

Powerful Practices Series

The **POWER** of Questioning?

Guiding Student Investigations



Julie V. McGough and Lisa M. Nyberg

NSTApress
National Science Teachers Association

Copyright © 2015 Julie V. McGough and Lisa N. Nyberg. All rights reserved. For more information, go to www.nsta.org/permissions.
TO PURCHASE THIS BOOK, please visit www.nsta.org/store/product_detail.aspx?id=10.2505/9781938946288

The
POWER
of Questioning
Guiding Student Investigations



Julie V. McGough and Lisa M. Nyberg

NSTApress
National Science Teachers Association
Arlington, Virginia

**Dedicated to all teachers
who inspire children
with minds full of wonder
to seek answers to
a lifetime of questions.**



Claire Reinburg, Director
Wendy Rubin, Managing Editor
Andrew Cooke, Senior Editor
Amanda O'Brien, Associate Editor
Donna Yudkin, Book Acquisitions Coordinator

ART AND DESIGN

Will Thomas Jr., Director

PRINTING AND PRODUCTION

Catherine Lorrain, Director

NATIONAL SCIENCE TEACHERS ASSOCIATION

David L. Evans, Executive Director
David Beacom, Publisher

1840 Wilson Blvd., Arlington, VA 22201
www.nsta.org/store
For customer service inquiries, please call 800-277-5300.

Copyright © 2015 by Julie V. McGough and Lisa M. Nyberg.
All rights reserved. Printed in the United States of America.

18 17 16 15 4 3 2 1

NSTA is committed to publishing material that promotes the best in inquiry-based science education. However, conditions of actual use may vary, and the safety procedures and practices described in this book are intended to serve only as a guide. Additional precautionary measures may be required. NSTA and the authors do not warrant or represent that the procedures and practices in this book meet any safety code or standard of federal, state, or local regulations. NSTA and the authors disclaim any liability for personal injury or damage to property arising out of or relating to the use of this book, including any of the recommendations, instructions, or materials contained therein.

PERMISSIONS

Book purchasers may photocopy, print, or e-mail up to five copies of an NSTA book chapter for personal use only; this does not include display or promotional use. Elementary, middle, and high school teachers may reproduce forms, sample documents, and single NSTA book chapters needed for classroom or noncommercial, professional-development use only. E-book buyers may download files to multiple personal devices but are prohibited from posting the files to third-party servers or websites, or from passing files to non-buyers. For additional permission to photocopy or use material electronically from this NSTA Press book, please contact the Copyright Clearance Center (CCC) (www.copyright.com; 978-750-8400). Please access www.nsta.org/permissions for further information about NSTA's rights and permissions policies.

Library of Congress Cataloging-in-Publication Data

McGough, Julie V., 1969-

The power of questioning : guiding student investigations / by Julie V. McGough and Lisa M. Nyberg.

pages cm

Includes bibliographical references.

ISBN 978-1-938946-28-8 (print) -- ISBN 978-1-941316-78-8 (e-book) 1. Science--Study and teaching. 2. Questioning. I. Nyberg, Lisa M., 1959- II. Title.

LB1585.M375 2014

507.1--dc23

2015001191

Cataloging-in-Publication Data for the e-book are available from the Library of Congress.

Contents

Part 1: Why Is Questioning a Powerful Teaching Tool?

Connecting Questions and Learning

- Why is questioning a powerful teaching tool? 2
- Why is questioning important when linking literacy to learning investigations and authentic performance assessments? 4
- How does the Powerful Practices instructional model work? 6
- Why does skill in questioning engage students in purposeful standards-based learning? 8
- Using unit planning guides 13

Developing Questioning Strategies

- What types of questions do I need to ask, and when should I ask them? 18
- What is wait time? 21
- What is Depth of Knowledge? 22

Part 2: How Do I Prepare for the Power of Questioning?

Engaging Students and Teachers

- How do I prepare for the Power of Questioning? 30
- Who are my students, and how do they think? 31
- How do I provide opportunities for *all* students to participate? 34

Building a Questioning Environment

- How do I build a collaborative learning community to support questioning? 38
- How do I organize resources to engage *all* learners? 42

Contents

Part 3: How Do I Implement the Power of Questioning?

Engaging in Purposeful Discussion

- How do I implement the Power of Questioning?..... 48
- How do I use questioning to engage students in purposeful discussions? 49
- How do I connect discussions within a unit of study?..... 53
- Discussion management tips 56
- How does questioning create opportunities that lead to deeper investigations and authentic assessments?..... 58

Resources and References 59

Index 61

Color Coding

Throughout *The Power of Questioning*, the text, illustrations, and graphics are color-coded to indicate the components of the instructional model.

Questioning is printed in **red**.

Investigations are printed in **blue**.

Assessments are printed in **purple**.

When thoughtful **questioning** is combined with engaging **investigations**, amazing **assessments** are produced—just as when **red** and **blue** are combined, **purple** is produced.

We've also provided links and QR codes to the NSTA Extras page where you can view videos related to content throughout the book. Visit www.nsta.org/publications/press/extras/questioning.aspx to view all supplementary content.

Learn from yesterday, live for today, hope for tomorrow.

The important thing is not to stop questioning.

Albert Einstein

(Relativity: The Special and the General Theory, 1920)

Why Does Skill in Questioning Engage Students in Purposeful Standards-Based Learning?

Students need opportunities to develop science literacy through solving problems and explaining phenomena and observations (NRC 2000). They also need to see purpose for what they are learning as they engage in literacy practices. Children ask questions and make connections to what is being learned in the classroom every day—on the playground, at home, walking to and from class, and when listening to stories and presentations. Sharing these connections through academic discourse helps students formulate new ideas and reconstruct old ones by adding new information from others' experiences.

Academic subjects are often regulated by national and state standards such as the *NGSS* and the *Common Core State Standards (CCSS)*. These standards may lead teachers to engage children in higher-level thinking than they otherwise would through questioning, investigations, and authentic performance assessments. The standards build a bridge to connect real-world problem solving to the application of academic knowledge and skills. Additionally, the standards may guide teachers to engage children in complex cognitive processes so students may produce multidimensional work products illustrating higher-level thinking.

For example, during a study of the structure and function of plants, Cienna remembered her experience of noticing the tiny root hairs growing on a carrot while harvesting plants in the garden (photo on opposite page). She applied the information from the experience when building a model plant, deepening her understanding of the concept of how plant roots work. (Visit www.nsta.org/publications/press/extras/files/practices/questioning/video2.htm or scan the QR code on p. 18 to see a video.) Table 1.1 (p. 10) illustrates the *CCSS* and *NGSS* relevant to Cienna's discovery.



Table 1.1. Standards-Based Learning: Structure and Function of Plants
Examples of standards used during the study of the structure and function of plants.
DOK = Depth of Knowledge (see p. 22); ELA, English language arts.

National Standards	Standards-Based Learning
NGSS: Life Science LS1.A: Structure and Function NGSS: Engineering ETS1.2: Developing and Using Models CCSS ELA: Reading Informational Text RI.7: Use illustrations and details in a text to describe and explain key ideas CCSS ELA: Speaking and Listening SL.2: Ask and answer questions about key details SL.4: Describe things with relevant details CCR.4: Present information, findings, and supporting evidence SL.5: Add visual displays to descriptions to clarify ideas	NGSS Children learn that plants have internal (xylem, phloem, veins) and external (roots, stems, leaves, flowers, fruits) parts that help them survive and grow by investigating (e.g., planting seeds, placing a carrot top in water) and observing real plants over time (e.g., garden experiences) (DOK Levels 1 and 2). Children develop models to describe phenomena (DOK Level 3). CCSS ELA Children ask questions about the parts of the plant and how the parts work to help the plant grow. The children use informational text to explain the different internal and external plant parts. Students describe how plants work and present their information to others using the model plant as a visual display to clarify ideas.

What does a discussion reviewing the structure and function of plants with a model built by students sound like?

Scan the QR code or visit www.nsta.org/publications/press/extras/files/practices/questioning/video1.htm to listen to a discussion with different types of questions.



How does the water get to the leaf?
The blue marble shows the water moving up through the roots into the stem.



Connecting Questions and Learning: Structure and Function of Plants

When exploring the concept of structure and function during a unit on plants, students make connections to their world by observing specific details of real seeds, roots, stems, and leaves at home, on the school campus, and in a school garden (McGough and Nyberg 2013b). Students conduct investigations such as examining and labeling the parts of a pumpkin in the fall, observing and comparing different kinds of seeds from the garden, observing a sunflower plant go to seed at the end of its life cycle, and planting seeds.

A variety of learning experiences involving plants give students context to engage in thinking and questioning throughout the unit of study (McGough and Nyberg 2013a). Reading informational text in addition to making firsthand observations stimulates even more questions. The teacher asks, “What questions do you have about plants and how they work?” This question causes students to reflect on what they have learned so far and then extend their thinking.



Well, I know that plants have roots, a stem, and leaves, and plants need sunlight, water, and air. Now I am thinking, How do things move up and down in the stem?

Using Unit Planning Guides

Student questions prompt further investigations, which advance the cycle of learning. As you design a unit, a planning guide can help you determine engaging questions, purposeful investigations, and authentic assessments to push the cycle forward. Students’ extensive studies allow for crosscurricular connections. For example, after hands-on learning about plants, students might read informational text that describes and explains key ideas (English language arts standards) about how plants work (science content standards). Then, they could investigate how different variables affect plant growth (water, soil nutrients, and sunlight). Purposeful investigations help students build understanding of key concepts and might lead to an authentic performance task of building a model plant (science and engineering practices) to articulate how the structure of a plant helps a plant function (Figure 1.3).

Figure 1.3. Powerful Practices Model: Structure and Function of Plants
An example of the Powerful Practices model filled out during a unit on the structure and function of plants.



A comprehensive unit planning guide includes such crosscurricular possibilities (Figure 1.4, p. 14, illustrates a visual reference for crosscurricular connections) as well as content and academic vocabulary, resources, and differentiation strategies. An example of a complete unit planning guide for the unit on the structure and function of plants is shown in Figure 1.5 (pp. 15–17).

Figure 1.4. Brainstorming Crosscurricular Connections



Science: Investigate how seeds, roots, stems, and leaves work.



Technology: Produce and publish writing and collaborate with others through a classroom blog.



Engineering: Build a model plant to show how a plant works.



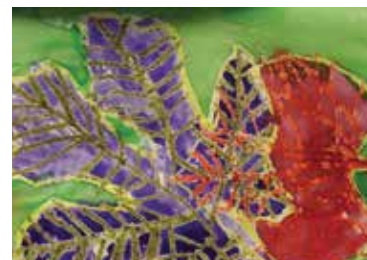
Math: Measure plants growing in the garden.



ELA: Record plant observations in a science journal including labeled drawings.



Social Science: Locate where foods are grown and transported to and from on the map.



Art: Observe leaf shapes and veins. Create a crayon resist of leaves.

Figure 1.5. Unit Planning Guide: Structure and Function of Plants

Unit Planning Guide	Timeline
<p>Core Idea/Topic: Structure and Function of Plants</p> <p>Concepts: Plant parts, plant needs, photosynthesis</p> <p>Questions to Drive the Inquiry</p> <ol style="list-style-type: none"> 1. What do you know about plants? 2. How do plants work? 	<p>Standards</p> <p>NGSS</p> <p>LS.A Structure and function of plants; LS.B Growth and development of organisms (plants); LS.C Organization for matter and energy flow in organisms (plants); LS.D Information processing; ETS1.2 Developing and using models</p> <p>CCSS ELA</p> <p>RI.1 Key ideas and details; RI.4, RI.5 Craft and structure; RI.7 Integration of knowledge and ideas; W.5, W.6 Production and distribution of writing; W.7, W.8 Research to build and present knowledge; SL.1, SL.2, SL.3 Comprehension and collaboration; SL.4, SL.5, SL.6 Presentation of knowledge and ideas</p> <p>Performance Assessment</p> <ol style="list-style-type: none"> 1. Students will build a model plant using straws, tubes, lids, netting, bubble wrap, and other objects. 2. Students will present their model plant to the class and explain how a plant works. 3. Students will write a report or create a brochure that explains how plants make food, what plants are used for, and why plants are important.
	<p>Investigations</p> <ol style="list-style-type: none"> 1. Observe how different variables affect plant growth (water, soil nutrients, sunlight). 2. Observe a celery stem in colored water. 3. Use straws to suck up water from a cup. Place a finger over the straw when it is in the water. Discuss. 4. Place a plastic bag over a leaf on a plant outside. Observe over time.
	<p>Student Questions</p> <ol style="list-style-type: none"> 1. How does a plant make food in that tiny, thin space in the leaf? 2. How do things move up and down in the stem? 3. How does air go in and out?

Index

Page numbers printed in **boldface** type refer to figures or tables.

A

A Framework for K–12 Science Education, 4
Analysis, thinking about, 32, 36
Assessments, in Powerful Practices model, 2, 4, **5**, 6
 authentic, 2, 4, 8, 13, 53, 58
 depth of knowledge and, 22

B

Big ideas, thinking about, 32, 36, 53

C

Chick growth and development unit
 asking questions and defining problems for, 26, **27**
 depth of knowledge framework for, 22, **23**
 Powerful Practices model for, **25**
 standards-based learning for, **24**
Clarifying questions, 18, 19, **19**, **40**, 51, 52, 53
Cognitive demand, 22, **23**
Cognitive learning environment, 38–39
Collaborative learning, 4, **14**, **17**, **24**, 31
Collaborative learning community, 38, 40, 57
Collaborative learning environment, 30
Common Core State Standards (CCSS), 8, **10**, **15**, **24**, 53
Connecting questions and learning, 2, 12, 53
Convergent questions, 18, **19**, 51
Crosscurricular connections, 4, 6, 13, **14**
Curiosity, 2, 26

D

Data collection tools, 38, 43, **45**
Defining problems, 4, 26, **27**
Depth of knowledge (DOK) framework, 22
 for chick growth and development unit, 22, **23**
Details, thinking about, 33, 37
Differentiation strategies, 13, **16**
Discussion(s)
 addressing disruptions during, 57
 connecting within a unit of study, 53
 dynamic, 30, 31, 38, 40, **40**
 Launch...Fuel...Propel concept for, 53, **53**, **54**
 management tips for, 56–57
 modeling metacognition for, 49–51
 participation of all students in, 34–35, 56
 purposeful, 48–53
 QR codes to listen to, 10, 18, 40, 49

setting expectations for, 21, 38–39, **40**, 50, 56, 57
template for, **55**
understanding how students' think for conducting, 30–33, 46–47
using questions for, 4, 6, **7**, 18–19, **19**, 49
wait time for, 21, 34, 51, 56
Divergent questions, 18–19, **19**

E

Einstein, A., vii
Engineering, 4, **10**, 13, **14**, **16**, 22, **24**, 26, **27**
English language learners, 34–35
Extending questions, 12, 18, **19**, 39, 53

H

How students think, 30–33
observation checklist for, 36–37

I

Investigation station, 6, 38, 39, 42, **42**, 43
organizing resources at, **44**
organizing tools at, **45**
Investigations, in Powerful Practices model, 2, 4, **5**, 6, 13, 22, 58

J

Justifying questions, 18, **19**, 53

L

Launch...Fuel...Propel concept, 53, **53**, **54**
Learning styles, **16**, 43
Literacy development, 4, 8, 42

M

Management tips for discussions, 56–57
Meaning, thinking about, 33, 37
Metacognition, 26, 48, 49, 50, 51
Misconceptions of students, 6, 18, **19**, 49, **54**

N

National Research Council (NRC), 26
Next Generation Science Standards (NGSS), 6, 8, **10**, **15**, **24**, **25**, 53
Nonfiction library, 38, 43, **44**
Nonverbal communication, 39, **40**, 41
NSTA Extras website, 59

O

Observation Checklist: How Do My Students Think?, 36–37
 Observation tools, 38, 43, **45**
 Organizing resources, 42–43, **44**
 Organizing tools, 43, **45**
 Outside-the box thinking, 33, 37

P

Participation of all students in discussions, 34–35, 56
 Performance expectations, 6, **7**
 Perspective, thinking about, 33, 37
 Physical learning space, 38
 Plant structure and function unit, 6, 8
 connecting questions and learning for, 12
 crosscurricular connections for, 13, **14**
 Powerful Practices model for, **13**
 questioning strategies for, 18–19, **19**
 sample discussion of, 10
 standards-based learning for, **10**
 unit planning guide for, 13, **15–17**
 Powerful Practices Instructional model
 in action, 6, **7**
 for chick growth and development unit, **25**
 components of, 2, 4, **5**, 6
 implementation of, 48
 organizing resources for, **42**, 42–43, **44–45**
 for plant structure and function unit, **13**
 preparing for, 30
 Probing questions, 18, 19, **19**, 50, 51, 53

Q

QR codes, 8, 10, 18, 35, 40, 49, 59, vii
 Questioning environment, 38–41
 Questioning strategies, 18–19, **19**
 Questions
 in Powerful Practices model, 2, 4, **5**, 6, 58
 thinking about, 32, 36

R

Reading information text, 42
 nonfiction library for, **44**
 for plant structure and function unit, **10**, 12, 13, **16**
 Reflection
 by students, 6, 12, **23**, **24**, 56
 by teacher, **17**, 59
 Respectful learning environment, 21, 38, 39, **40**, 41, 56, 57
 Rowe, M. B., 21

S

- Science, technology
 - engineering, and mathematics (STEM) instruction, 4
 - for plant structure and function unit, **14, 16**
- Science and engineering practices, 4, 13, 22
- Science journal, **14, 16, 17, 43, 45**
- Scientific habits of mind, 4
- Standards-based learning, 8, 53
 - for chick growth and development unit, **24**
 - for plant structure and function unit, **10**
- Students
 - English language learners, 34–35
 - misconceptions of, 6, 18, **19, 49, 54**
 - participation of all in discussions, 34–35, 56
 - understanding how they think, 30–33, 36–37
 - valuing ideas of, 39

T

- Teachable moments, 26
- Technology, 4, **14, 16, 24, 43, 44**
- Template for discussions, **55**
- Thinking
 - critical, 18
 - extended, **23**
 - higher-level, 8, 22, 26, 48
 - metacognitive, 26, 48, 49, 50, 51
 - strategic, **23**
 - understanding how students think, 30–33, 36–37

U

- Unit planning guide, 13
 - for plant structure and function unit, **15–17**

V

- Vocabulary, 13, 50, 52, 53
 - on plant structure and function, **16–17, 43**
- Vocabulary resources, 38, 43, **44**


W


- Wait time, 21, 34, 51, 56
- Webb, N. L., 22
- Writing supplies, 38, 43, **45**


The **POWER** of **Questioning**

Guiding Student Investigations

This pedagogical picture book invites you to nurture the potential for learning that comes from children's irrepressible urges to ask questions. Part of NSTA's *Powerful Practices* series for elementary educators, *The Power of Questioning* offers you

 **a solid foundation in both theory and practice.** The book's three-part instructional model is grounded in questioning, investigation, and assessment. Both you and your students will learn how to question effectively, making investigations more engaging.

 **an unusual opportunity to see a model brought to life.** The authors provide vivid pictures as well as links to special videos and audio recordings. You can actually hear teachers and students engage in questioning and watch two easy-to-adapt examples (involving plants and life cycles) of the model in action. Then, you can implement the new strategies right away in your own classroom.

 **standards- and STEM-friendly benefits.** The book also illustrates how to integrate state standards, the *Next Generation Science Standards*, the *Common Core State Standards*, and STEM education practices.

The Power of Questioning is a fresh, lively source of strategies both you and your students will enjoy. The authors are veteran educators who know how busy and demanding today's K–6 classroom is. This easy-to-use volume is proof that sometimes a powerful tool comes in a small package.

GRADES K–6

NSTApress
National Science Teachers Association

PB358X
ISBN: 978-1-938946-28-8

