature of Science: Dispelling the Myths*

What is the difference between physical, conceptual, and mathematical models?

Find a depiction of DNA online or in a textbook. Cut straws of varying length and build a short section of the DNA strand. Twist your model to show the three-dimensional DNA structure.

What did you learn making the model versus looking at a depiction? How are models useful in science? What other examples of modeling can you identify that assist in science investigation? List them in your notebook.

**Organization**

Read the following chapters in *Science for All Americans*:

- chapter 4 ("The Physical Setting")
- chapter 5 ("The Living Environment")
Write down in your notes different ways organization is used in science to provide useful ways of knowing the world.

**Constancy, Change, and Scale**

Read the following sections in chapter 11 ("Common Themes") of *Science for All Americans* at the website provided.

- "Constancy and Change"
- "Scale"

Consider the following:

- How do you differentiate between the objects and processes that are characterized by change and those that are characterized by constancy?

**Measurement**

Science is the study of approximations. Nearly everything in science is based on measurements, and all measurements are an approximation.

You will learn about the uncertainty of measurements, including accuracy and precision, and you will learn about the use of significant figures as a means for communicating the uncertainty of measurements.

This topic addresses the following competency:

- **Competency 602.6.1: Teaching Methods-Science (Secondary)**
  The graduate understands and provides safe, effective, research-based instruction in science.

**Significant Digits**

Review the rules for determining significant digits:

- [Significant Figures - Rules](#)

Take the following quiz:

- [Significant Digits Quiz](#)

Be sure to check your answers against the [Significant Digits Answer Key](#).

**Math Conversions**

Study the following examples of how units can be used to convert measurements from one set of units to another. This is called Dimensional Analysis. Using this system of conversions can help verify that the conversion equation is correctly developed and will yield a reliable answer.
Using Mathematics to Report Investigation Results

Complete the following lesson in *Teaching Science as Investigations*:

- lesson 4.1 in *chapter 4 ("Investigation 4: Energy")*

In your notebook, answer the following questions:

- What tools did you need to complete this investigation?
- In what capacity did you use mathematics?
- Complete the APPLY activities.

Review the teacher version of the lesson.

- Why is it important for students to "understand, select, and use units of appropriate size and type to measure"?

Data from this lesson can be displayed in various ways.

- Why would one way be better for some data than another
- What is the appropriate way to write scientific data using significant units?

Document your findings or questions in the message board.

**Presenting Data Appropriately**

Complete the following lesson in *Teaching Science as Investigations* (you may do this on your own or with your students):

- lesson 4.2 in *chapter 4 ("Investigation 4: Energy")* (starting on p. 102)

In your notebook, answer the following questions:

- Why do scientists use multiple trials in collecting data?
- How does this occur in lesson 4.2?

Make a table with the names of different types of graphs. Then give examples of when each type would be most appropriate to use. Interpolating and extrapolating from graphs, what patterns are evident in the graphs? Estimate additional points on the graphs given the pattern.

Watch the following video tutorial on dimensional analysis:
Answer the following questions (either in your notebook or on the message board):

- What is the difference between an experiment and an investigation? Give examples of each.
- What math skills does the student need to engage in science? (e.g., be able to use measurement conversion; understand appropriate notation of digits in recording data)
- How can the teacher engage the student in activities that teach these skills? (e.g., use inquiry activities that allow students to practice the skills)
- Use activities that help the student see the need for the skills (e.g., engage in global projects using the Internet where data is given in one form and students need to convert it to the English system)
- Use measuring tools in metric to complete activities where the directions are in the English system.

Introduction to Science Teaching

Most educated individuals feel they can teach. In fact, most believe they can teach better than most of the teachers that have taught them. After all, between elementary, middle, secondary, and post-secondary schools, college graduates have spent a significant amount of time in the classroom. However, teaching effectively is far more complex than many people realize. It often is not until student teaching or their first year of teaching that education students finally realize the complexities of teaching.

Introduction to Science Teaching

To be an effective science teacher and build effective units of study, you need to consider the key features of science teaching:

- purpose
- assessment
- planning
- teaching
- management

These concepts cannot be learned independently of each other and it is difficult to learn about all of them at once. So, we will begin our study of science pedagogy with an overview of how these topics relate by looking at how the actions and thoughts of a beginning teacher compare to that of a veteran teacher.

This topic addresses the following competency:

- Competency 602.6.1: Teaching Methods-Science (Secondary)
The graduate understands and provides safe, effective, research-based instruction in science.

Getting Into Teaching
Read the following chapter in *Science Instruction in the Middle and Secondary Schools*.

- chapter 1 ("Thoughts and Actions of Beginning Science Teachers")

As you read, take notes on how the five key areas of teaching (purpose, assessment, planning, teaching, and management) are all related to each other. Complete the science teaching inventory at the end of the chapter, and check your results in Appendix D.

**Introduction to NSTA**

The [National Science Teachers Association (NSTA)](https://www.nsta.org) is a large national professional organization of science educators. NSTA establishes standards for the teaching of science and the preparation of science educators, as well as holding conferences and publishing science teaching journals. If you have not already done so, you are encouraged to visit the NSTA website and become a member of NSTA.

**Observation and Interview**

If possible, arrange to observe a veteran science educator teaching a science lesson. Spend a few minutes before or after the lesson interviewing him or her to find out the most important elements you can gain from your science pedagogy courses. Write these in your notebook.

**Why You Want to Teach**

Write a brief description about why you want to teach science.

- Are you hoping to impact students?
- Did you have an influential teacher?
- Do you like to teach?

Post your description on the message board and respond to one or two posts from other candidates.

**Modeling Science Attributes**

Review the following websites to better understand how you can teach your students by example to use science in personally and professionally appropriate ways.

- Biographies of Scientists
- Famous Scientists
- More Biographies of Scientists
- African Americans in the Sciences

Why is it important to recognize and demonstrate the contributions of women and other cultures in science? How can culture be integrated into the science classroom? What contributions to science can come from embracing different cultures?

Use the Internet or other resources to find lessons that draw on the history of science and
Science Education Reform

If you entered a secondary science classroom and asked the teacher to describe the goal of science education, what kind of response would you expect? How would the students answer that question? How would you answer that question?

Before it is possible to be a proficient science educator, you need to have an understanding about why science is taught, what students will learn, and how they will apply it in society.

Science Education Reform

Most science educators know why they want to teach and how they believe science should be taught. However, surprisingly few can articulate why students need to learn science. It seems important, but why?

You will learn the expectations and goals of the U.S. educational system and the evolution of science education in the United States.

This topic addresses the following competency:

- **Competency 602.6.1: Teaching Methods-Science (Secondary)**
  The graduate understands and provides safe, effective, research-based instruction in science.

Personal Philosophy

In your notebook, create a detailed description of why you believe science should be taught. In other words, why is science taught, and what aspects of science are important for students to understand?

The Purpose of Teaching Science

Read the following chapter in *Science Instruction in the Middle and Secondary Schools*:

- chapter 2 ("The Purpose of Teaching Science")

Describe a couple of key features that distinguish science education in the United States from other countries. Describe Project 2061 and the National Science Education Standards, including who wrote the documents, the purpose of the documents, and a summary of what the documents recommend.

Why Teach for Understanding?

Read the following chapter in *Teaching for Understanding*:

- chapter 1 ("Why Should We Teach Science for Understanding?")
Consider the following:

- How does your view of science education compare to the new and old paradigms described in this text?
- Do you agree that science understanding cannot be transmitted? Why or why not?
- Do you agree that science knowledge is socially constructed? Why or why not?
- How does your experience as a science student compare to this new vision?
- Do you agree that science is rarely taught effectively?
- Why do you think change to the new vision has been slow?

**Update Your Philosophy**

Update your description of why science should be taught. Consider as many aspects of science as you can, including how you hope students will apply their science knowledge in society.

**Understanding Science**

Beginning science teachers often spend most of their time identifying and organizing the content knowledge they would like their students to understand. They spend relatively little time considering

- what their students already know or believe,
- how their students learn, and
- what it means to really understand science.

In this topic, we will explore what it means to understand science.

This topic addresses the following competency:

- **Competency 602.6.1: Teaching Methods-Science (Secondary)**
  The graduate understands and provides safe, effective, research-based instruction in science.

**Preconceptions**

In your notebook, write a paragraph describing what it means to understand science.

**Understanding Science**

Read the following chapter in *Teaching for Understanding*.

- chapter 2 ("What Does It Mean to Understand Science?")

Use examples to describe the difference between memorizing and understanding a concept in science, such as inertia. How is the modeling of complex concepts more like a three-dimensional, interactive movie than a static picture? How can this help individuals explain phenomena in the world around them?

Write a sentence to describe each of the six facets of understanding discussed in this text. How did this chapter change your thinking about teaching and assessments?
Modify Your Description

How has your view of understanding science changed? Update your description of what it means to understand science.

Science Learning Environment

Establishing a supportive and positive learning environment is important in science education. The learning environment includes the physical arrangement, interpersonal aspects, and instructional activities that effect student learning.

In science education, developing a cooperative community of science learners is an important aspect of the science learning environment.

Classroom Management

For many beginning teachers, classroom management is the most difficult aspect of teaching. They often focus on teaching rules and procedures and student obedience, while seasoned teachers rely more on developing trust and encouraging students to take responsibility for their own actions.

During this topic, you will learn how to develop an appropriate classroom leadership plan.

This topic addresses the following competency:

- **Competency 602.6.1: Teaching Methods-Science (Secondary)**
  The graduate understands and provides safe, effective, research-based instruction in science.

Classroom Management

Read the following chapter in *Science Instruction in the Middle and Secondary Schools*:

- **chapter 6 ("The Science Learning Environment")**

On the message board, post one idea for what you might do to develop positive relationships with your students. Post one idea for what you might do to develop positive relationships between students.

In your notebook, describe democratic practices you would consider implementing in your classroom.

Classroom Leadership Plan

Create a classroom leadership plan that you can use when you begin student teaching.

If you are already teaching, modify your current classroom leadership plan based on what you learned from this chapter.

Make sure your plan includes
how you will consider cultural influences on student behavior,
student-teacher relationships, and
student-student relationships.

Send your plan to the course instructor for feedback.

**Inquiry Teaching Models**

Inquiry has been used to describe appropriate science education for many years. Despite the effort to reform education and use inquiry-based teaching models, there is still significant confusion surrounding inquiry. This subject will help you gain a better understanding of how learning theories support inquiry-based teaching and what inquiry-based teaching looks like; it will introduce you to several key teaching models that use inquiry.

**Inquiry Models**

Effectiveness as a teacher begins with an understanding of what it means to really understand science. Once you have the goal in mind, you can turn your attention to the models and strategies you can use to help your students gain a deeper understanding of science.

This topic addresses the following competency:

**Competency 602.6.1: Teaching Methods-Science (Secondary)**
The graduate understands and provides safe, effective, research-based instruction in science

**An Introduction to Science Learning**

Read the introduction in *Teaching Science as Investigations*.

For each individual listed in the text, write a short description of their contributions.

In your notebook, draw a graphic organizer of the information within the introduction.

Include the topics of NSTA standards, inquiry, how learners construct meaning, misconceptions, constructivism, and inquiry learning models. How are these topics linked?

**Models of Teaching Science Through Inquiry**

Read the following chapter in *Teaching for Understanding*:

- chapter 4 ("Models of Teaching Science for Understanding through Inquiry")

Write a definition of inquiry in your science notebook.

**Inquiry and Teaching Science**

Read the following pages in *Science Instruction in the Middle and Secondary Schools*:

- pages 120-129 of chapter 8 ("Inquiry and Teaching Science")
- pages 164-171 of chapter 10 ("Learning in Middle Grades and Secondary Schools")
Write a paragraph describing the major ideas of constructivism and how a constructivist approach to teaching is different from a traditional approach.

**Compare Inquiry Teaching Models**

Refer to the readings in the previous activities as necessary to create a four column table describing the following inquiry teaching models:

- The Learning Cycle
- Apprenticeship Model
- Conceptual Change Model
- Equilibrium Model

In column one of your table, list the model. In column two, provide a description of the model. In column three, describe why the model is considered an inquiry teaching model. In column four, give an example of using the model in your specific science field.

Which of these models aligns most closely with how you learn?

**Science Instructional Strategies, Part 1**

Instructional teaching strategies can help you teach more effectively. They define an approach used during a portion of a lesson. There are a number of teaching strategies that can be used depending on the goals of your lesson. For example, some of the teaching strategies often used in science education include lecture, discussion, demonstration, laboratory or field work, reading or writing, group work, and recitation.

**Science Teaching Skills**

This section covers the personal characteristics, teaching skills, instructional strategies, and reinforcement techniques that are important to facilitating a classroom lesson. While a large part of effective teaching is the preparation that happens before class, there are certain skills, strategies, and techniques that are important during a lesson in order to effectively facilitate science learning.

This topic addresses the following competency:

- **Competency 602.6.1: Teaching Methods-Science (Secondary)**
  The graduate understands and provides safe, effective, research-based instruction in science.

**Science Teaching**

Read the following chapter of *Science Instruction in the Middle and Secondary Schools*:

- [chapter 5 ("Teaching Science")](#)

Review figure 5.1.

- Which of the personal characteristics, teaching skills, instructional strategies, and
learning techniques do you feel will come naturally for you?
  - Which ones will you need to make a conscious effort to use?

**WGBH Video (Investigating Crickets)**

Review the following video:

- "Investigating Crickets"

List several goals you believe the teacher had before the unit began. Write how those goals were met. Consider the following:

- What teaching strategies were used?
- What were goals or objectives that the students created?
- What teaching strategies were used to meet those objectives?
- What secondary objectives were met while the students were investigating their primary goals or objectives?
- What assessments were used to measure how well students have mastered the concepts?

**Inquiry in Science Teaching**

Helping students learn to ask questions and seek answers is at the heart of good science pedagogy. Students and society benefit when science is question driven. But teaching inquiry skills and teaching as inquiry are not so simple.

There are a number of important facets of inquiry-based instruction that need to be considered by the teacher.

- When should open inquiry be used instead of guided inquiry?
- When should students be in charge of identifying the problem that should be researched?
- When should students be in charge of deciding the methods to use in solving the problem?
- What supporting strategies and techniques should be used to enhance inquiry-based instruction?

This topic addresses the following competency:

**Competency 602.6.1: Teaching Methods-Science (Secondary)**
The graduate understands and provides safe, effective, research-based instruction in science

**Guided Versus Open Inquiry**

Using the 5e-model, complete the following lesson in *Teaching Science as Investigations*:

- lesson 2.1 in chapter 2 ("Investigation 2: Solubility")

Be sure to complete each stage of the lesson, answering all questions.
Now revisit this investigation from a teacher's point of view. Review the teacher's lesson plan including the “Teaching Focus” boxes. Think about the purpose of each section of the lesson. How does this lesson follow the definition of inquiry on page 49?

Lessons 2.2 and 2.3 are additional activities on dissolving. You might want to complete them yourself. Teach the lessons on dissolving to a group of students.

**Inquiry Support Strategies**

Read the following pages of *Science Instruction in the Middle and Secondary Schools*:

- pages 129-140 in *chapter 8 (“Inquiry and Teaching Science”)*

How many of these strategies would you feel comfortable using in your teaching right now?

**Thinking Like Scientists**

Watch the following video:

- "Thinking Like Scientists"

**Science Instructional Strategies, Part 2**

Instructional teaching strategies are tools that can be used to help you teach more effectively. They define an approach used during a portion of a lesson. There are a number of teaching strategies that can be used depending on the goals of your lesson. For example, some of the teaching strategies often used in science education include lecture, discussion, demonstration, laboratory or field work, reading or writing, group work, and recitation.

**Diverse Students**

The educational system is being challenged to find methods that promote the learning of science for students with different backgrounds, interests, and abilities. As the diversity in our schools continues to grow, science educators need to rethink the instructional strategies that may have worked in the past.

During this section, you will learn about the demographics of today's classrooms, the importance of considering diversity in the classroom, and strategies to promote learning more effectively in diverse-population classrooms.

This topic addresses the following competency:

**Competency 602.6.1: Teaching Methods-Science (Secondary)**
The graduate understands and provides safe, effective, research-based instruction in science

**Diverse Populations**

Read the following chapter in *Science Instruction in the Middle and Secondary School*:

- chapter 9 ("Diverse Adolescent Learners and Differentiated Instruction")
Consider the following:

- Why is it important to understand the culture and the linguistic needs of students in the classroom?
- How is multiculturalism different from the universalistic tradition of science education?
- What is differentiated instruction?

**Considering Diversity in Lesson Plans, Part 1**

Review the following lesson in *Teaching Science as Investigations*:

- lesson 2.3 in *chapter 2* ("Investigation 2: Solubility")

You do not need to complete the lesson at this time. Look at the teacher version.

Read, "Teaching Focus, Diversity-Helping English Language Learners with Inquiry Science."

Consider the following questions:

- What inquiry skills do you think English Language Learners might struggle with? Why?

Create a list of ways to make inquiry activities friendlier to culturally diverse students.

**Considering Diversity in Lesson Plans, Part 2**

Review the following lesson in *Teaching Science as Investigations*:

- lesson 3.2 in *chapter 3* ("Investigation 3: Density")

You do not need to complete the lesson at this time. Look at the teacher version.

Read "Teaching Focus, Diversity-Assessing English Language Learners" and "Teaching Tip, Including Experiences from Culturally Diverse Students."

Consider the following questions:

- Why might it be important to adapt assessments for diverse language students?
- Some say this is "watering down the curriculum." What is your response?
- How can you maintain high expectations while still helping all students access science content?

Make a list of some ways to include experiences from culturally diverse students.

**Considering Diversity in Lesson Plans, Part 3**

Review the following lesson in *Teaching Science as Investigations*:

- lesson 4.3 in *chapter 4* ("Investigation 4: Energy") (starting on p. 111)
You do not need to complete the lesson at this time. Look at the teacher version.

Read "Teaching Tip, Diversity-Gender Differences in Science."

Consider the following question:

- How would you respond to a student that felt that "science is not for people like me"?

Create a list of ways that you can make your classroom friendlier to gender differences.

**Considering Diversity in Lesson Plans, Part 4**

Review the following lesson in *Teaching Science as Investigations*:

- lesson 6.1 ("Flower Power") in chapter 6 ("Investigation 6: Flowering Plants")

You do not need to complete the lesson at this time. Look at the teacher version.

Read "Teaching Focus, Diversity-Provide a Language-Rich Environment" and "Teaching Focus, English Language Learners."

Consider the following questions:

- How could a word wall be used to provide a language rich environment for your students?
- What would this look like?
- How would the class determine which words get onto the wall?

**Considering Diversity in Lesson Plans, Part 5**

Review the following lesson in *Teaching Science as Investigations*:

- lesson 6.3 ("Fruits and Vegetables") in chapter 6 ("Investigation 6: Flowering Plants")

You do not need to complete the lesson at this time. Look at the teacher version.

Read "Teaching Tip, Diversity-Include Examples of Scientists from Many Cultures."

Consider the following questions:

- What are the benefits of including examples of scientists from different cultures?
- What is the best way to integrate this into your lessons?

**Considering Diversity in Lesson Plans, Part 6**

Review the following lesson in *Teaching Science as Investigations*:

- lesson 10.2 ("Moon Phases") in chapter 10 ("Investigation 10: Motions of the Moon")
You do not need to complete the lesson at this time. Look at the teacher version.

Read "Teaching Focus, Diversity-Accessing Misconceptions with English Language Learners."

Consider the following question:

- Why might it be more difficult for culturally diverse students to recognize and change misconceptions?

Create a list of things you can do to help culturally diverse students overcome their misconceptions.

**Community of Science Learners**

Scientific talk and argumentation are important aspects of the science learning community. Students should be provided with a variety of methods to communicate their understanding of science concepts, including defending their views and listening to the views of others with the goal of discovering the relationship between ideas and evidence.

During this topic, we will discuss the following strategies for promoting a community of science learners: discussions or discourse, lectures, demonstrations, writing, and group work.

**Learning Community Philosophy**

In your notebook, describe how your vision of teaching includes a learning community approach.

**Discussion, Demonstration, and Lecture**

Read the following chapter in *Science Instruction in the Middle and Secondary Schools*:

- chapter 11 ("Discussion, Demonstration, and Lecture")

Consider the following questions:

- What kinds of discourse patterns encourage scientific talk and argumentation?
- When should discussions, demonstrations, and lectures be used to facilitate science learning?
- What would you say to convince a colleague to use scientific talk and argumentation in the classroom?

**Active Learning Environment**

Read the following chapter in *Teaching Science for Understanding*:

- chapter 5 ("Teaching Strategies that Foster Understanding")

Consider the following:

- What has been your experience with working in groups?
• Do you feel that the approaches discussed in this topic will allow you to use groups effectively with your students? Why or why not?
• What skills do you anticipate you will need to develop in your students before they can work effectively in groups?
• Why is writing an important tool in developing understanding?

Modified Learning Community Philosophy

Modify your vision of teaching science using a learning community approach based on what you learned in this topic. What concerns do you still have about using a learning community approach?

Science Instructional Strategies Part 3

Instructional teaching strategies are tools that can be used to help you teach more effectively. They define an approach used during a portion of a lesson. There are a number of teaching strategies that can be used depending on the goals of your lesson.

Reading and Writing Strategies

The ability to effectively read and write about scientific concepts is important. Reading and writing about science are also important instructional strategies that can reinforce learning, help assess student understanding, and allow students to practice scientific communication.

You will learn how to effectively use reading and writing in the science classroom, including how to use trade books and charts and tables in science.

This topic addresses the following competency:

Competency 602.6.1: Teaching Methods-Science (Secondary)
The graduate understands and provides safe, effective, research-based instruction in science.

Teaching Reading Skills

Review the following lesson in Teaching Science as Investigations:

• lesson 6.1 (“Flower Power”) in chapter 6 (“Investigation 6: Flowering Plants”)

You are asked to make your observations prior to reading. Reflect on this and then answer the following in your journal:

• Why is this important?
• How does it act to access your prior knowledge and act as an advanced organizer for later reading?
• If students read the information before investigating or making observations, are they more apt to see the reading as scientific facts to be memorized?

Complete the APPLY portion of the lesson in your notebook. Go to the teacher version of the lesson.
Read "Teaching Focuses: Introducing Vocabulary, Vocabulary Development."

Consider the following questions:

- Why is it important to put off introducing vocabulary at the beginning of the lesson?
- When is it appropriate?
- How much vocabulary is appropriate?
- Does age and developmental level affect this decision?

Read "Teaching Focus: Helping Students Use Effective Reading Strategies in Science Research" and make a list of strategies for reading in science. How can photographs be used to enhance reading?

**Exploring Teaching Resources: Trade books**

Review the following lesson in *Teaching Science as Investigations*:

- lesson 6.2 ("Flower Pollination") (pg. 153) in chapter 6 ("Investigation 6: Flowering Plants")

In this lesson the teacher uses a "wisdom walk." What is this and what is the purpose? What effect does this have on helping students read and communicate in science?

Read "Teaching Focuses: Selecting Reading Materials and Finding Quality Trade Books" (p. 158).

- What role does a traditional text play in inquiry learning?
- How can you select trade books that are conceptually challenging but allow students at all levels of reading access to the content?

Go to NSTA web page to review the list of trade books appropriate for students put out by NSTA each year. How can you meet the needs of language diverse students while providing challenging reading material for other students?

**Reading Charts and Tables in Science**

Review the following lesson in *Teaching Science as Investigations*:

- lesson 6.3 ("Fruits and Vegetables") (pg. 159-165) in chapter 6 ("Investigation 6: Flowering Plants")

Read "Teaching Focus: Reading Charts and Tables."

- How can students use charts and tables that they have developed to practice reading?
- Do reading charts and tables require cognitively different skills?

**Teaching Writing Skills**

Complete the following lesson in *Teaching Science as Investigations*:
Consider the following questions:

- What methods did you use to communicate your observations and findings?
- What skills were required to describe patterns?

Complete the APPLY portion of the lesson. Describe the importance of communicating scientific information.

Now go to the teacher version of the lesson. This lesson incorporates standards from IRA and NCTE. What are these standards? How are they addressed in the lesson? Why is it important to address these standards?

Read "Teaching Focus: Communicating Predictions Visually."

- How do visual models enhance communication of scientific knowledge and understanding?

Make a list of models students could construct in your area of specialty that could be used to communicate scientific concepts. These may be models that are used as preassessments and later as post-assessments.

How can graphic organizers be used for pre-writing?

If you have not already downloaded the program Inspiration, do so now. (You can get a free trial version for a month. However, this is an excellent program for you and for your students and is highly recommended for the classroom.)

Use Inspiration software to design several graphic organizer templates to use in pre-writing activities within science lessons. How does organizing data as it is collected affect students' ability to communicate results orally and in writing?

**Questioning Strategies**

Questions are fundamental to scientific inquiry. A properly framed question can lead to effective investigation and useful results. Questioning techniques can also be used to probe students to think more deeply about their initial thoughts.

This topic addresses the following competency:

- **Competency 602.6.1: Teaching Methods-Science (Secondary)**
  The graduate understands and provides safe, effective, research-based instruction in science.

**Asking Questions**
Read the following pages in *Science Instruction in the Middle and Secondary Schools*:

- pages 130-131 in chapter 8 ("Inquiry and Teaching Science")
- pages 182-183 in chapter 11 ("Discussion, Demonstration, and Lecture")

In your own words, describe the yes/no questioning technique. Give examples, other than the ones listed in your book that would prompt students to think more deeply about an answer or response they have given.

**Using Question to Promote Thinking**

Complete the following lesson in *Teaching Science as Investigations*:

- lesson 7.1 ("How Many Do You Have?") in chapter 7 (Investigation 7: Bones”) (the picture for this activity is on page 171)

When you have completed the lesson, look back at the type of questions you were asked. What type of questions were these? Were they open-ended, factual, discrepant (ones that cause dissonance or dissatisfaction)?

Now look at the teacher version of the lesson (p. 170) and answer the discussion questions. Read through the background information and misconception information.

- How does having this information affect the kinds of questions you would ask students?

Think of some open-ended questions or probing questions you could ask students to access their prior knowledge and beliefs before beginning the lesson. Make a list.

- Why might it be important to have students predict how many bones they have prior to beginning the lesson?

Inquiry based teaching allows you to move around from group to group. This gives the teacher the opportunity to use good questioning strategies to probe student understanding, assess understanding, encourage students to think more deeply, and focus students’ attention back to the main question. What are “Explorable Questions?” Make a list of questions you could use.

What is the role of wait time in questioning?

Why is this important?

**Kinds of Questions**

Complete the following lesson in *Teaching Science as Investigations*:

- lesson 7.3 ("How Strong Are Your Bones”), pg 185

This lesson introduces convergent and divergent questions and gives questioning guidelines. Complete all discussion questions and activities.
Now that you have developed some of your own questions in the previous step, see how they compare to this new information.

- Were your questions convergent or divergent?
- How could you change your questions to make them divergent?
- What are some uses for convergent questions?

Look up on the web information about accretion. How can this be different from simply "fishing for the right answer"?

Review the guidelines provided on page 187 for questioning. While these guidelines were initially developed for primary students, most still affect secondary students, particularly those in the "middle." Did you consider these points when you developed your questions? Is there anything you want to add or change in your questions after reviewing the guidelines?

**Developing Questioning Skills**

Teach one or more of the lessons 7.1–7.3 (pp.170-189) from *Teaching Science as Investigations* to a group of students.

Using the "Teaching Focus, Reflecting on Your Questioning Skills," answer the questions about your use of questioning during the lesson(s). What effect did you see on student learning in response to different questioning?

**Exploring Mars**

Watch the "Exploring Mars" video.

- How does the teacher use communities of learners effectively?
- What types of questions does she ask the class?
- How do the groups facilitate community learning?

**Identifying Misconceptions**

Identifying and addressing alternative conceptions is important in science. Beliefs we hold about the way the world works are not easily changed. It is important to use preassessments (formal or informal) to identify misconceptions, use inquiry activities for students to investigate concepts associated with the misconceptions, and allow them the appropriate time and structure to analyze and reflect on the evidence and perhaps modify their understanding.

This topic addresses the following competencies:

- **Competency 602.6.1: Teaching Methods-Science (Secondary)**
  The graduate understands and provides safe, effective, research-based instruction in science.

**Misconceptions**

What is a misconception? How do you differentiate between misconceptions, alternative...
conceptions, and naïve conceptions? How are misconceptions changed, or can they be?

Think about what makes the seasons. List all of your own ideas about how this happens.

Later you will come back and compare what you thought to what scientists say. You might find you have some misconceptions. This is not uncommon as most individuals have developed strong conceptions about how the world works either from experience or from prior teaching.

Having misconceptions is not a problem in science. How you, as a teacher, deal with them is the key.

**Collecting and Analyzing Data**

Complete the following lesson in *Teaching Science as Investigations*:

- lesson 10.1 ("Moon Patterns and Motions")

This lesson requires that you collect data over a period of four weeks. While you are collecting the data, go ahead to the next activity. Do not mark this activity as completed until you have collected your data and can come back and finish this activity.

After completing lesson 10.1, return to the teacher version of the lesson and complete the discussion questions and activities.

Read the science background and misconception information. Are there concepts that you did not know or were unclear? Did you hold some of the same misconceptions? This is common. Misconceptions are often deeply rooted and not displaced simply because you were exposed to the "scientific model" in school. Some people hold a "school" model that they use on tests and an "everyday" model for the rest of the time.

- Why is it important to assess students' conceptions prior to beginning this lesson?
- What do you do about misconceptions?

List some initial ideas you have about how to deal with misconceptions.

It is suggested that there are two major ways to deal with misconceptions:

- Tell the students that it is a misconception and give them the correct scientific model, or
- Use strategies to help students evaluate and challenge their misconceptions and then build new or modified mental models of the concept.

What are the pros and cons of each of these ways?

Refer back to the paper you read in the first weeks by Thagard. Thagard discussed many theories proposed by researchers in conceptual change. These deal with misconceptions. Strategies to cause students to focus on their misconceptions and challenge them include discrepant questioning, models, using evidence and discrepant events, and demonstrations.
Student Preconceptions


This article can be found on e-reserve in the WGU e-library.

What misconceptions did students in this study hold? How did they affect student learning?

Using the Internet, locate other articles on common student misconceptions in science. What effect do you think having misconceptions about the world around us can have on choices we make?

Name some ways prior conceptions can affect student learning in science. Students may hold dual models of a concept; that is, they hold on to their prior model to use in real life situations and memorize the more scientific model for school. If students believe the scientific model is plausible, they may be willing to modify their prior model. If the teacher, after accessing students' prior conceptions, engages them in activities that begin to challenge their prior conception, they may gradually modify that model into a more scientific one. This does not happen quickly, nor does this happen to large concepts. Large concepts must be broken down into small steps.

The Physics of Optics

Review the following video:

- "The Physics of Optics"

Consider the following questions:

- How does the teacher use student's prior knowledge as a starting point?
- How does the teacher promote authentic learning?
- How does the teacher guide the investigations?

Lesson Evaluation

Complete the following lessons in Teaching Science as Investigations:

- lesson 10.2 and 10.3 (pp. 254-267)

- How does the teacher lesson plan deal with misconceptions?
- How does focusing students' attention back to prior models as they progress in understanding help them to see how their model has changed?

Identifying Misconceptions

Teach any of the lessons 10.1–10.3 in Teaching Science as Investigations to a group of students.
Write down students' misconceptions and compare them to the misconceptions listed in the text. Identify each strategy used to address misconceptions. Were you able to follow the strategies or did you fall back on correcting misconceptions?

Change in teaching behavior takes time and patience just as changing content misconceptions takes time and patience.

**Science Instructional Strategies, Part 4**

Instructional teaching strategies are tools that can be used to help you teach more effectively. There are a number of teaching strategies that can be used depending on the goals of your lesson.

**Other Instructional Strategies**

Some of the teaching strategies often used in science education include lecture, discussion, demonstration, laboratory or field work, reading or writing, group work, and recitation.

This topic addresses the following competency:

- **Competency 602.6.1: Teaching Methods-Science (Secondary)**
  The graduate understands and provides safe, effective, research-based instruction in science.

**Science, Technology, and Society**

Read the following in *Science Instruction in the Middle and Secondary Schools*:

- pages 114-115 of chapter 7 ("The Nature of Science")
- chapter 12 ("Science, Technology, and Societal Issues")

In your notebook:

- Describe technology and how it relates to science.
- How are socioscientific issues related to science and technology?
- Compare the Design & Build and Investigate & Improve strategies for teaching about technology.
- Describe the advantages of SSI instruction to STS instruction for teaching about socioscientific issues.
- What would you do if you were teaching a topic conflicting with the religious beliefs of one of your students?

In your notebook, describe what you would say to a parent who feels you are not teaching the science content because you are using an SSI approach to science instruction.

**Societal Issues Lesson**

In your notebook, design a lesson to teach science through investigation of a societal or global issue.
What kind of assessment will you use to measure student learning?
What kind of performance tasks and alternative assessments would be appropriate?

**Laboratory Work and Field Work**

Read the following chapter in *Science Instruction in the Middle and Secondary Schools*:

- **chapter 13** ("Laboratory Work and Field Work")

What is the purpose of laboratory work and field work? Compare at least five types of laboratory approaches. What are the important elements that need to be included in pre-laboratory and post-laboratory activities?

**Mapping and Modeling**

Read the following pages of *Science Instruction in the Middle and Secondary Schools*:

- pages 171-176 in chapter 10 ("Learning in Middle Grades and Secondary Schools")

**Technology Tools**

Technology and science education interact in a variety of ways. It is important that students understand technology and how it relates to science. It is also important that students learn the skills of technological design.

This section focuses on how to use technology to enhance science education. This includes, but is not limited to, how technology can be used to access and plan lessons to facilitate learning and as a tool students can use to collect and analyze data and communicate scientific results and findings.

This topic addresses the following competency:

- **Competency 602.6.1: Teaching Methods-Science (Secondary)**
  The graduate understands and provides safe, effective, research-based instruction in science.

**Integrating Technology into Science Instruction**

Read the following chapter in *Science Instruction in Middle and Secondary Schools*:

- **chapter 15** ("Computers and Electronic Technologies")

Consider the following questions:

- How can technology be used effectively during instruction?
- How can technology be used to assist in all stages of investigation?
- How can the Internet be used as a source of information in science education?

**Technology in Science Instruction**

Read the section "Make the Available Science Tools, Materials, Media, and Technological
Resources Accessible to Students" in "Teaching Standard D" of National Science Education Standards.

Make a chart of the major points in the standards that should be addressed in a lesson. Using Technology to Organize Data

Complete the following in Teaching Science as Investigations.

- **lesson 8.1 ("Examining Our Traits")** pg. 191

This activity requires working with at least one partner and collecting data from a small group of individuals. You might solicit members of your family or colleagues.

Look at the teacher's version of lesson 8.1. Review "Teaching Focus: ISTE National Education Technology Standards."

**Use of Technology in Science Instruction**

Review the following in Teaching Science as Investigations.

- **lesson 8.2 and 8.3**, pg. 200-219

Complete Lesson 8.2 first by yourself and then with your class (if possible). What technology is used in these lessons? Why is it used? What effect does it have on student learning?

**Evaluating Internet resources**

Read the following in Teaching Science as Investigations:

- **"Teaching Focus: Using the Internet for Research and Equal Access"** on page 217

- How important is it to assess students' knowledge and skills in using computers?

Create a template to use for evaluating Internet sites for appropriateness and authenticity. Look up eight Internet sites and include them in your template.

**Using Technology to Support Investigation**

Use the Inspiration program to complete the concept map of pedigrees in lesson 8.2 in Teaching Science as Investigations.

**Using Technology in Teaching (PCE Activity)**

Develop and teach a set of short activities in your specialty area that

- integrate the use of common tools such as temperature probes, pH meters, and force measures,
- require students read and record numerical data from scientific instruments,
- use data analysis and data reporting equipment and software appropriate for the activity and specialty area, and
• use technology to communicate scientific information.

**Science Assessments**

Assessments are used to diagnose the prior beliefs, knowledge, and interests of students; to modify and guide instruction; to measure student’s knowledge, dispositions, and skills; and as a means for students to engage in self reflection. To accomplish all of this, teachers need to use well-planned assessment strategy that utilizes a variety of different assessments, including formative and summative assessments, informal and formal assessments, and a variety of different assessment types in a variety of situations.

**Science Assessments**

Preassessment and formative assessments are important in science education. They allow the teacher to better understand the prior knowledge of students and alter instruction as necessary to maximize learning. Post-assessments should be used to allow students to reflect on their learning and for teachers to reflect on their teaching. Rubrics should be used to assess drawings and other performance assessments that are vital to measuring science skills, dispositions, and knowledge.

**Read the following chapter in *Science Instruction in the Middle and Secondary Schools*:**

- chapter 4 ("Assessing Science Learning")

Write a description for the purpose of learning goals, before-instruction assessments, during-instruction assessment, and after-instruction assessments.

- Describe what it means for an assessment to be valid and reliable.
- Describe what it means for a unit to have a balanced assessment approach.
- Describe what it means for an assessment plan to be coherent.
- Describe the differences between criterion-referenced and norm-referenced grading.
- Which method matches the recommendations of NSES?

**Dispositions Assessment**

Create three assessment items to measure a student’s science dispositions. The first item should be a Likert scale item. The second item should be an open response question that includes a rubric. The third item should be a checklist item you could use while observing students during class.

Post these items to the message board or share them with the course instructor for feedback.

**Teaching and Learning Condition**

Review the teaching and learning conditions in figure 4.1 in *Science Instruction in the Middle and Secondary Schools*.

Create your own teaching and learning condition for a learning goal you create. Post it on the message board or share it with the course instructor for feedback.
Formative Assessments

Read the following chapter in *Teaching Science for Understanding*:

- chapter 7 ("Why is Formative Assessment Essential?"

How does formative assessment differ from summative assessment? Draw a diagram of the "Conceptual Model for Formative Assessment."

Use different colors to identify recurring parts of the model as it cycles. How could you use the conceptual model to design assessment of a unit of study? Make a list of examples.

Discuss how you can use assessment of student work as a guide for re-teaching missed concepts. Why is it important to use formative assessments rather than waiting until the end of the unit to assess student understanding?

Review "Key Ideas" (p. 96) in the same text. How can key ideas help when you assess student understanding? How can teaching activities also be assessment activities? Read "An Example from a Middle School Classroom" (pp. 98 – 99) in the same text. Then complete the "Reflection & Discussion Question" (p. 99): "What would be your next instructional actions if your students expressed ideas like these?"

**Assessing Learning Through Inquiry**

Complete the following lesson in *Teaching Science as Investigations*:

- lesson 3.1 ("Which is More Dense")

Now look at the teacher version of the lesson and complete the discussion questions and activities below in your notebook.

Consider the following questions:

- Why and how does the teacher elicit students' prior knowledge?
- How can you use this as an informal preassessment?
- How might a formal preassessment be used? What would it look like?
- Based on the preassessment, how would teaching change?
- What is the role of drawing in science?
- How can drawing be used as ongoing assessments of student conceptual understanding?

How does a student's conceptual model change in response to an activity such as a discrepant event or an animation?

Describe the role of rubrics in helping students understand expectations, ongoing assessments, and final assessments.
Review the rubric scoring guide on page 73 of *Teaching Science as Investigations*.

Make hypothetical student responses that would meet each of the four points for this lesson. They should clearly fall within the criteria for each score.

- How can writing a rubric before a lesson help the teacher recognize desired outcomes?
- What are some other assessment methods for science (laboratory practical, essays of conceptual understanding scored with a rubric, portfolios that consist of a collection of student work, ongoing assessments for a unit of study, etc.)?

**Writing Appropriate Assessments**

Complete the following lesson in *Teaching Science as Investigations*:

- lesson 3.2 ("Do Raisins Sink or Float")

Before looking at the teacher version of this lesson, think about what outcomes you would expect students to have after completing the lesson. Design an informal assessment to determine whether students are developing conceptual understanding as they proceed through the lesson.

Now look at the teacher version and read "Teacher Focus, Assessing With Drawings and Performance Assessment." How did your assessment compare to this new information about using drawings as assessments? What questions do you still have?

Read "Teaching Tip, Teaching Abstract Ideas" (Part I) and (Part II). Consider the following questions:

- Do all students develop the ability to understand abstract ideas at the same time?
- What affect will this have on teaching?
- How can it affect how you assess in science?
- Does using a rubric help to assess students when they are at different developmental levels?

**Using PreAssessments to Direct Instruction**

Choose lesson 3.1, 3.2, or 3.3 from *Teaching Science as Investigations* and teach it to a group of students.

- How did the preassessment help you in your teaching?
- If you taught the lesson to multiple groups, would the preassessment results be the same?
- What effect did this have?

If you have culturally diverse students, try adapting an assessment to meet their language needs while still assessing for science content.

**Science Unit Planning**
In this section you will begin to develop an understanding about how to plan a science unit. This integrates all the knowledge and skills you have learned thus far. As you progress through this section you will gain a better understanding about the importance of planning, items to consider when planning a unit, the components of a unit, and how to go about creating a unit that contains effective activities that will promote science learning.

**Science Unit Planning**
Whenever possible, planning units should involve gathering lessons from

- textbooks,
- the Internet, and
- other science teachers.

Using frameworks developed to meet state and national standards is an excellent place to start. It should be noted, however, that many of these lessons will focus on verifying or demonstrating concepts that have already been learned.

You will need to adapt these lessons into inquiry-based educational models. You also need to adapt these lessons to meet the specific needs of your students based on their prior knowledge and the misconceptions you identify.

**An Introduction to Unit Planning**

Read the following chapter in *Science Instruction in the Middle and Secondary Schools*:

- **chapter 3** ("Planning to Teach Science")

In your notes, answer the following questions:

- What does it mean to plan with the end in mind?
- What are the key components of a unit plan?

**WGBH Video (Chemical Reactions)**

Review the "Chemical Reactions" video. Think about the planning that went into this lesson.

- What has the teacher taught the students prior to this lesson so that they are capable of succeeding in this lesson?

**Adapting Lessons**

Read the "In Conclusion" chapter in *Teaching Science as Investigations*.

Without looking at the chapter, explain each step in the process for adapting lessons into inquiry learning cycle explorations. Refer back to the chapter and modify your explanations as necessary.

**Criteria to Guide Planning**

Read the following chapter in *Teaching Science for Understanding*:
Project 2061 proposed seven categories for effective lesson plans in science. Read through the list on page 109.

Describe the importance of the three criteria in Category I in your own words.

- How do the four criteria in Category II expand your view about your job as a teacher?

Category III deals with providing real world experience for students and engaging students in inquiry.

- Why is this important?

Category IV ("Developing and Using Scientific Ideas") takes Category III further to give meaning and connection to real world experiences.

- What does this look like?
- Why is it so important in science education and particularly in developing curriculum?

Rather than concentrating on memorizing fact or scientific models, Category V stresses helping students base their developing scientific knowledge in data from investigations and promoting student thinking about phenomena.

Choose a concept you would teach in your specialty area of science.

- How could you design a lesson that used investigation with data collection?
- How could you help students in this content area think deeply about the phenomena?

Using Criteria to Select Resources

Read the following chapter in *Teaching Science for Understanding*:

- chapter 9 ("A Plan for Planning: Using Criteria to Select Resources and Plan Instruction")

After you read the first part of this chapter (page 120-122), read and respond to the "Discussion Questions" dealing with your responsibilities for curriculum development and supplementing resources in your classroom.

You will probably find you have some strong ideas about what your responsibility should be and how this will affect the time required to plan for teaching. Write down some feelings.

Describe the "Backward Design Process of Wiggins and McTighe."

- Why is it called backward design?
- Why is it an important model for designing instruction?
- How do the National Science Education Standards figure into this model?
- Why is it important to coordinate purposes, assessments, and activities?

Review the table in figure 9.2. This will be used as a guide when you plan your lessons so that you can see where you meet the seven categories of Project 2061.

**Lesson Analysis**

Select a lesson sequence from chapter 10, 11, 12, 13, or 14 in *Teaching Science for Understanding*. Review how the lesson sequence is planned. As you read through the process, complete each of the "Reflection & Discussion" section questions.

Consider the following questions:

- How are goals and purposes of the lesson developed?
- How is content determined?
- How are common misconceptions determined?
- What types of assessments are used?
- Does it include both formative and summative assessments?
- How can assessments be adapted to meet the special needs of diverse students?
- How are activities organized?
- Why are the activities chosen?
- Why are they ordered as they are?
- How can activities be adapted for differentiated instruction?

**Developing an Inquiry Unit**

Select a chapter from an available textbook in your subject area and create an inquiry unit. Incorporate what you have learned previously about inquiry and the National Science Education Standards. Use the lesson sequence from the previous activity as a guide.

- Include the National Standards
- Describe common misconceptions in the area
- Include all assessments
- Make the plan detailed enough so that the questioning types are evident
- Provide clear details of activities so that anyone could pick it up and teach from it
- Clearly identify and describe all strategies
- When necessary, adapt activities and assessments to meet the individual needs of students, including language diversity and special education needs

**Teaching Inquiry**

If you have access to students, teach your instructional unit to a group of science students at the appropriate grade level. Evaluate the effect of instruction on student learning. How would you adapt or modify your instruction to meet the needs of students as reflected in the assessments? Describe how students use self-assessment to affect learning.

**Safety Issues**
Science educators have a responsibility to provide a safe environment for science investigations. It is essential that educators are aware of potential hazards and teach students proper procedures. Federal and state laws mandate that science teachers provide their students with safe learning environments. If an accident happens in your classroom, you are liable.

**Safety in the Science Laboratory**

Safety in the science laboratory is a lot more than requiring your students to wear their goggles.

- How will you react when you discover that your science classroom does not have the appropriate fume hoods?
- How will you react when your administrator requires you to teach 30 students in a classroom laboratory that can only safely hold 20 students?
- What will you do or say when a student brings a live insect to class?
- What will you do with a storage room full of old chemicals and some of them that are not labeled?

Legal issues regarding classroom safety, general safety, and chemical, physical, and biological safety issues are addressed.

**Equipment in the Lab**

It is important to know how to properly use lab equipment so that you can pass this knowledge along to your students. It is also important that you know what laboratory equipment is appropriate for the grade level and curriculum you teach. Improper choice of equipment requires students to engage in activities that they may not be developmentally ready for and can be a safety risk.

Technology can be electronic (internet, etc) or non-electronic (lab equipment).

To learn more about lab equipment, review the following documents:

- Equipment to meet Standards
- On High School Equipment
- Safety Reference

What equipment is appropriate for younger middle school students and what equipment is appropriate for high school?

All students use thermometers, barometers, and pH paper. High school students use more involved physics and chemistry instruments. Younger students may make their own instruments rather than use an actual instrument.

**Safety in the Lab**

Review the following helpful resources on safety:
How would you check equipment for safety? Design or modify an existing checklist that can be used regularly to check safety issues in the classroom.

Teaching Safety in the Laboratory

Design a brief laboratory activity that includes procedures to ensure the safety of all students and the ethical care of organisms and specimens. Make a chart that can be posted in the classroom outlining the procedures for responding to a laboratory accident, including first aid. Design a chart of the classroom that will provide quick and safe access to all safety equipment.

Planning for Safety in the Science Lab

Read the following chapter in *Science Instruction in the Middle and Secondary Schools*:

- chapter 14 ("Safety in the Laboratory and Classroom")

Construct a concept map of the main ideas of this chapter using a software program (e.g., Inspiration, etc).

Safety in Field Investigations

Students can benefit greatly from opportunities to conduct science investigations in the field. There are also many opportunities for accidents to occur. Science educators who conduct field investigations have a responsibility to anticipate and avoid dangers, and to know how to respond when dangers occur. Students need to be taught to avoid/respond appropriately to dangerous situations.

Safety on Field trips

Read the following section of *Science Instruction in the Middle and Secondary Schools*:

- section "Fieldwork and Classroom Snapshot 13.3" in chapter 13 ("Laboratory Work and Fieldwork")

Final Steps

Congratulations on completing the activities in this course! This course has prepared you to complete the assessments associated with this course. If you have not already been directed to complete the assessments, schedule and complete your assessments now.