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## The Authors

**Michael Felske** has been and always will be a teacher at heart. During a 33 year career in a suburb of Milwaukee, he taught middle school and high school science, taught perspective teachers at the University of Wisconsin-Milwaukee, presented science education programs at local, state, and national conventions and was a member of the executive board of the Wisconsin Society of Science Teachers. For his work, Mike received several awards for distinguished science teaching. Since retiring from public education, Mike has expanded his job titles to include Science Ed Consultant for a local Montessori school, Flight Instructor and Vagabond Pilot/Ski Instructor. When not in a classroom, he can be found flying his 1949 Piper Clipper around the skies of Wisconsin or ski instructing at a local ski resort. He lives on a small lake in East Troy, Wisconsin with his wife, Claudia (2011 Wisconsin High School Teacher of the Year) and son, Eliot.

**Craig Berg** taught middle and high school science before pursuing an M.S. and Ph.D. in Science Education from the University of Iowa. His daily adventures now include directing the science teacher preparation program at the University of Wisconsin-Milwaukee, working with undergraduates, post-baccalaureates, and M.S. students in pursuit of exemplary science teaching. Research, writing, publishing and service to local school districts fills the rest of his calendar. He is truly blessed with being able to work with many of the exemplary teachers in the area on a variety of grants and projects such as this one. His twenty-four years of work in Milwaukee resulted in the 2011 UW-System Regents Excellence in Teaching Award. He draws inspiration from his wife Kathleen who is an NBCT of science and a creative wizard in the science classroom. Until his battery runs out he plans on continuing to work at something he truly loves doing on a daily basis - pursuing excellence in science education.

**Contributors:** Greg Bisbee, Raymond Scolavino, Andi Winkle, Greg Zimmer, Robin Kroyer-Kubicek, Scott Gundrum

# Introduction

In my thirty plus years as a science teacher and science-teacher educator, I find that the great ideas for teaching science stem from researchers studying teaching and learning, and from teachers who have persevered to find ways to reach more children in order to maximize learning in their classroom. Many of these creative and highly effective teaching ideas arise from teachers who are embedded in the most challenging situations, and, as such, are motivated to explore, find, or develop new strategies or materials to use with their students so as to have a greater impact on their learning.

Teachers who embrace these challenges of teaching and learning accumulate a substantial set of teaching tools, combined with a clear framework and rationale for teaching (see section IV), are able to utilize *the appropriate tool for the moment at hand*. Dialogues are another teaching tool; a teaching strategy that will help teachers reach children in ways that other strategies might not. Dialogues involve students in speaking and listening, acting and reacting, tapping into emotional and kinesthetic parts of the brain. The Common Core State Standards for English Language Arts and Literacy in subject areas are very clear in that “students must learn to read, write, speak, listen, and use language effectively in a variety of content areas.” The Next Generation Science Standards are also very clear in that we must engage our students in learning using strategies that maximize engagement in all aspects of the process. In short, dialogues maximize student’s engagement in the learning process; all students are involved as active participants when dialogues are in play.

Dialogues have been tested from elementary to college levels and in urban, suburban and rural classrooms. You might decide to use them as is, or might modify them and add your own spin or local context to them. You might also craft some from scratch, or have students write dialogues; we have included some suggestions and tips for writing dialogues.

Credit for the germ of this idea and the initial spreading of the seed goes to Donald Cronkite of Hope College, who developed and used dialogues with his college biology students and shared this teaching strategy with high school teachers at a Woodrow Wilson Institute. Greg Bisbee was one of those in attendance, who then grabbed on with both hands and began writing dialogues for his own students in biology classes. Greg, a biology teacher extraordinaire, also began to spread the word and captured the attention and interest of myself and the coauthor of the *Dialogues for the Biology Classroom*, Kathleen Westrich. Westrich began writing dialogues for her students. Seeing the success of Bisbee and Westrich, being a science teacher educator, I quickly connected my future teachers with Bisbee and Westrich in order to learn about dialogues. Gradually we brought many others on board for writing and using dialogues in the classroom - in this case, an outstanding physical science teachers. Now the single seed planted by Professor Cronkite and his colleagues has turned into a blooming field of dialogues.

Dialogues engage learners at high levels, so try them! Your students will enjoy the activity, learn something about the content you are trying to teach them, and learn something about themselves.

Editor - Dr. Craig Berg

# Using This Book

**There are four major units to this book:**

**Section I - Abstracts:** This section provides the reader with a quick overview of each dialogue and the science concepts or terms embedded within. Scanning the abstracts helps the reader determine which dialogue might be suitable for the upcoming lesson.

**Section II - Using Dialogues in the Classroom:** This section details the key aspects of using dialogues in the classroom - the what, when, and how to, of using and writing dialogues. This section provides examples of how dialogues can target content goals, be used in conjunction with a lab activity, help teach about historical aspects of the subject, and help students grapple with current issues or science-based ethical dilemmas. In addition, there are numerous suggestions and tips for implementing dialogues in the classroom, and the benefits thereof, with guidelines on how to write your own dialogues, and how to have students create their own dialogues as a measure of what they learned.

**Section III - The Physical Science Dialogues:** This section contains the sixty-four dialogues that cover eleven different units, beginning with what is science and properties of matter, with the rest focused on the chemistry aspect of physical science. The dialogues are designed to help you teach many of the topics covered in a typical physical science class.

**Section IV - Science Dialogues and Teacher Decision-Making:** This unit provides the reader with an overview of how dialogues fit into the big picture of classroom instruction, and how using dialogues connects to, and supports, the goals for students in science classrooms. While this unit is important, the typical reader will probably be more interested in the what and how to, and therefore read Section IV last. However, read Section IV to better understand how teacher decision-making is so critically important to success in the classroom, and how dialogues is one of the teaching tools that helps teachers accomplish the difficult task of helping students to develop a better understanding of physical science. Use this section to help frame one's thoughts about teaching, in preparation for talking with administrators (or parents, or sometimes colleagues) who could benefit from a better understanding about what it takes to effectively teach science.



# Section I - Dialogue Abstracts

## Unit 1 - What is Science?

**1.1 Why Science?:** Kailey and Kyle are hanging out by the pond at the park, late in a summer's day, when their conversation turns to discussing reasons why science originated.

*Science concepts or terms include:* how science works, nature of science, what is science?

**1.2 What is Science?:** Kailey and Kyle are watching the sunset over the pond in the park when a need to locate cookies causes them to turn to a discussion of what defines science.

*Science concepts or terms include:* doing science daily, how science works, scientific methods.

**1.3 Hypotheses, Theories and Laws, Oh My!:** Kailey and Kyle are still at the park, when darkness settles in and they wrestle with the difference between hypothesis, theories and laws.

*Science concepts or terms include:* experiments, explanations, hypotheses, laws, scientific evidence, scientific question, theories.

## Unit 2 - Properties of Matter Part 1: Floating and Sinking

**2.1 What is Stuff?:** Kyle is sitting at the firepit in his back yard with his friend Sam making s'mores. They're talking about girls, and the difference between matter and energy.

*Science concepts or terms include:* matter vs energy, waves.

**2.2 What is Stuff Made of?:** Friends Kyle and Sam are hanging, making s'mores on a cool summer night. Kyle is curious about what matter is made of and how to talk about it.

*Science concepts or terms include:* matter vs energy.

**2.3 Packedtogetherness: To Float or Not to Float?** – Kyle and Sam are hanging out at the park pond on a summer's day. Kyle is skipping stones on the pond and they begin discussing why geese float and rocks sink using the term "packedtogetheridness."

*Science concepts or terms include:* density, floating, sinking.

**2.4 Floating and Sinking:** Kyle and Sam are continuing their discussion on why things float and sink, expanding their thinking using the concept of "density."

*Science concepts or terms include:* density, floating, sinking.

**2.5 Floating and Sinking, Sinking and Floating:** Kyle and Sam do a lab activity using alcohol, water and a candle in order to explore floating and sinking and better understand how density and perhaps gravity plays a role.

*Science concepts or terms include:* density, floating, gravity, sinking.



**2.6 Flinking:** Kyle challenges Sam to make something “flink” so they begin to get the materials needed to try it out.

*Science concepts or terms include:* floating, sinking.

**2.7 Sink, Sank, Float, Flink:** Seeing the results of the flinking experiment, Kyle and Sam discuss how the behavior of the gum in salt water was like Kyle’s experience swimming in the Great Salt Lake. They proceed to try another “flinking” lab using only water this time.

*Science concepts or terms include:* density, floating, sinking.

**2.8 Dive! Dive! Dive!:** Kyle and Sam are using an eye dropper to explore the concept of pressure affecting floating and sinking and work to refine their notion of what factors affect whether something floats or sinks.

*Science concepts or terms include:* buoyancy, floating, gravity, pressure, sinking.

## Unit 3 - Properties of Matter Part 2 - Air and Water

**3.1 Squishability:** Kyle is walking back from Sam’s with his dropper diver when he runs into Kailey. He shows her how it works and they discuss pressure, volume and how air has squishability and water doesn’t.

*Science concepts or terms include:* air pressure, floating, sinking, submarine, volume.

**3.2 Kyle’s Theory of Squishability:** Kyle and Kailey continue to explore the squishability of air and water using a syringe.

*Science concepts or terms include:* compressing air.

**3.3 Water Drops on a Penny:** Motivated by the concept of “pouring air” Kyle and Kailey begin by seeing how many drops of water they can add to the top of a penny laying flat on its side.

*Science concepts or terms include:* testing ideas.

**3.4 Solids, Liquids and Gases, Oh My!:** Thinking about what they learned from the drops on a penny experiment, Kyle and Kailey think about energy and movement of molecules to explain how liquids, gases and solids behave differently.

*Science concepts or terms include:* energy, gases, kinetic motion, kinetic theory, liquids, solids, variables.

**3.5 Fast and Slow, Hot and Cold:** Still contemplating “pouring air” Kyle and Kailey reconsider the dropper experiment and how changing the water temperature might affect the outcome.

*Science concepts or terms include:* density, hot and cold, particles, temperature, testing ideas.

**3.6 Pour Me Some Air:** Thinking they are finally ready to tackle the “pouring air” idea, Kyle announces that he can show Kailey an experiment using an upside down glass in a sink full of water, to better understand how to “pour air.”

*Science concepts or terms include:* density, density of gases, floating, sinking.

**3.7 The Wicked Witch and Changes:** Referring to the Wizard of Oz, Kyle and Kailey discuss matter and chemical and physical changes.

*Science concepts or terms include:* chemical reaction, dissolving, fire, heat energy, liquid, melting, physical change, solid.

**3.8 Changing Changes:** Kyle and Kailey are discussing the differences between chemical and physical changes using examples they are familiar with.

*Science concepts or terms include:* boiling, chemical vs physical change, condensation, freezing, melting.

**3.9 Water Ya Know – A Play in One Act:** Sam and Kyle are sitting at an outdoor café overlooking the local river, drinking ice tea, and discussing who is the greatest superhero, when Zip decides to direct the conversation towards the importance of water and the properties that make it such a valuable molecule for living things.

*Science concepts or terms include:* properties of water, melting point, boiling point, Celsius scale, phases, specific heat, evaporation, temperature regulation, thermometer, transpiration, density, hydrogen bonding, polar molecule, crystalline structure, surface tension, cohesion.

## Unit 4 - Atoms, Atomic Models and The Periodic Table

**4.1 Shrewd Honesty:** Sam and Kailey are at a school picnic in the park reflecting on Kyle’s growing ability to think through ideas in science. They discuss how science springs from a desire to understand how things work and the need to explain the world around them.

*Science concepts or terms include:* biases, ideas in science, indirect evidence.

**4.2 Knowing:** Kailey and Sam wonder about what makes someone know that they know something and talk about how models work in science.

*Science concepts or terms include:* atomic models, atomic theory, confidence in scientific ideas.

**4.3 A Balancing Act:** Continuing the discussion about theories and models, Kailey and Sam think about how balance is critical with regard to chemical reactions and the structure of atoms.

*Science concepts or terms include:* atomic model, balanced charges, chemical reaction, compounds and molecules, electrons, theories in science.

**4.4 Think of a Banana:** Kyle and Sam continue with their discussion of atoms and reflect on how models of the atom have changed over time to better represent our understanding.

*Science concepts or terms include:* atomic models, atoms, Bohr Model, visual models.

**4.5 Bohr-ing:** Kyle and Sam discuss the Bohr model of the atom, balanced charges, atomic numbers, and movement of electrons around the nucleus of the atom, summed up by the Heisenberg Uncertainty Principle.

*Science concepts or terms include:* Bohr Model, charges, electron, mass number, neutron, periodic table, proton.

**4.6 Now There are Two:** Kyle and Sam use their understanding of the model of the atom to draw the electrons and protons for Hydrogen and Helium.

*Science concepts or terms include:* charges, electrons, neutrons, protons.

**4.7 The Second Level:** Expanding their understanding of the atom, Kyle and Sam continue with examining the protons and electrons of Lithium and in the process discuss energy levels, orbits and electronegativity values.

*Science concepts or terms include:* electronegativity, electrons, energy levels, orbits, protons, values.

**4.8 And So On:** Using their basic knowledge of electrons, protons and energy levels, Kyle and Sam continue with an indepth look at how the Periodic Table has been structured and the patterns that exist with the table.

*Science concepts or terms include:* periodic table patterns.

**4.9 It's All About the Patterns:** Kyle and Sam continue to discuss the Periodic Table and expand their understanding of how the Periodic Table was constructed according to the commonalities and differences between various atoms, and placing the atoms on the table in a manner that created visual patterns.

*Science concepts or terms include:* periodic table patterns, valnce electrons.

## Unit 5 - Atoms, Valence Electrons and Bonding, Chemical Reactions

**5.1 Magic:** Kailey rejoins Kyle and Sam for a discussion of how science is like magic unless you understand the workings of chemistry.

*Science concepts or terms include:* alchemists, atom, chemical reaction, how science works.

**5.2 Magic or Chemistry:** Somewhat twitter-patted, but mostly perplexed, Kyle talks to Sam about more of the patterns that exist within the periodic table, and how valence electrons, with gains or losses, affect the balance of the atom.

*Science concepts or terms include:* chemical reactions, gain and loss of electrons, ion, periodic table patterns, valance electrons.

**5.3 It's Definitely Not Magic:** Kyle and Sam use the valence electrons, energy levels, and balance to figure out why sodium and chlorine combine to form salt.

*Science concepts or terms include:* energy levels, chemical reactions, valence electrons.

**5.4 Lazy Electrons:** Kyle and Kailey discuss how gain and loss of electrons seems to work according to thermodynamics and efficient energy use regarding movement of electrons.

*Science concepts or terms include:* balanced reactions, electrons, energy, thermodynamics.

**5.5 Two Plus Six or Six Plus Two?:** Kyle and Kailey discuss valence electrons and how various elements in the same column on the periodic table have patterns of similar valence electrons.

*Science concepts or terms include:* element, periodic table patterns, valence electrons.

**5.6 Sharing is Caring:** Kyle and Kailey expand their understanding of how electrons bond by discussing sharing electrons by covalent bonding and some of the complexities involved in bonding.

*Science concepts or terms include:* electrons, covalent bonding, ionic bonding.

**5.7 Sharing is Caring (continued):** Kyle and Kailey continue their discussion of bonding and how the electronegativity values affect whether an atom gains or loses electrons.

*Science concepts or terms include:* bonding, covalent bond, electronegativity values, energy gain or loss, valence electrons.

**5.8 Sharing is Caring – Continued Again!:** Kyle and Kailey continue with an explanation of how electronegativity values help predict how elements will bond in a chemical reaction.

*Science concepts or terms include:* bonds, electronegativity values, elements.

**5.9 Balance:** Kyle and Kailey return to talking about the idea of balance when elements bond to form molecules.

*Science concepts or terms include:* balanced chemical reactions.

## Unit 6 - Chemical Equations, Reactions and Molecules

**6.1 The Bigger Picture:** Sam, Kyle and Kailey expand their knowledge of balancing charges in compounds to discussing balancing charges in chemical equations.

*Science concepts or terms include:* balanced charges in chemical equations.

**6.2 Back to the Bigger Picture:** Sam, Kyle and Kailey discuss the bigger picture of what it takes to balance the chemicals in a chemical equation.

*Science concepts or terms include:* balancing chemical equations, products and reactants.

**6.3 When Does 1 + 1 not equal 2?:** Sam, Kyle and Kailey continue their discussion of balancing equations.

*Science concepts or terms include:* balanced equations, products, reactants, valence electrons.

**6.4 It's Like Dating:** Sam, Kyle and Kailey discuss synthesis and decomposition reactions.

*Science concepts or terms include:* charges, decomposition reactions, ions, synthesis reactions.

**6.5 Breaking Up is Hard to Do:** Sam and Kyle chat about decomposition reactions and how activation energy levels, exothermic and endothermic factors affect reactions.

*Science concepts or terms include:* activation energy, decomposition reactions, endothermic, exothermic, molecules.

**6.6 The Love Triangle:** Sam, Kyle and Kailey discuss how single replacement reactions are similar to dating.

*Science concepts or terms include:* single replacement reactions.

**6.7 Swing Your Partner Round and Round:** Continuing to relate the familiar to the unknown, Sam, Kyle and Kailey talk about how square dancing is similar to double replacement reactions.

*Science concepts or terms include:* balanced equations, double replacement reactions.

**6.8 A Balancing Act:** Sam, Kyle and Kailey think and talk through how to balance the products in a double replacement reaction.

*Science concepts or terms include:* balanced equations, charges, double replacement reactions.

**6.9 Nature Leads:** Sam, Kyle and Kailey fine-tune their understanding of balancing equations by using coefficients to help balance both sides of the equation.

*Science concepts or terms include:* balancing equations, coefficients.

**6.10 One More Thing:** Looking at an exception to the rule, our three friends discuss how diatomic elements bond to form molecules.

*Science concepts or terms include:* covalent bonding, diatomic elements.

## Unit 7 - Acids and Bases

**7.1 Acids, Bases and Salts – Oh My!:** Kailey and Kyle are chomping on a burger and fries, washing it down with a soda, when Kyle wonders about the acidity of the soda. Kailey tutors Kyle on the key aspects of acids and pH.

*Science concepts or terms include:* acid, base, hydrogen ions, hydronium ions, pH scale, salt, strength of acids.

**7.2 Acids in Our Body and Beyond:** Kyle and Kailey continue to chat about acids, this time about how pH levels in the body are critical, and how acids in the environment do a great deal of damage.

*Science concepts or terms include:* acid mine drainage, acid rain, acids, bases, buffers, neutralize, pH, salts, strong versus weak acid, vehicle emissions.

**7.3 Bases:** In this conversation, Kailey and Kyle discuss characteristics of bases and how bases can neutralize acids.

*Science concepts or terms include:* acids, alkaline, bases, disassociation, hydronium ions, hydroxide ions, neutralize, pH.

## Unit 8 - Solutions, Suspensions and Colloids

**8.1 Solutions, Suspensions and Colloids:** Kailey and Kyle converse about the differences between solutions, suspensions and colloids, and also where they can be found in life.

*Science concepts or terms include:* colloids, dissolved, solute, solution, solvent, suspension.

## Unit 9 - Organic Chemistry

**9.1 Polymers:** Kailey and Sam are chatting about her car shopping episode. She tells Sam about the interaction with the car salesman who needed some help with understanding polymers and car bodies.

*Science concepts or terms include:* chain scission, covalent bonds, molecule, monomers, natural or synthetic, ozone, polymerization, polymers, tensile strength.

**9.2 VOC's Take Over the Library:** Kyle and Sam enter the library and are overpowered by the smell from the new carpet, which prompts a discussion about volatile organic compounds and toxicity.

*Science concepts or terms include:* boiling point, evaporate, pressure, sublimate, temperature, toxicity, vapor pressure, volatile organic compounds.

## Unit 10 - Chemistry in the World Around Us

**10.1 Catching More Mercury Than Fish:** Kyle and Sam are fishing while they discuss the effects of Mercury found in fish, on humans and the environment.

*Science concepts or terms include:* mercury poisoning, neurotransmitters, biomagnification.

**10.2 Sam and Kyle Run Out of Gas:** Sam and Kyle head out on another road trip, but soon discover that their gas mileage is not what they thought and they run out of gas. While being rescued by a truck driver named Kip, the discussion turns to alternative fuels for vehicles.

*Science concepts or terms include:* alternative fuels, ethanol, energy units, hybrid cars.

**10.3 Ban Chemicals Now!:** While walking around downtown one Saturday afternoon, Sam comes across her friend Kyle at a protest in the park. where people are shouting “Ban DHMO.”

*Science concepts or terms include:* scientific literacy.

## Unit 11 - The Last Chat

**11.1 The Big Ending (or maybe not):** Wrapping up their discussions of science topics, Sam, Kyle and Kailey reflect on how far Kyle has come in terms of understanding specific aspects of science, and how science actually works.

*Science concepts or terms include:* how science works.