Doing Good Science in Middle School

A Practical STEM Guide

Including 10 New & Updated Activities

Expanded 2nd Edition

Olaf Jorgenson
Rick Vanosdall
Vicki Massey
Jackie Cleveland

NSTA press
National Science Teachers Association

Doing Good Science in Middle School

A Practical STEM Guide

Including 10 New & Updated Activities

Expanded 2nd Edition

Doing Good Science in Middle School

A Practical STEM Guide

Including 10 New & Updated Activities

Expanded 2nd Edition

Olaf Jorgenson
Rick Vanosdall
Vicki Massey
Jackie Cleveland

NSTA press
National Science Teachers Association
Arlington, Virginia

NSTApress®
National Science Teachers Association

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

ART AND DESIGN
Will Thomas Jr., Director
Rashad Muhammad, Graphic Designer

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.

17 16 15 14 4 3 2 1

Library of Congress Cataloging-in-Publication Data
Jorgenson, Olaf.
Doing good science in middle school : a practical STEM guide / Olaf Jorgenson, Rick Vanosdall, Vicki Massey, Jackie Cleveland. -- Expanded Second edition.
pages cm
Includes index.
ISBN 978-1-938946-07-3—ISBN 978-1-938946-63-9 (e-book) 1. Science—Study and teaching (Middle school) 2. Technology—Study and teaching (Middle school) 3. Engineering—Study and teaching (Middle School) 4. Mathematics—Study and teaching (Middle School) 5. Inquiry-based learning. I. Title.
Q181.J69 2014
507.1'2—dc23 2013042891
Cataloging-in-Publication Data for the e-book are available from the Library of Congress.

Contents

Contents

Acknowledgments

The authors wish to thank author, leader, and educational innovator Doug Llewellyn for his wisdom, encouragement, resourcefulness, and guidance throughout our comprehensive rewrite of this book. Thanks also to our peer editors and master teachers, Jacqueline Kimzey and Bruce Jones, to our technical advisor John Hunt, and to our families for their patient support.

Dedication

For Juliette, Wesley, Grant, and children everywhere who benefit from good science and great teachers; and to Kash, Krew, and Paige, who are part of the next generation of science learners.

About the Authors

OLAF (OLE) JORGENSON served as director of K–12 science, social sciences, and world languages in the Mesa Unified School District in Mesa, Arizona. Previously he was a teacher and administrator in U.S. and international schools, mostly at the middle school level. Ole is past president of the Association of Science Materials Centers (ASMC) and served on faculty with the National Science Resources Center's Leadership Assistance for Science Education Reform (LASER) strategic planning institute, with a focus on middle school science issues. He has presented on middle school science reform at the National Science Teachers Association's annual meeting and at ASMC's Next Steps Institute, and is a past member of NSTA's National Committee for Science Supervision and Leadership. Ole's other publications focus on topics in instructional leadership. He holds a doctorate in educational leadership from Arizona State University. Ole lives with his wife, Tanya, and their daughter, Juliette in San José, California, where he is head of school at Almaden Country School. He can be reached via e-mail at *olafjorgenson@yahoo.com*.

RICK VANOSDALL is a professor in the College of Education at Middle Tennessee State University and also serves as interim director of the doctoral program in Assessment, Learning, and School Improvement. Rick has held various teaching and leadership positions in preK–12 and higher education across the past three decades, including principal investigator on various education service and research projects funded by the National Science Foundation, the Department of Health and Human Services, and the U.S. Department of Education. Rick has delivered national and international conference presentations and is active in science education action research. Rick earned his doctorate in educational leadership at Arizona State University. He lives in Tennessee with his wife Kim, son Grant, and daughter Wesley, along with the family pooch, Sedona. He can be reached via e-mail at *rvanosdall@gmail.com*.

VICKI MASSEY completed her 35-year teaching career in the Mesa Public Schools by serving as the district's secondary science specialist. Vicki currently teaches science methods courses at Northern Arizona University (NAU) and Arizona State University and does science consulting and professional development around the United States. She has served as past president and board member for the Arizona Science

Teachers Association, director of NSTA Division XIV and NSELA Region D, and board member for the Arizona Science and Engineering Fair. Vicki received her Masters of Arts in Science Teaching from NAU. Her experience as a curriculum developer and professional-development specialist deepened her appreciation for science teachers and the tremendously important job they do each day. Vicki lives in Mesa, Arizona, with her husband, horse, and ever-loyal pug and border collie dogs. She can be reached by e-mail at *vickimassey@cox.net*.

JACKIE CLEVELAND completed her career in education as a K–6 science specialist in the Mesa Public Schools, where she also served as a basic skills specialist. She is the recipient of the Presidential Award for Excellence in Science Teaching and a 1991 semifinalist for Arizona Teacher of the Year. During her tenure, Jackie held positions as the National Science Teachers Association preschool/elementary director and president of the Arizona Science Teachers Association. Jackie taught science methods courses at Arizona State University, Northern Arizona University, and University of Phoenix. Jackie lives in Gilbert, Arizona, with her husband Neal. She can be reached via e-mail at *cleveland1@cox.net*.

Background

This book grew out of the authors' experiences while they worked in the Mesa Public Schools (MPS) in Mesa, Arizona. MPS is a metropolitan district serving 70,000 students and 90 schools, K–12. Mesa has used learner-centered methods, inquiry principles, and hands-on science units since 1974, with a science resource center for kit development and distribution starting in 1979. Mesa's science program has earned praise from the National Science Teachers Association, *Harvard Educational Review, Newsweek, American School Board Journal, Parenting* magazine, *American Scientist*, and *The Executive Educator*. In the past two decades, the district has celebrated five awardees of the Presidential Award for Excellence in Science Teaching.

The district's science program and resource center was developed by longtime director Dr. Susan Sprague, now a semiretired science consultant living in northern Arizona. Mesa's resource center refurbishes and distributes more than 10,000 kits annually to its 55 elementary schools. The middle school program also includes two self-contained fifth-grade flight centers with aircraft and helicopter simulators and night-vision goggle stations, serving all of the district's approximately 4,000 fifth graders each year. To find out more, please visit the MPS Science and Social Sciences Resource Center (SSRC) website at *www.mpsaz.org/ssrc*.

Introduction

Changes, Changes, Changes!

Talk about an explosive decade for teachers and learners! When we wrote the first edition of this book, YouTube and Facebook had not preoccupied America's waking hours, and "Google" was not yet a verb. As teachers across our nation recognize, the rapid proliferation of digital technology and concurrent accelerated "flattening" globalization of the world's economy have reshaped the potential and purpose of American education in profound ways.

Middle school teachers today serve a new generation of children weaned on social media that didn't exist in 2004. They instantly access information in and out of the classroom that was previously hoarded, protected, and strategically dispensed by their teachers. It is, to say the least, a very different classroom world today compared to 10 years ago, when we wrote the first *Doing Good Science*.

And these seismic shifts—combined with the emergence of distance and blended learning, flipped instruction, interactive digital textbooks, the furious rise of standardized testing, the popularity and widespread embrace of robotics, development of the Common Core Initiative and the *Next Generation Science Standards* (*NGSS*)—all called us to revisit our work and evaluate how we might make the book more useful in the context of 21st-century skills that teachers today are expected to cultivate in their students.

We realized quickly that improving the second edition would require more than updating and freshening our original book. We've added chapters and sections to help teachers assimilate STEM principles, understand and apply the *NGSS* and *A Framework for K–12 Science Education* (including the new expectations for engineering design), and integrate the *Common Core* literacy and writing standards. We've also learned from teacher feedback about some holes in our first version, such as advice about how to arrange and conduct collaborative table groups and about the critical role of scientific argumentation that we've addressed in this new book.

Most important, since teacher-friendly, ready-to-use STEM activities are the core of this second edition, we've gathered more teacher feedback to provide 10 new and updated investigations aligned with the revised standards and reflecting the emergent emphases on engineering design, STEM, and the 5E method that were present but less pronounced in the original 10 activities.

Based on reader reviews from the first edition, we've also sought to *deepen* the activities as well—beyond explaining what each activity is about, we aim in the new set of activities to help teachers engender productive conversations with students about the investigations and their resulting data.

Throughout our work in rewriting the book, though, the same basic goals that motivated us to create *Doing Good Science* have guided our efforts in this version:

1. Provide a useful resource for science teachers of varying ability and experience levels, staying focused on colleagues in their first years of teaching middle school science, who serve students in a wide range of school and community settings and with differing levels of resources and support.
2. Keep the book readable and user-friendly, addressing the demands teachers face concerning integration of STEM and literacy skills.
3. Provide activities that address the standards, engage students (good science is *fun!*), and are neither costly nor dependent on access to science kits or expensive technology.

Above all, we want *Doing Good Science in Middle School* to be a book by teachers, for teachers, that can make what you do for your students a little easier, richer, and more enjoyable.

We hope you agree that we achieved our objectives. Enjoy!

—Ole, Rick, Vicki, and Jackie

Preface

A middle school science classroom was once described to us as "a nuclear reaction about to happen, on an hourly basis." At the time, that description was meant to illustrate the unstable, unpredictable, and at times irrational behavior of a group of middle schoolers. Years later, we know that the behavior in question is pretty typical, but it can be significantly more challenging to deal with when middle-grade students are confined to neat rows of desks and numbed by textbooks, teacher-centered instruction, and lack of meaningful interaction with peers or their teachers.

In this book, we propose opportunities for learning and teaching amidst the sound and fury of a different sort of explosive (but productive) middle school science classroom. In our experience, good science—by which we mean activity-based STEM instruction—promotes the unexpected and delightful development of adolescent middle school students.

For us, good science constitutes a shift away from the textbook-centered direct instruction that emphasizes discrete factual knowledge claims and passive observation of science phenomena toward active, learner-centered, hands-on and minds-on investigations conducted to some degree by students themselves. Good science and middle school learners are very compatible, as we'll explain in Chapter 1.

Who are we? We are four educators who worked together in Mesa, Arizona, in a school district that has embraced good science instruction since 1974. We are among those who have come to enjoy the blossoming intellects, often comical behaviors, and insatiable curiosity of middle schoolers and who *choose* to work with them! With more than 130 years' combined experience in the profession, we've gathered a lot of ideas to share. We know from our interactions with educators around the country that relatively few quality resources exist to assist science teachers "in the middle," and this was a central impetus for writing and then updating *Doing Good Science in Middle School*.

Our book is aligned with *A Framework for K–12 Science Education* (2012) and the *Next Generation Science Standards* (2013), which set forth eight practices that are fundamental to understanding the nature of science:

- Asking questions (for science) and defining problems (for engineering)
- Developing and using models
- Planning and carrying out investigations

- Analyzing and interpreting data
- Using mathematics and computational thinking
- Constructing explanations (for science) and designing solutions (for engineering)
- Engaging in argument from evidence
- Obtaining, evaluating, and communicating information

We've used the *Framework* (2012), *NGSS* (2013), and the *Common Core State Standards* (2010) as the basis for recommendations to assist middle-grade science teachers, while unpacking the *NGSS* to make them more easily accessible. Throughout the book, we kept in mind teachers who work in self-contained team formats as well as departmentalized middle school configurations.

Our work here is meant to meet other important objectives but above all, we intend it to be teacher-friendly. We wrote *Doing Good Science* as practitioners, for practitioners. In this book, you will find

- a comprehensive overview of science and engineering practices, STEM, and inquiry-based middle school science instruction, aligned with the *Framework* and the *NGSS*;
- a conscious connection to the *Common Core* literacy and math skills embedded in the *NGSS* that help determine—and are fostered by—student success in good science instruction;
- 10 teacher-tested activities that integrate STEM with literacy skill-building (with emphasis on safety in the science classroom);
- information on best instructional practices including argumentation and formative assessment, along with useful print and Web-based resources, science associations, workshops, and vendors;
- a solid foothold for new teachers to help them teach science and engineering practices while better understanding their often enigmatic middle-grade students; and
- an opportunity for veteran teachers to reaffirm that what they do is "good science."

We hope readers will find this book easy to use. It can be read in its entirety or perused section by section as a reference for lesson and unit planning and as a basis for evaluating and modifying existing lessons. It will help teachers explain to their principals why their classes at times need to be noisy, bustling, and "social" to be effective.

We also hope this book is for some readers a point of departure from relying solely on teacher-centered methods with passive text- and worksheet-dependent curricula and in favor of the active learning potential and rich teaching opportunities that good science makes possible in the middle grades.

Let the journey begin!

References

NGSS Lead States. 2013. *Next Generation Science Standards: For states, by states*. Washington, DC: National Academies Press. *www.nextgenscience.org/next-generation-science-standards*

National Governors Association Center for Best Practices and Council of Chief State School Officers (NGAC and CCSSO). 2010. *Common core state standards.* Washington, DC: NGAC and CCSSO.

National Research Council (NRC). 2012. *A framework for K–12 science education: Practices, crosscutting concepts, and core ideas.* Washington, DC: National Academies Press.

Activity 5: Some Striped Seeds Seem Similar!

Biology: Genetic Variation

For almost all species, there is a range of variation among the individuals within a population of that species. Some of these variations affect the survivability of individuals, who then become vulnerable and may not endure. Some variations are affected by environmental factors. Some variations have no effect on survivability, or may not be affected by changes in the environment.

However, there is a pattern in nature that appears almost every time we measure or count individuals of a species based on a *specific characteristic*.

This activity puts students in the role of scientists as they learn about statistics and genetic variation within a species and use the statistical understanding to describe frequencies of specific variations within a species. In this activity, students will focus on the discovery of statistical patterns that emerge from the data.

Safety First

In every activity, we remind you to be certain that you understand the potential risks involved and are confident you can ensure your students' safety. Before attempting any of these activities in class, we recommend completing them yourself, and optimally with a teaching partner.

STEM

This activity capitalizes on the patterns in nature and how close observations of natural objects can reveal a new level of appreciation for mathematical thinking as it is revealed in science.

This activity also introduces students to (or reinforces) a process in which they experience how *scientific knowledge* is developed and tested. Then, students use the scientific knowledge to *predict and test* other variations among members of another species.

Tying it to *NGSS*

Construct an explanation based on evidence that describes how genetic variations of traits in a population increase some individuals' probability of surviving and reproducing in a specific environment. (MS-LS4-4)

[Clarification Statement: Emphasis is on using simple probability statements and proportional reasoning to construct explanations.]

Science and Engineering Practices

Analyzing and Interpreting Data

Analyze displays of data to identify linear and nonlinear relationships. (MS-LS4-3)

Analyze and interpret data to determine similarities and differences in findings. (MS-LS4-1)

Using Mathematics and Computational Thinking

Use mathematical representations to support scientific conclusions and design solutions. (MS-LS4-6)

Constructing Explanations and Designing Solutions

Apply scientific ideas to construct an explanation for real-world phenomena, examples, or events. (MS-LS4-2)

Construct an explanation that includes qualitative or quantitative relationships between variables that describe phenomena. (MS-LS4-4)

Plan for safety by determining which engineering controls, safety procedures and personal protective equipment will be needed.

Obtaining, Evaluating, and Communicating Information

Gather, read, and synthesize information from multiple appropriate sources and assess the credibility, accuracy, and possible bias of each publication and methods used, and describe how they are supported or not supported by evidence. (MS-LS4-5)

Disciplinary Core Ideas

LS4.B: Natural Selection

Natural selection leads to the predominance of certain traits in a population, and the suppression of others. (MS-LS4-4)

Crosscutting Concepts

Patterns

Graphs, charts, and images can be used to identify patterns in data. (MS-LS4-3)

Connections to Nature of Science

Science assumes that objects and events in natural systems occur in consistent patterns that are understandable through measurement and observation. (MS-LS4-1), (MS-LS4-2)

Tying It to *Common Core State Standards, ELA*

RST.6-8.1 Cite specific textual evidence to support analysis of science and technical texts, attending to the precise details of explanations or descriptions. (MS-LS4-4)

RST.6-8.9 Compare and contrast the information gained from experiments, simulations, video, or multimedia sources with that gained from reading a text on the same topic. (MS-LS4-3), (MS-LS4-4)

WHST.6-8.2 Write informative/explanatory texts to examine a topic and convey ideas, concepts, and information through the selection, organization, and analysis of relevant content. (MS-LS4-2), (MS-LS4-4)

SL.8.4 Present claims and findings, emphasizing salient points in a focused, coherent manner with relevant evidence, sound valid reasoning, and well-chosen details; use appropriate eye contact, adequate volume, and clear pronunciation. (MS-LS4-2), (MS-LS4-4)

Tying It to *Common Core State Standards, Mathematics*

MP.4 Model with mathematics. (MS-LS4-6)

6.RP.A.1 Understand the concept of a ratio and use ratio language to describe a ratio relationship between two quantities. (MS-LS4-4), (MS-LS4-6)

6.SP.B.5 Summarize numerical data sets in relation to their context. (MS-LS4-4), (MS-LS4-6)

7.RP.A.2 Recognize and represent proportional relationships between quantities. (MS-LS4-4), (MS-LS4-6)

Common Misconceptions

There are numerous misconceptions about genetics and variation among individuals of a species. One common misconception is that individual organisms are identical if they are the same species. Another common misconception is that visible differences between individuals indicate that they are not the same species.

Textbooks and other teacher resources perpetuate these misconceptions when they provide only a superficial explanation without paying attention to how the authors use technical vocabulary. Additional sources of misconceptions are the result of the application of nonscientific beliefs to influence the interpretation of scientific data.

If you search the internet, you will find many websites that provide a range of explanations about genetic variation. However, exercise caution when evaluating these internet sources. NSTA has excellent resources on the topic of evolution and the principles associated with it; evolution is, to say the least, a sensitive topic that deserves careful planning to present effectively in some school communities.

We do not have the space to go into great detail in this section; therefore, we suggest readers seek additional information from the NSTA website (*www.nsta.org*) and the NSTA Learning Center (*learningcenter.nsta.org*; search for genetic variation or genetics and heredity).

For more on helping students break through scientific misconceptions, consider the resources developed by Dr. Philip Sadler and others associated with the Harvard-Smithsonian Center for Astrophysics: see "Minds of Our Own" and other free online resources and video resources at *www.learner.org/resources/series26.html*.

We also urge readers to consider Page Keeley's series about identifying the prior knowledge your students bring to your classroom: see *Uncovering Student Ideas in Science* (*http://uncoveringstudentideas.org*).

Objectives

By the end of this activity, students will have demonstrated the ability to

- collect, analyze, and pool data;
- look closely at biological objects (sunflower seeds), and carefully record data regarding patterns among the individuals of a species;
- analyze data and use data tables and graphs to describe patterns in nature (the variation in the number of stripes on a sunflower seeds);
- follow procedures consistently; and
- work collaboratively to process large sets of observations.

Academic Language

Trend, bell curve, natural distribution, visual physical graph, biostatistics, range, domain, mean, median, variance, seed case, magnifying glass

Focus Question(s) (Scientific Inquiry)

- Are all sunflower seeds the same?
- How do individual sunflowers seeds vary?
- How much variation is there among individuals of the same species?
- How do scientists and engineers collect large data sets?
- What advantages do scientists and engineers have when they use large data sets for analysis?
- When do you know you have enough data to have a high degree of confidence to make a "claim based on evidence"?

Framing the Design Problem(s) (Engineering Practice)

Nonnative invasive species are destroying habitat and biodiversity. Biodiversity is a measure of the number of different species in a defined geographic area. The health and stability of an ecosystem is demonstrated by the biodiversity in that ecosystem.

For example, zebra mussels are mollusks that are destroying fishing, recreational boating, and shipping in the Great Lakes. This costs taxpayers millions of dollars each year to combat the invasive mussels.

One option for a design problem might look like this: "Based on what you have learned about variation among a species in this activity, propose some investigations that will provide you with the information you could use to develop a device, process, or regulation to reduce the number of new zebra mollusks that are introduced into the Great Lakes."

Refer to Figure 4.3 "The Engineering Design Process" (p. 45) for more information about how to frame the design problem for this activity.

Teacher Background

For this activity, students are going to count the number of white stripes on each striped sunflower seed. Students need to keep track of the number of seeds with each number of stripes and sort the seeds into piles based on the number of stripes on the sunflower seeds. After students have completed counting and sorting their sunflower seeds, they will

- add their data to the class data on the whiteboard, and
- bring their piles of seeds sorted by number of stripes and add each of their piles to the appropriate piles (cylinders; see p. 144) at the front of the room.

For this activity, you'll need to collect 16 graduated cylinders or other transparent containers and arrange them across a table in order of number of stripes (from 0 stripes to 15 stripes). Students will collect data in teams of two, and then pool their data as a class.

One way to easily collect the class data is to make a chart on the whiteboard such as the Class Data Chart (see sample data tables, below). As students complete their data collection, they will record their data in their lab notebook data tables as well as the Class Data Chart on the board. For additional impact, teachers may collect the class data as a visual physical graph—either simple piles of seeds, or in a series of transparent cylinders. (An additional variation in middle schools where teachers change students every class period. Teachers can collect data the seeds for each class in plastic bags, and combine multiple class periods of data to demonstrate the effects of increasing sample size on the shape of the physical graph of data.)

Individual Group Data Table

Number of Stripes	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Number of seeds																

Class Data Table

Number of Stripes	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Seed counts from Group 1																
Seed counts from Group 2																
Seed counts from Group 3																
Seed counts from Group 4																
Seed counts from Group 5																
Seed counts from Group 6																
Seed counts from Group 7																
Seed counts from Group 8																
Seed counts from Group 9																
Seed counts from Group 10																
Seed counts from Group 11																
Sum of seed counts																

We suggest teachers research various internet resources (including the NSTA Learning Center's information on genetics; there also are many good YouTube videos, Khan Academy videos, and TEDed resources) to review content knowledge associated with genetic variation.

Preparation and Management

You'll need to gather the materials for the student work group kits. Each student work group will need the following:

- 1 resealable bag of ¾–1 cup of striped sunflower seeds (with an optional magnifying glass to see the stripes more clearly). (*Safety note:* Some seeds contain pesticides or herbicides. Remind students not to eat the seeds and also wash their hands with soap and water after completing the activity.)
- Safety glasses or goggles

Prep Time

60 minutes to fill the bags of sunflower seeds and prep the cylinders.

Also, schedule time for students to use computers for internet access.

Teaching Time

45–90 minutes

Materials

- Student access to computers to access websites or information printed from websites on invasive species (Zebra mussels or other important invasive specie in your area), statistics, and biostatistics.
- Whiteboard, markers, and eraser for each student pair (Large chart paper and felt pens can be used in place of whiteboards.)

5E Instructional Model

Engage

Show PowerPoint slides (or YouTube/TeacherTube videos) that show extremes of size variation of living organisms.

Ask students to share what they have heard about or experienced regarding the range of sizes of a particular animal or plant, and have students offer any ideas they have to explain the variation. (Always ask students to provide evidence or their thinking that led them to the idea that they expressed.)

Note: This section is not about being right or having the best answer. The *Engage* phase is all about getting students to think and involve themselves in the topic cognitively. This section also provides important information about student thinking and misconceptions.

Preassessment

Here are two questions you can use to gauge prior knowledge:

- How can you explain the variation among these observations?
- What evidence do you have for your explanation?

These questions may be given as writing prompts or in small-group discussions that you observe. You'll discover how and what students think about their observations (and you'll glimpse their argumentation skills). Your preassessment serves to help you shape the rest of the activity and subsequent lessons.

Explore

Tell students that they will work in teams of two to do the work of biostatisticians as we investigate the variability of a characteristic in a living organism (the number of white stripes on a sunflower seed).

Pass out the bags of sunflower seeds and have the students count and sort the sunflower seeds to determine the number of white stripes on the seeds. They will need to record their individual team data, record their data on the class data set, and add their piles of sorted seeds into the class visual physical graph setup at the front of the classroom.

Students should be cautioned to not eat the sunflower seeds as they have been handled by students in several different classes. If it's permitted at your school, you could reassure the students that they will be provided with some sunflower seeds to eat at the end of the lesson.

Explain

Each team of biostatisticians needs to record the class data and analyze their team data as it compares to the class data. Once the teams complete their analyses and comparisons, they will compose whiteboard explanations of the benefits and limitations of data based on the sample size of the data. (How does the number of data points affect the reliability and validity of claims based on the data?)

These should be shared with the class, and the teacher facilitates the discussion. (This is an excellent opportunity to implement formative assessment practices for clarifying and reteaching topics and information that may be needed to improve the accuracy of what the students have learned.)

After each group has defended its information, the information should be written up in an "official report" to be presented (published) for their classmates, family, or friends to compel them to increase their critical thinking about information presented in advertisements and other presentations.

Elaborate

Students should build on the understanding that there is variability among most individuals of a species, to develop a series of potential devices or systems/processes to reduce the introduction of invasive species (e.g., zebra mussels).

Evaluate

Students are evaluated based on the depth of understanding expressed in their *Exploration* as well as *Elaboration* phases. The teams with the most thorough explanation of the effect of sample size on reliability of claims based on evidence should be given the opportunity to reveal their correct understanding to their classmates. *Evaluation* should be based on the quality of their detail and the alignment between claims and evidence in the report to their classmates, family, and friends, and the *Elaboration* information from the engineering Design Challenge.

Discussion and Argumentation

Students should be given multiple opportunities to voice their claims and evidence. They should also be given the opportunity to refine their claims based on class-pooled evidence.

Discussions are generally facilitated by the teacher and should focus on the nature of scientific ways of knowing (systematic review of data and the processes used to collect the data). We are not searching for one correct answer. Instead, we suggest the students stay focused exploring and articulating what they "know" and the evidence they have. If the students need to go back to the activity to run additional tests, that should be encouraged. The scope of Discussion and Argumentation depends on the time you have available—there is a lot of potential for higher order thinking here.

You'll have the opportunity to discuss and debate the notion that "the more data we collect, the better," and to critically review questions such as, "Is there a point where you have enough data to make a claim, and there is diminishing return on the investment of time and energy to continue collecting data? If there is a point of diminishing returns, how do you know when you are at the point where you don't need to collect additional data?"

Differentiation

1. **Broader Access Activity:** Limit the number of seeds in some of the bags. By limiting the number of seeds, students who are easily distracted would have their attention focused only on the items necessary for a particular stage of the activity and have a reasonable expectation of completing the counting and sorting task around the same time that other teams are ready to record their data on the class data chart.
2. **Extension Activity:** Expand the options and have students explore the limitations of variability for seeds versus adult body size, or versus sunflower stalk height, or versus any other biological variable. Also, students could explore the role of genetics and environment on the variability of other types of organisms.
3. **Modified Assessment:** Modify the assessment to focus on the verbal, written, or diagrammatic elaboration of the principles in this lesson.
4. **Challenge Assessment:** Allow students to present a comparison of the effects of genetics and environment on variability among individuals of a species. They might present the data in multiple representations and provide a rationale for how they decided to represent the information.

Note: These are examples as illustrations of possible differentiation options. The actual adaptations you create will depend on the results of your preassessment and ongoing formative assessments of individual students.

Index

Doing Good Science in Middle School

A Practical STEM Guide

Expanded 2nd Edition

"We are among those who have come to enjoy the blossoming intellects, often comical behaviors, and insatiable curiosity of middle schoolers—and choose to work with them! With more than 130 years of combined experience in the profession, we've gathered a lot of ideas to share. We know from our interactions with educators around the country that precious few quality resources exist to assist science teachers 'in the middle,' and this was a central impetus for updating *Doing Good Science in Middle School*."

—From the preface

This lively book contains the kind of guidance that could only come from veterans of the middle school science trenches. The authors know you're crazy-busy, so they made the book easy to use, whether you want to read it cover to cover or pick out sections to help you with lesson planning and classroom management. They also know you face new challenges, so they thoroughly revised this second edition to meet the needs of today's students. The book contains

- big-picture concepts, such as how to understand middle school learners and explore the nature of science with them;
- a comprehensive overview of science and engineering practices, STEM, and inquiry-based middle school science instruction, aligned with *A Framework for K–12 Science Education* and the *Next Generation Science Standards*;
- 10 new and updated teacher-tested activities that integrate STEM with literacy skill-building;
- information on best instructional practices and professional-development resources; and
- connections to the *Common Core State Standards* in English language arts and mathematics.

If you're a new teacher, you'll gain a solid foundation in how to teach science and engineering practices while better understanding your often-enigmatic middle-grade students. If you're a veteran teacher, you'll benefit from a fresh view of what your colleagues are doing in new times. Either way, *Doing Good Science in Middle School* is a rich opportunity to reaffirm that what you do is "good science."

PB183E2
ISBN 978-1-938946-07-3

GRADES 6–8

NSTApress
National Science Teachers Association