TABLE OF CONTENTS

Introduction . . . 1

Pre-Assessment . . . 5

Unit 1: What Do Scientists Do? . . . 9
- Lesson 1.1: What Does a Scientist Look Like? . . . 10
- Lesson 1.2: What Is a Scientist? . . . 14
- Lesson 1.3: Project: Scientific Careers . . . 17

Unit 2: What Is the Scientific Method? . . . 25
- Lesson 2.1: Observing Mystery Objects . . . 26
- Lesson 2.2: Evaluating Hypotheses . . . 30
- Lesson 2.3: Evaluating Data . . . 35
- Lesson 2.4: Evaluating Types of Graphs and Charts . . . 38
- Lesson 2.5: Transformed "Floating Leaf Disc" Lab . . . 44

Unit 3: What Is the Role of Evidence? . . . 49
- Lesson 3.1: Analysing Claims . . . 50
- Lesson 3.2: Theories Are Like Puzzles . . . 54
- Lesson 3.3: Uncovering Misconceptions . . . 60

Unit 4: What Is Critical Thinking? . . . 63
- Lesson 4.1: Using the I^2 Strategy . . . 64
- Lesson 4.2: Deep Thinking Using Claim, Evidence and Reasoning . . . 67
- Lesson 4.3: Project: Making Models of Earth Motions . . . 71
- Lesson 4.4: Project: Engineering a Boat . . . 75

THINKING LIKE A SCIENTIST

Unit 5: Putting Scientific Skills to Use 81
Lesson 5.1: Project: Solar Oven Construction 83
Lesson 5.2: Project: Testing in Terrariums 90
Lesson 5.3: Project: Working in Research Teams 97

Post-Assessment 103

Answer Key 106

References 111

About the Author 113

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INTRODUCTION

PURPOSE

For Years 5–6 science teachers, there is a wealth of science content to teach. How teachers approach this content to best convey it to students is key. Teachers should employ strategies that encourage students to explore content like scientists. For high-achieving students, the need to interact with and investigate ideas is central.

The purpose of this book is to provide you with lessons and strategies to engage students and help them achieve their potential. Although the examples in this book have been written for Years 5–6, they can also be made more rigorous for higher year levels. It is my goal to help you reach your students by extending the lessons and inspiring your students to learn more.

ORGANISATION OF THE BOOK

Thinking Like a Scientist is designed to guide students to understand how scientists approach problems, investigations and research. Unit 1 introduces students to types of scientists and what scientists' work entails. The lessons in this unit will engage students as they delve into scientific career possibilities. Students will use literacy skills as they read, summarise and paraphrase information about the work of scientists. By learning more about scientists, students may also be able to imagine themselves as scientists.

Unit 2 focuses on the scientific method. Students will use their skills of making observations and inferences as they form hypotheses. They will also employ critical thinking skills as they evaluate data and visual representations of data, such as charts and graphs.

THINKING LIKE A SCIENTIST

Unit 3 explores the roles of questioning claims, evaluating evidence and assessing experimentation, as well as the changing nature of science. Students will learn that they can uncover and correct misconceptions through experimentation and evidence. The self-correcting nature of science is upheld by the practice of testing hypotheses and gathering data. Students will engage in activities to investigate misconceptions and analyse claims.

Unit 4 covers critical thinking skills used in science. Students will apply these skills by questioning what data represent and uncovering the claims, evidence and reasoning in scientific articles and texts. Model-making also requires the creativity and critical thinking skills of scientists. Students will be tasked with making models of natural phenomena and explaining the reasoning behind the formulation of these models.

Unit 5 includes several projects that involve the skills students have learned in the preceding units. Through practising the thinking skills of scientists, students will perform the roles of scientists as they observe, make inferences, develop hypotheses, experiment and communicate scientific findings. In the culminating project, students will work as part of a team to conduct research and experiments. Teachers can extend these activities by working with students to develop a project involving the school or the community.

Thinking Like a Scientist also includes a pre- and post-assessment to be completed before and after the units.

SCIENCE NOTEBOOKS

A simple composition notebook, supplied by the teacher, can lend itself to a world of possibilities when it is used as a science notebook. This notebook contains students' record-keeping of their scientific learning. Organised and personalised, it has certain features to help students arrange science content coherently and meaningfully. It should contain a table of contents, page numbers, and dates and subjects for each entry. Students should write in their notebooks daily as they take notes, respond to prompts and record data. Additionally, students can use graphic organisers to better understand content.

At the end of each lesson, you may want to provide a prompt for students to reflect on the lesson. Many lessons in this book contain reflection prompts in the Extension Activities sections. Students will write several sentences about what they have learned and the questions they may have. These entries communicate students' depth of understanding and any misconceptions they may have. Teacher feedback should occur at frequent intervals and be specific to student writing (e.g. "Can you tell me more about the effects of erosion, especially on mountains?" or "How do you know that this effect is a result of erosion?").

These science notebooks are not just a tool for formative assessment; they are prized and treasured repositories of student artefacts. Students may keep leaves from an excursion inside their notebooks. They might also design creative covers using designer tape, drawings, photos and stickers. More ideas on creating and using science notebooks can be found online at https://www.fossweb.com/delegate/ssi-wdf-ucm-webContent?dDocName=D1423685.

THINKING LIKE SERIES

This book is one in a series, developed in conjunction with the Center for Gifted Education at William & Mary, intended to develop process skills in various learning areas and enhance discipline-specific thinking and habits of mind through hands-on activities. Each book in the series focuses on a specific discipline and year level:

- In Thinking Like a Geographer, students in Years 2–3 develop and practise geography skills, such as reading and creating maps, graphs and charts; examine primary and secondary sources; and think spatially on a variety of scales.
- In Thinking Like a Mathematician, students in Years 3–4 engage in exploration activities, complete mathematical challenges, and then apply what they have learned by making real-world connections.
- In Thinking Like an Engineer, students in Years 4–5 complete design challenges, visit with an engineer and investigate real-world problems to plan feasible engineering solutions.
- In Thinking Like a Scientist, students in Years 5–6 use inquiry-based investigations to explore what scientists do, engage in critical thinking, learn about scientific tools and research, and examine careers in scientific fields.

UNIT 1

WHAT DO SCIENTISTS DO?

RATIONALE

Donning goggles and lab coats, students feel like scientists when they engage in the skills of making observations, collecting data and drawing conclusions. By actively participating in scientific inquiry in class, students glimpse what it is like to be a scientist. High-achieving students will want to know more about scientific careers and the types of scientists and research. They can gauge the appeal of various careers by researching those of interest. The following lesson plans provide a platform for students to investigate and teach others about careers in science.

PLAN

In Lesson 1.1, students will describe scientists and their work through illustration and literacy. In Lesson 1.2, students will list characteristics of scientists by using a Frayer model. In addition, they will synthesise information from a text and class discussion to add to the Frayer model. In Lesson 1.3, students will build upon the previous lessons to produce a research project about careers in science.

LESSON 1.1

WHAT DOES A SCIENTIST LOOK LIKE?

RESOURCES AND MATERIALS

- Lesson 1.1 Draw-a-Scientist Test

ESTIMATED TIME

50 minutes

OBJECTIVES

In this lesson, students will:

- illustrate their conceptions of a scientist
- explain their illustrations through reflection.

CONTENT

The Draw-a-Scientist Test (DAST; Chambers, 1983) was developed as a means of assessing stereotypes regarding scientists. This informal test is simple to administer but reveals important conceptions that students hold about what a scientist looks like and does as a career.

PRIOR KNOWLEDGE

Students should have learned about some different types of scientists from school, home and popular culture. For example, children may have parents or friends whose parents are scientists. Additionally, many children are aware of the stereotypical "mad scientist" from cartoons and movies.

INSTRUCTIONAL SEQUENCE

1. Distribute Lesson 1.1 Draw-a-Scientist Test and instruct students to draw a scientist. You may specify to students that their scientists should be "doing science". Allow students no more that 15 minutes to complete the task.
2. When students have completed the handout, they can display their products and compare them to other students' drawings.
3. Ask students: What do you notice about the drawings? How are they similar? How are they different? Students can discuss in small groups or with partners, and then share their impressions with the class.
4. Have students use what they learned from the DAST as a springboard to think about themselves as scientists. Questions to ask include:
   - What is your scientist doing? What do you like to do while doing science?
   - What might a scientist find difficult to do? What is difficult for you to do while you are doing science?
   - Most students drew White men as their scientists. Can anyone be a scientist? Why is it important to have scientists from diverse backgrounds? What can we learn from each other?

EXTENSION ACTIVITIES

- Have students write a reflection paragraph about this activity. They may respond to the following questions:
  - Can you imagine yourself as a scientist?
  - What type of scientist would you like to be?
  - What types of science activities do you like doing?

- If you administer the DAST at the beginning of the year, keep these drawings until the end of the school year. By then, students should have been exposed to female and male scientists of diverse backgrounds. Administer the DAST a second time at the end of the year and have students compare their earlier drawings to their most recent ones. Follow-up questions can probe how and why the drawings are different (e.g. What do you understand now about scientists that you didn't understand at the beginning of the year?).

ASSESSMENT OBSERVATIONS

- Students should draw scientists who are reflective of the students.
- Students should draw their scientist engaging in scientific activities, such as using scientific tools and measurements. (Note. A rating scale for the DAST is available online, if quantitative data are needed. The rating scale evaluates gender, symbols of typical scientists, attire, research and technology.)

UNIT 2

WHAT IS THE SCIENTIFIC METHOD?

RATIONALE

Science is a way of knowing and understanding natural phenomena through investigation and exploration. All branches of science, such as astronomy, biology, chemistry, physics and geology, adhere to the objective means of understanding natural events. In their everyday lives, students also follow the scientific method, although not as stringently as a scientist would. Students might employ this approach as they try to repair a broken computer or construct an innovative machine. In all cases, what drives high-achieving students to investigate is a desire to know and understand.

When students realise that they use scientific processes in a multitude of situations, they not only realise the importance of this objective means of problem solving, but also incorporate critical thinking skills, such as making observations, inferences and drawing conclusions, that underlie the scientific method. In effect, they are thinking like scientists in their daily lives.

PLAN

In Lesson 2.1, students will employ the scientific skills of observation and making inferences to draw conclusions. In Lesson 2.2, students will evaluate hypotheses and determine testable predictions. In Lesson 2.3, students will evaluate data so that they can draw strong conclusions. In Lesson 2.4, students will evaluate graphs and charts and decide how well they represent the data. In Lesson 2.5, students will incorporate the scientific skills of devising hypotheses and evaluating data as they carry out an inquiry-based experiment.

UNIT 3
WHAT IS THE ROLE OF EVIDENCE?

RATIONALE

Science content knowledge is continually updated and added to the textbooks and standards teachers utilise. Due to technological advances and greater collaboration among diverse types of scientists, scientific knowledge is expanding. For example, science textbooks published before 1980 most likely have no mention of exoplanet discoveries. This is a testament to the vibrant nature of science: it is changeable, and scientists are forever exploring and investigating. As a result of the evidence-based, yet tentative, nature of science, scientists must always analyse claims, refute theories and uncover misconceptions. Engaging in these scientific skills facilitates our students' development of problem-solving and critical thinking skills. Opportunities to evaluate claims, ideas and hypotheses abound for our students (e.g. through the advertising directed at them).

PLAN

In Lesson 3.1, students will evaluate and analyse claims in advertisements and understand the connection between claims and evidence. In Lesson 3.2, students will differentiate the scientific use of the word theory from the everyday use of the word and provide examples of scientific theories. In Lesson 3.3, students will assess claims and evaluate their veracity by looking for support, and then rewrite the claims, if needed, using evidence.