Team Teaching Science

Success for *All* Learners

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NSTA press
National Science Teachers Association

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Contents

To our parents and teachers who taught us,
to our families who support us, and
to our students who inspire us.

About the Authors

Ed Linz has been teaching science and mathematics in Virginia public schools since 1985. He currently team teaches physics at West Springfield High School. Prior to teaching, Mr. Linz served in the U.S. submarine force for 20 years and was commanding officer of USS *Kamehameha*, a ballistic missile nuclear submarine. He holds degrees in mathematics from the U.S. Naval Academy, with an M.A. in economics from Christ Church College, Oxford University, and an M.Ed. in secondary education from George Mason University. He is the author of *Life Row* (1997), numerous professional articles, and a weekly opinion column. His hobbies include kayaking, cooking, and hiking.

Mary Jane Heater has been a substitute teacher, an instructional aide, and a special education teacher at West Springfield High School since 2001. Prior to teaching, Mrs. Heater was an independent contractor with the U.S. government for 13 years. She earned a B.S. in speech from The College of Wooster (1977) and a master's in education from the University of Virginia (2003). She is the author of an article that was the basis for this book and has lectured about team teaching at national education conventions and local universities. Her hobbies include fluting and reading, as well as summer activities at the Jersey shore (boating, swimming, biking, and hiking).

Lori A. Howard, Ph.D., earned a master's degree in educational audiology from the University of Northern Colorado. She began her career in special education working with deaf and hearing-impaired students. Subsequently, she earned a doctoral degree in educational psychology from the University of Virginia. She has taught special education courses related to collaboration and instruction, teaming, consultation, and IEP development in the special education program at the Northern Virginia Campus of the University of Virginia. She has also taught special education curriculum and methods courses at George Mason University in Fairfax, VA. She is the co-author of *The Effective Special Education Teacher: A Practical Guide for Success*. Most recently, she has co-written, with Elizabeth Potts, the book *How to Co-Teach: A Guide for General and Special Educators* and an article titled "Using Co-Planning Time: Strategies for a Successful Co-Teaching Marriage." In her downtime, she enjoys playing with her rowdy golden retriever, MacDuff.

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Introduction

It is the supreme art of the teacher to
awaken joy in creative expression and knowledge.

–Albert Einstein

Recently, an increasing number of teachers are receiving assignments to team teach science classes. This trend has developed due to a variety of factors, often external, but the result is that a science teacher and a special education teacher may find themselves in the same classroom team teaching an apparently disparate set of students. The classroom may be elementary, middle school, or high school, but the challenge is constant: how to mold an effective team to maximize student learning. The typical team taught science classroom can, in practice, not be classified as "typical" because the mix of students may include differing proportions of general education students, English speakers of other languages (ESOL), students with disabilities or special needs, and even Advanced Placement (AP) or International Baccalaureate (IB) students—each with dramatically different backgrounds and learning needs.

These team-taught "inclusion" classes pose new challenges for both the science and the special education teacher. Each has had unique training, classroom experiences, and educational backgrounds that have the potential to create a positive learning environment for all students in the class. However, these same factors can also generate a difficult teaching relationship that can adversely affect instruction and learning.

The purpose of this book is to address the concerns of both teachers while providing guidance for successful instruction in science. Science is a discipline with specialized vocabulary, laboratory methodology and accompanying safety concerns, and integration of knowledge learned in other disciplines (e.g., mathematics). These concerns can be overwhelming for an individual teacher, even without the accompanying issues that can arise when two teachers must work together to ensure instruction for every learner in the classroom.

Often special education teachers receive some education in the area of team teaching; however, it may be a theoretical approach without addressing specific content areas. General education teachers in science are often well-versed in the content of science, while having received little or no education in the area of team teaching and, all too frequently, minimum exposure to the practical and legal requirements of special education. Obviously, combining poor or limited content area knowledge with little knowledge or experience in methods relating to team teaching does not ensure success for either teacher in a co-taught or teamed science class.

There is also the issue of relationship "basics." Who does what in the teamed classroom? How often do we communicate to each other about our teaching? Who does the planning? Who is going to set up the labs? Who is going to make sure the tests are graded? How do we make sure that we are working together for all of the students? And timing is often a factor. Because many team-teaching assignments are made at the beginning of the school year, there may be little time to establish a relationship before the school year starts. The result is that both teachers bring their own perspectives to the team with insufficient time for dialogue to establish parameters, resolve differences, and understand the other's teaching philosophy. Obviously, these issues affect team teaching in every discipline, but because of the unique content of most science courses, the results can be particularly worrisome.

Despite this rather dismal portrayal of potential co-teaching teams, there is the possibility of creating something more than "the sum of the parts" when two teachers commit to teaching science together. Once the teachers have established a sense of trust and risk-taking with each other, the possibility exists that both teachers can approach instruction in creative ways to engage each of their students in learning science. First, there is the obvious benefit: When there are two teachers in a classroom, the student-to-teacher ratio is reduced. Simply, there are two teachers to manage the students, provide different instructional strategies, clarify misunderstandings, and encourage more participation by the students. Taking attendance and grading can be shared between the teachers, which may help reduce the administrative duties of each teacher and allow more time for lesson planning or creating materials to use. It is our belief that there is much more to be gained from team teaching science if a specific approach is used.

This book evolved from the experiences of a pair of team teachers assigned to teach an entry-level physics class to a mix of general education and special education students. Both teachers previously had less-than-optimal team teaching experiences, but this new team created a dynamic relationship that has achieved academic gains for both general education and special education students. Each teacher is a vital member of this team. Both bring their own experiences and educations regarding how the students are taught. The science teacher uses examples and demonstrations to convey principles of physics. The special education teacher (who admits to having known little about science before teaching physics) provides different instructional strategies to support the learning of all of the students. By the end of the third year of team teaching together, it would be difficult for an outside observer to determine which team member is the science teacher and which member is the special education teacher. It has become a fluid, seamless, and highly effective team. These experiences were originally discussed in a 2008 *CECPlus* journal article, "Team Teaching High School Science: Game Plan for Success," by the authors, and has now been expanded in this book to include all science disciplines at all levels, K–12.

Their co-taught classroom is a fun, engaging, and challenging learning place. While there is much laughter, students are working on problems, following instructions for lab experiments, reviewing material, and answering questions asked by the teachers. Both teachers move around the classroom and know every student (not just the ones studying their particular subjects). Students are challenged to remember the formulas for "word problems" (e.g., distance, speed, and time) or to explain a physics principle (e.g., buoyancy).

There is a focus on teaching science; however, there is also the art component (discussed by Einstein) that addresses how the relationship between the teachers evolves to support the learning. The art component allows for a symbiotic relationship in which the two teachers assess their individual strengths and weaknesses to produce an end result which maximizes learning. Both teachers "feed" off the creative energy of the other thus creating better instruction by using an approach in the classroom that engages students while challenging them to achieve a better understanding of science. It is the contention of the authors that these results can be achieved by other team teachers in science.

Throughout this book, the co-teaching "team" uses the metaphor of creating a game plan to describe the important tasks that must be accomplished throughout the school year. (School systems often use different terminology for inclusive classes with two teachers; some call the classes *team taught*, while others prefer the term *co-taught*. In this book, we use *team teach* and *co-teach* interchangeably—the terminology is not nearly as important as the results.) Preseason planning is accomplished prior to school starting, in-season tasks are accomplished on a daily or weekly basis, and a postseason follow-up allows time for processing what worked well and what might be changed in the future. While this sports-season metaphor hints at the "fun" nature of the relationship, the tasks are accomplished in a planned and effective manner (Linz, Heater, and Howard 2008).

Most important, the art of teaching science is vital to any science co-teaching team. This book provides both strategies for effective science teaching and strategies to help co-teaching teams work together. There will be a combination of solid, research-based practices and personal insights from the team teachers who make it work. Chapters 2–4 provide general background information on teaching science and team teaching. Chapters 5–11 give information about each specific science subject and how it is addressed, and *how* a science co-teaching team proceeds through a typical school year.

Although it may not be possible for every science co-teaching team to achieve immediate results, we are confident that the information provided in this book offers useful techniques that can assist in developing a highly effective team. Of equal importance, the success you can achieve while team teaching science will provide considerable personal satisfaction for both team teachers while improving learning opportunities for their students. It truly can be a win-win situation.

Reference

Linz, E. R., M. J. Heater, and L. Howard. 2008. Team teaching high school science: Game plan for success. *TEACHING Exceptional Children Plus* 5 (2): 22–30.

Chapter 7
Team Teaching Science at the High School Level

Introduction

The focus of this chapter is the specific challenges of team teaching each individual discipline in the typical high school or secondary school. Although science curricula vary not only from state to state, but even district to district, there is general uniformity in the courses that are offered in grades 9–12 in the United States. The order in which the courses are offered may vary, but most schools teach biology, chemistry, physics, and Earth science (now sometimes taught as a course called Geosystems) at some time during a student's high school years. Typically, biology or Earth science is taught first, with chemistry or physics taught last. This order is not standard; in some states, such as California, an introductory physics course is the first science class for students entering high school. A smaller number of school jurisdictions prefer a mixed science curriculum, during which students have blocks of one of the sciences lasting several weeks, followed by another in a different science, and so on, for each year for every year of high school.

Our purpose in this chapter is not to advocate one form of course progression over another, but to provide information to co-teachers when they are teaching a particular discipline. We will address the specific challenges of each discipline and provide strategies for success in that area. In addition to the four most common courses (biology, chemistry, Earth science, and physics), we will discuss other content areas, such as astronomy, oceanography, and anatomy, which are often offered as electives but which may include a population of special education students.

The existing national standards for high school science were produced by the National Research Council (NRC) in 1995 and were published in 1996 under the very apt title *National Science Education Standards*. As of fall 2010, these standards were in the process of being revised. Among the six standards of science education outlined, are the standards for teaching, assessment, and content. The content standards outline what students should know, understand, and be able to do.

Within the content standards, there are eight categories. None refer to the names of the courses taught by subject material in most high schools, such as biology or physics, by name. There are five generic categories and three specific areas:

1. Unifying concepts and processes in science
2. Science as inquiry
3. Science and technology
4. Science in personal and social perspectives
5. History and nature of science
6. Physical science
7. Life science
8. Earth and space science

The content of each science course taught in the typical American high school should draw from these eight categories. Some, such as biology, obviously will contain content focusing more on standards from life science than Earth and space science, while others, such as physics, may contain standards from each of the eight categories. Regardless of the content, what appears to be a common finding is that hands-on activities in all science disciplines, particularly those with special education students, are "greatly favored over textbook activities by students who have experienced both. Students generally considered the activities more facilitative of learning, more motivating and more enjoyable than the more traditional textbook activities" (Scruggs et al. 1993, p. 10).

In each discipline, it is critical for lesson plans to be prepared based on national, state, and local standards and to show which co-teacher will take the lead in teaching each part of the lesson. The specific format of the lesson plan is not as critical as the content. Appendix A contains one useful co-taught lesson plan template. Another format showing a typical high school team-taught lesson plan is shown in Figure 7.1. There will be numerous instances during lessons, of course, when situations emerge that have not been anticipated in the lesson plan. In such cases, both teachers must adjust on the fly to maximize instruction. An example of the ongoing dynamic between the science teacher and the special education teacher in such a situation during a team-taught high school lab is depicted in the A Classroom Scenario sidebar (p. 84).

We will now discuss each of the main science disciplines (biology, chemistry, Earth science, and physics) that are team taught in most high schools. For each discipline, we will discuss general background information, standards and curriculum requirements, strategies for success, safety concerns, field trip information, and teacher perspectives. Because co-teachers in each science discipline may have occasion to plan field trips, please see Figure 7.2 (p. 85) for a checklist to use when planning a field trip for a combined science class.

Figure 7.1. Sample High School Co-teaching Lesson Plan

Note: **SPT** = Special Education Teacher, **ST** = Science Teacher

Title: Introduction to Energy

Textbook: *Conceptual Physics*, 3rd ed. Hewitt, Chapter 8

Applicable Standards

- National: Science content standard 9-12 B (Conservation of Energy)
- State (examples from two states): PS. 6 (Virginia); 9-10 E and F (Ohio)

Learning Objectives: At the end of this lesson, students will be able to

- define work, energy, and power and state units of each;
- solve problems involving potential energy, kinetic energy, and power (using P.I.E.S.); and
- be able to discuss alternative forms of energy production and pros and cons of each.

Instructional Sequence

Warm-up (SPT): Ask students to write down what they think "work" is and what they think "energy" is. Give students two to four minutes to do this as both teachers circulate around the room. Have students provide responses, which SPT writes on blackboard under each heading.

Discussion (ST): Discuss student responses and then call on student(s) to take turns reading aloud introductory remarks on page 103, paying particular emphasis to energy's centrality to human life and the difficulty of precisely defining energy.

Definitions of work and power and units of each (ST): Textbook (pp. 103–105). Have students write definitions and equations in notebooks. Explain historical basis of units (Joules and Watts). *Note:* SPT should circulate to assist students while they are taking notes. Discuss similarities and differences between student responses during warm-up and textbook.

Word problem practice using P.I.E.S. (**ST** puts problem on blackboard; **SPT** leads students through solution using P.I.E.S.): Do two problems each for work and power, using $W = Fd$ and $P = W/t$. Both teachers circulate to observe and assist students while doing problems. Ensure P.I.E.S. format is followed and that student work is neat and understandable.

Energy discussion (both): Have students list as many different forms of energy as they can think of (e.g., solar, wind, nuclear, electrical). They should be able to come up with at least 12, with prompting. Both teachers should provide prompting as necessary. Ask for student responses and SPT can list them on the blackboard. ST can lead a discussion of the pros and cons of each form of energy listed. Have students read section 8.3 concerning mechanical energy and its relationship to potential and kinetic energy.

Wrap-up and homework assignment (ST): Review concepts of work and energy and associated equations and different types of energy. Discuss (but do not assign) future project involving investigating different methods to produce energy. SPT can put homework assignments on Blackboard (p. 119, RQ 1–6; p. 120, P & C 1–3) and remind students that all homework assignments can be found on Blackboard and class website.

A Classroom Scenario

During a science lab involving metric measurements, the special education teacher noticed that many of the students were having difficulty coming up with correct answers in their calculations. Upon investigation, she noticed that most of the students understood the science concepts which had been presented by her co-teacher but were having problems understanding how to convert between different metric units—in this case, how to change measurements in centimeters (cm) to meters (m) (The lab calculations required that the distance measurements be in meters.) Knowing that many students (both special education and general) struggle with metric conversions and that students tend to understand things better when there is a visual representation, she brought a meterstick, a dollar bill, a dime, and a penny for individual instruction with each group, while her co-teacher was monitoring progress of other students and safety for the entire lab. Her plan was to use money, another 10-based system that essentially all high school students understand, to explain the 10-based system (metric) that was confusing them.

Using the coins and the dollar bill, she went over the relationships between pennies, dimes, and dollars by quizzing them on how many pennies are in a dime, how many dimes are in a dollar, and how many pennies are in a dollar. Most students quickly understood these relationships. So, she went on, if given 83 pennies, that would be 83 cents. If we want to write this amount as a portion of a dollar (which is 100 pennies), the decimal point simply moves two places to the left, becoming 83 cents ($0.83), just as if 83 were divided by 100.

Then she took the meterstick and showed that like the dollar, it is broken down into 10 decimeters (relating deci to dime) and also into 100 centimeters (pointing out the word *cent*), just like the dimes and cents of a dollar. She explained that conversions here worked the same as with money. To convert from **cent**imeters to meters was the same as converting **cent**s to dollars; that is, the decimal point will again move two places to the left (83 cm becomes 0.83 m). To reinforce this, she also had the students use their calculators to divide the number of centimeters by 100, again obtaining the result 0.83 m, the same as moving the decimal point two places to the left. To summarize this “mini-lesson,” the special education teacher gave each group five sets of data in centimeters to convert to meters and watched to ensure that they made the correct conversion. Considerable improvement was noted on both the lab results and on subsequent testing on metric units.

Figure 7.2. Field Trip Checklist

1. Does the date work with the school calendar?
2. Have you obtained, and from whom, approval for the trip?
3. Is the destination appropriate for learning?
4. How many students can the trip accommodate?
5. What kind of transportation will be used?
6. What forms and documents do you need the students and parents fill out?
   - Emergency care cards with contact numbers
   - Parent or guardian permission forms
   - Insurance verification for drivers
   - Releases from other teachers
   - Any other local forms
7. How many chaperones do you need?
8. Is there funding or will the students pay?
9. Will students need spending money?
10. Will you need to find a place for lunch, or can the students bring bag lunches?
11. What first aid supplies and student medications will you need to take?
12. What is the appropriate attire?
13. Do you have a written agenda?
    - What will be happening during the day?
    - Do you need to plan meeting places to convene at intervals during the day?
    - Where will you meet the students at the end of the day?
14. Do you need extra supplies?
    - Sunscreen
    - Bug repellant
15. Do you have contingency plans?
    - Weather (Do students need to bring appropriate outerwear?)
    - Do we cancel field trip in the event of bad weather (rain or snow)?
16. Do you have a procedure to collect appropriate receipts or documentation?
17. Have you made arrangements to ensure that all students will be met by parents at the end of field trip, if the return is after school hours?

Biology

Background

Biology often is the first science laboratory course for high school students. Because of this alone, it is often challenging for both the general education student and the student with special needs. There are many vocabulary words that are difficult to pronounce (much less spell correctly), concepts that are complex, and a scope of material that is vast. For many students, it is the first introduction to laboratory work involving greater detail than in middle school, both in terms of complexity and reporting requirements. Biology is also, for many students, the first high school science course for which there is high-stakes, end-of-year testing, which brings considerable pressure both to the student and the co-teachers.

Most inclusive biology classes contain predominately 9th- and 10th-grade students. In addition to a general unfamiliarity with the increased demands of high school, there are also inherent immaturity issues for biology teachers to overcome.

Standards and Curriculum

The 1996 *National Science Education Standards* (under revision as of fall 2010) contain all applicable content standards for biology. Most of the standards for biology can be located in the Life Science section. High school students are expected to gain an understanding of the cell; the molecular basis of heredity; biological evolution; interdependence of organisms; matter, energy, and organization in living systems; and behavior of organisms. Other topics applicable to biology can be found under many of the other seven categories of science standards, such as Science in Personal and Social Perspectives and History and Nature of Science.

The general education teacher is primarily responsible for ensuring that the content of the course meets not only national standards, but also all local and state requirements. Because biology is almost always a subject for high-stakes end-of-year testing, it is particularly important for the curriculum to have all appropriate content to prepare students to successfully complete these examinations. In this regard, the special education teacher must also be fully aware of which topics are covered on such exams, and even what percentage of questions typically come from each content area. If, for example, 25% of the questions on the state exam are related to topics associated with an understanding of the scientific method, then it is essential to ensure that this area receives an appropriate level of instruction and review.

Specific Challenges

Perhaps the greatest challenge for the co-taught biology class is vocabulary. Some science textbooks contain more new vocabulary words than are recommended for comparable foreign language textbooks (Scruggs and Mastropieri 2007). This is particularly true in biology, where many of the most difficult words encountered by students are associated with the study of the cell. The names for the organelles are difficult to pronounce and next to impossible for most students to spell correctly. Words such as *mitochondria*, *ribosome*, *centriole*, and *vacuole* are just some of the challenging terms the biology student must master when studying cell structure. Other areas within the course have similar challenges. In heredity, for example, terms such as *genotype, phenotype*, *dominant, recessive*, *homozygous,* and *heterozygous* confuse the majority of students. When studying biological classification, the words *phylum*, *genus*, *prokaryote*, and *eukaryote* are just some of the challenges for all students but particularly, in many cases, for students with special needs.

Another routine challenge for biology students is the array of difficult concepts for students to grasp. Natural selection is one topic that seems to pose difficulty for many students. Other areas of confusion involve distinguishing between and understanding similar words, such as *mitosis* and *meiosis*.

Although most students have been exposed to and used microscopes in elementary and middle school courses, the proper usage of this equipment always seems to be an area requiring emphasis by biology co-teachers. Because most biology courses involve the use of microscopes early in the curriculum, co-teachers must teach proper techniques for the equipment. They should also cover general lab safety procedures to students who may not have been exposed to this level of complexity in earlier studies.

One problem area for some students with poor reading skills can be the biology textbook itself. It is important to determine what reading level is associated with the textbook being used, and then to identify which students may have difficulty with that level. It may be useful to have alternative textbooks targeted for lower-grade-level reading skills in the classroom to assist those students who are experiencing difficulty with the textbook in use. Because many students with language deficiencies are placed in co-taught classes, reading comprehension may become an area requiring major focus by both co-teachers.

Strategies for Success

Because vocabulary issues are such a challenge for biology students, co-teachers should use a variety of approaches to assist them. All of the traditional techniques (e.g., crossword puzzles, hangman games, fill-in-the-blank and matching exercises) should be considered for use. Repetition, repetition, repetition! Wetzel (2009) recommends the use of a variety of strategies and techniques, such as students creating their own flashcards or concept maps for learning science definitions. Many biology co-teaching teams use graphic organizers throughout the course to assist students with vocabulary problems.

When teaching cell replication and reproduction, some teachers have found it useful to teach mitosis first for students to learn the names of the phases (interphase, prophase, metaphase, anaphase, telophase, and cytokinesis) by using mnemonics. Students can use some of the stock mnemonics for these terms (e.g., "I Prefer Many Apples to Cantaloupes"), but we have found that the mnemonics that students remember best are those which they make up as a class or in a group. This exercise can become a student favorite by having groups of students vie to form the best, or most original, mnemonic. The use of mnemonic strategies to improve vocabulary has been shown in numerous (13) studies to be "extremely effective in promoting memory for science content" (Scruggs and Mastropieri 2007, p. 61).

A technique, or activity, for students to learn about what actually happens in each phase of mitosis is to use two different colors of pipe cleaners cut in different lengths to represent chromosomes. Have the students manipulate the pipe cleaners to show each phase of mitosis. Understanding mitosis and meiosis is often extremely confusing to students, if only because the words are so similar. One useful technique for assisting differentiation is to point out the "t" in mitosis, which can be equated to the number "two." In mitosis, there is a splitting of the cell, making two cells, whereas in meiosis the outcome will be four cells. See Figure 7.3 for an example of how to structure this activity.

Obviously, there are tricks and learning games that can be applicable to each topic in biology. What is important is that both teachers actively search for techniques that work best for students in their classes. The best resource for finding such tricks are other biology teachers, both in the same school and those met at district training sessions and national conferences. There is also now a wealth of online resources, such as QUIA, that can be accessed to assist students in learning biology terms.

Because biology students typically have little high school lab experience, we recommend conducting a lab early in the course. Students often have difficulty understanding the rigor of labs involving independent and dependent variables. They must learn how to collect data, analyze that data, and create a meaningful document reporting their findings. Because of these deficiencies, co-teachers should conduct initial labs in a slow and controlled manner, with considerable assistance from both teachers during the lab. We recommend that the first lab report be prepared in small groups during class periods so that both teachers can monitor progress and correct problems. It is also helpful for all students, but particularly many students with special needs, to have these first labs broken into components that directly correspond to specific sections of the associated lab report. Then students can complete each section as the lab progresses. McCann (1998, p. 3) discusses how labs may need to be modified: "As with lesson content, students

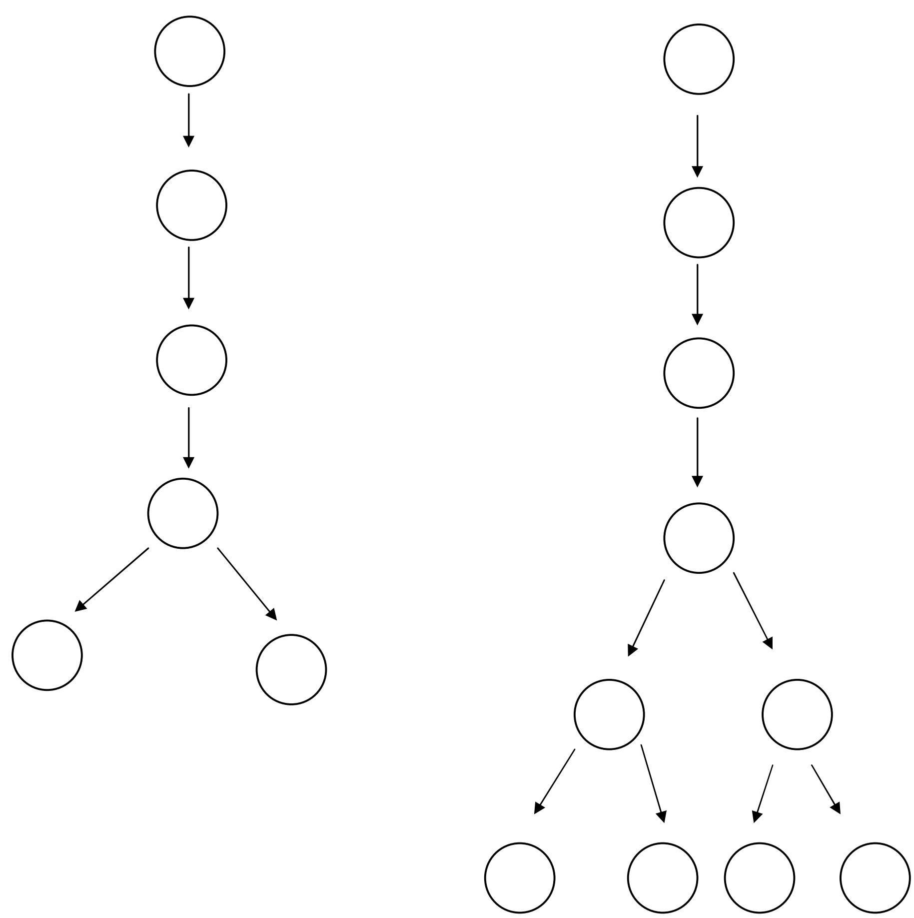
Figure 7.3. Mitosis Versus Meiosis

Supplies

- Newsprint
- Pipe cleaners in two colors (cut in two different lengths)
- Circular object that can be traced (plastic cups from a fast food restaurant will work)
- Marker

Instructions

Draw the following circle-and-arrow patterns on the newsprint by tracing the cups.



with learning disabilities may require more organized information given in smaller increments." Some biology co-teachers have found the use of a detailed template (see Figure 7.4) for lab reports to be extremely helpful in easing student anxiety because it allows the student to obtain immediate feedback from the teachers as the lab progresses. When students become more comfortable and proficient in doing high school labs, then a greater amount of independence in writing the reports can be the norm.

When teaching difficult concepts, such as natural selection, it is often helpful to incorporate hands-on activities to illustrate the ideas. One traditional activity is to use alphabet pasta or colored candies in which a designated group of each particular "generation," such as the vowels or the blue and yellow candies, is removed. After 25 repetitions, the makeup of the last generation is compared to those selected from the first generation to see that the "trait" that is being systematically eliminated in each generation has essentially died out after 25 generations.

When conducting labs, it is important for the biology teacher and the special education teacher to carefully analyze the strengths and weaknesses of each student in the class so that appropriate partner assignments can be made. Although this process is applicable to any science lab setting, it is particularly important in biology, where the lack of any experience in high school labs is likely. Students who have specific disabilities should be paired with other students who can assist, at least for the first several labs.

Safety Concerns

Biology classes do not typically pose the same level of safety issues as in some of the other science classes, such as chemistry. However, because this course may be the first high school laboratory science class for many of the students, it is mandatory to carefully review generic lab safety practices prior to the first lab session. The primary concerns in biology are broken glass and dropping expensive equipment. If dissections are being performed later in the course, additional instruction must be conducted prior to the use of scalpels. During labs, both co-teachers must be circulating to ensure that students are actually following both proper safety procedures and the appropriate steps of the lab itself.

Field Trips

Taking biology students outside the building can be an extremely useful learning experience, if only because of the obvious opportunities to observe biology in action. Extended field trips to specific learning opportunities, such as nature centers or national forests, can generate even more student interest and involvement. When taking any field trip, it is essential that both co-teachers plan responsibilities prior to departure and have what amounts to a cogent lesson plan for the activity. If a few students in the class have IEPs requiring close supervision or additional

Figure 7.4. Lab Report Template

TITLE: ____

By
(your name)

With
(partners' names, spelled correctly)

PURPOSE: (can be cut and pasted from the lab instruction sheet, or use your own words)

METHOD: (In your words, how did you get your data? Provide detail and include sketches if appropriate)

DATA:

Smooth Data (needs to be in the same units)

Trial	Dependent Variable	Independent Variable

(include drawing or sketches if appropriate)

ANALYSIS: (may include one or more graphs) (Examine results and report significant information.)

ERROR ANALYSIS: (Include at least three sources of error that are unavoidable, and what you can do to minimize these.)

CONCLUSION: (Explain your results and why you came to this conclusion.)

COMMENTS: (Suggest improvements and adaptations.)

services, it may be advisable to enlist parent volunteers to assist supervising the class, while at least one of the co-teachers supervise those with special needs.

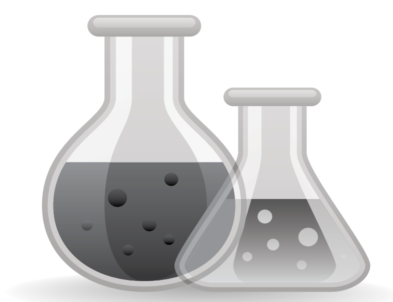
Teacher Perspective

There are few math deficiencies that will hold back biology students. Most are taking algebra or geometry concurrently with biology, and there are few calculations throughout the course. For this reason, the special education teacher, who may feel weaker in mathematics, may find biology to be a rewarding course to co-teach in science.

The fact that many students may be taking biology as their first science course can generate challenges for co-teachers, if only because there is little student understanding of the increased rigor and expectations associated with a high school laboratory science class. However, this challenge can also result in considerable reward for the co-teachers because of the opportunity to shape student lab performance for all subsequent science courses.

If the course will include dissection of animals, it is important for both teachers to be comfortable with this task and to come to philosophical agreement prior to the syllabus being distributed. Specifically, if the special education teacher is opposed to the use of animals in lab settings, an alternative approach, such as virtual dissections, needs to be discussed.

The special education teacher must also become expert in microscope terminology and use prior to classes that involve its use. This experience can be obtained only by actually sitting down with the general education teacher to learn step-by-step procedures, followed by considerable practice.



Chemistry

Background

Chemistry is one of the sciences that is taught in nearly every American high school. Although many school systems continue to teach chemistry as an 11th-grade subject, many others have shifted to a sequence in which 10th-grade students take chemistry following a year of biology. For teachers with an inclusive class of students, the grade levels often include students in grades 10–12. No matter what grade levels are involved, chemistry often poses a difficult challenge for all students, but particularly those with special needs. The challenge involves several areas of learning throughout the course, but often can be traced to student deficiencies in applied mathematics. For this reason, many school districts have successful completion of Algebra I as a prerequisite for taking chemistry. Other students struggle in chemistry simply because the subject requires a level of cognitive thinking which may not yet have been attained.

Chemistry is also a course that is frequently subject to state-mandated high-stakes testing at the end of the school year. This requirement poses a challenge for both the science teacher and the special education teacher in a chemistry class due to the broad scope of topics covered and the detailed understanding required of students to pass such an examination in such a complex course.

Most textbooks used in a standard chemistry class proceed in a predictable manner beginning with matter, atomic structure, and the periodic table through bonding, chemical reactions, states of matter, acids and bases and salts, oxidation-reduction reactions, and electro and nuclear chemistry. It is indeed a broad, and challenging, task to cover this amount of material for any group of students. Some school districts offer a course in consumer or applied chemistry, which often is team taught as an alternative to the standard chemistry class. Although the material covered is less both in terms of mathematics requirements and the scope of topics, the students may still be subject to the same end-of-year state testing.

Chemistry is primarily a laboratory science. In fact, many would argue that the laboratory component of the course should be the major focus of learning in chemistry. This aspect of the course poses its own set of challenges for co-teachers, if only because of the extremely important safety concerns that must be emphasized and closely monitored in the lab setting. Students (and teachers) have been seriously injured during chemistry labs. It is critical for both co-teachers to be continuously aware of safety requirements and to continuously monitor the actions of each group of students to minimize risk.

Standards and Curriculum

The existing science standards for chemistry are contained primarily in the Physical Science category of the national standards, though several other of the generic standards (e.g., Unifying Concepts and Processes in Science) are also applicable. As with each of the science disciplines, the suggested focus is on learning through inquiry. Chemistry laboratory experiences are obviously a setting in which the inquiry process can flourish. Both the science teacher and the special education teacher should become experts in guiding this inquiry process in the inclusive classroom. Specific details of the chemistry curriculum, based on the national standards, have been mandated by state and local school systems. It is usually the responsibility of the content teacher to ensure that the requirements outlined in these documents are being covered in the chemistry course being taught.

Specific Challenges

Many co-taught chemistry classes struggle when facing the use of mathematics. For some students, this is the first time in which abstract concepts, such as solving simple equations, must be translated to real-life scenarios. For example, many chemistry students have great difficulty solving general gas law problems ($P_1V_1/T_1 = P_2V_2/T_2$) when the unknown variable is in the denominator. There are also math-related challenges for students attempting to find the slope of graphed data, even in relatively simple linear situations, such as when obtaining a value of density from a graph plotting mass versus volume. Other students have math-related difficulties when trying to use dimensional analysis to change units from milligrams (mg) to kilograms (kg) or, even more challenging, from ounces (oz.) to milligrams (mg). Students who may have reached a comfort level in beginning algebra classes often struggle when faced with similar problems the following year in chemistry.

Another math-related area of emphasis in high school chemistry courses is scientific notation. Because large and small numbers are common when working with chemical quantities, students must quickly become comfortable doing all mathematical operations with numbers in scientific notation, such as 8×10^{-6}. These numbers are no longer an abstract exercise, but rather the only method practical for solving many chemistry problems. When the topic of pH is broached, many chemistry students are very weak in logarithmic operations, and remedial instruction must take place in the chemistry classroom. Because of the heavy mathematics component in a first-year chemistry course, co-teachers may find themselves providing considerable support in mathematics to students throughout the course.

The special education teacher working in a co-taught chemistry classroom must be proficient in each of these mathematical operations. If the special education teacher does not have this expertise when assigned to teach chemistry, it is imperative to master this simple level of mathematics as quickly as possible. This is a situation in which there must be total candor, and cooperation, between co-teachers to reinforce this skill set so that both teachers are sufficiently proficient to teach the required math skills to every student in the class.

There are also vocabulary issues when teaching chemistry. Although the number of new words are not as frequent as in biology, there are many terms (e.g., *condensation* or *salt*) that students may have heard, but may not understand the meaning in chemistry. Other words, such as *moles*, are particularly confusing for many students because the definition is very technical.

For many students, the chemistry course is their first introduction to the concept of significant figures (or significant digits). Many students have become very comfortable in the early years of their education entering numbers into a calculator, performing the operation, and then simply recording the answer with no concern about the correct number of decimal places. For such students, the chemistry course is a harsh introduction to the importance of correct precision based on how a measurement has been obtained. This is another area in which the special education teacher may not initially have expertise.

The greatest challenge, by far, for teaching a chemistry course is safety, both for the students and for the teachers. Many school systems require that an entire week be devoted to safety concerns in the initial weeks of the course, that a safety agreement be signed by each student (and parents), and that a safety quiz be successfully completed prior to that student being allowed to participate in lab activities. The frequent use of heat, the presence of dangerous chemicals, the threat of broken glass, the use of corrosive acids, the presence of fumes—each of these pose very real threats to the safety of everyone in a chemistry classroom. Not only must both co-teachers be constantly vigilant during any lab activity, but they must also lead by example when conducting lab exercises.

Strategies for Success

Although having a solid grasp of basic mathematics is important for success in chemistry, some teachers have found it useful to begin the school year with activities and labs that do not require the use of mathematics to build on the innate excitement of many students to do "fun stuff in white coats" (Penick 1995). Consider beginning the school year with several "cool" labs to build student interest and enthusiasm for the subject. There will be plenty of time to blend in the math as the school year progresses. One of our colleagues who co-teaches a chemistry class delays covering the first chapter of the text (which is heavy on math) in favor of the following chapter on physical and chemical changes. She conducts a lab using a mixture of calcium chloride (CaCl) and baking soda in a zipped plastic bag. When the students pour in a test tube of phenol red, the color changes to yellow. Students then exhale their breath into another bag before pouring phenol red into it. When that color also turns yellow, there is also an "Aha!" or "Wow!" moment as the students realize that the same carbon dioxide (CO_2) from their exhaled breath is probably the gas being created by the CaCl–baking soda mixture. She also likes to have the students test the pH of as many household chemicals as possible during these first weeks of school. Then she returns to the math chapter.

Because safety concerns are so paramount in the chemistry classroom, it is extremely important for both the general education teacher and the special education teacher not only to be experts on the correct procedures and safety precautions that must be followed, but also to be very comfortable in taking immediate corrective action if an accident does occur. For example, we recommend that both teachers actually use the eyewash station themselves prior to teaching a chemistry class. There should be a detailed and lengthy discussion between co-teachers prior to each lab to go over exactly what to expect during the lab, as well as what to do and who will do it if an accident takes place. If a student has, for example, a known deficit in motor skills, it may be appropriate to assign that student specific tasks in a team so that the danger of dropping a beaker or pouring acid onto the table or onto a hand is minimized. This is a situation where detailed knowledge of a student's IEP is particularly useful. It is also important to establish lab teams that group students according to known skill strengths and weaknesses. We have found it productive to assign lab partners for most labs in co-taught classes, rather than allowing students to self-select. The most comprehensive safety information for chemistry teachers can be found in *Safe Lab: School Chemistry Laboratory Safety Guide*, jointly published by the U.S. Consumer Product Safety Commission (CPSC), the National Institute for Occupational Safety and Health (NIOSH), and the Centers for Disease Control and Prevention (CDC). This must-read document was updated in 2006 and is available online from the CDC.

Outside of safety considerations, perhaps the main focus of both teachers in the co-taught chemistry classroom is to develop approaches that help students learn bewildering (to them) material. This often can be accomplished by using analogies, such as thinking of how a snowman is built upward with sections of spheres of snow with decreasing size and diameters. This analogy is then used to describe how elements on the periodic chart actually contract in size as one proceeds from the left to the right. Just as the order of the magnitude of the snowman spheres decreases if the snowman is pushed over, the elements show the same size relationship if the student imagines the snowman having been pushed over. Other chemistry teachers have students cut and paste the periodic table into a more intuitive shape, which helps them better understand the relationships between elements.

Many teachers have found graphic organizers to be of considerable assistance for students to learn chemistry vocabulary. When using graphic organizers during chemistry laboratory exercises, for example, some teachers have found the technique of pairing new words, such as *phosphates*, with actual lab activities involving those chemicals to be useful.

Safety Concerns

Although we have previously identified safety as one of the primary concerns for both co-teachers in a chemistry classroom, it is worth reiterating how important this area of concern should be throughout the course. Most teachers spend considerable time stressing safety at the beginning of the course, but there also needs to be constant vigilance on the part of both teachers whenever potentially dangerous labs or demonstrations are being conducted. Analysis of occupational injury reports from all disciplines reinforces the necessity of initial safety training and reinforcement. Within the workplace, there is a higher incidence of injury during the worker's initial phase of employment, followed by a decrease with experience until a new task is assigned (Roy 2010). The same trend takes place in the student lab. Our recommendation is to stop all activities at least once every quarter and reteach safety fundamentals.

We have seen a situation in which one high school chemistry student dared another to sip a liquid while the teacher was working with another set of lab partners. Unfortunately, the student accepted the challenge, with the result that emergency services had to be called. One of the advantages of having two teachers in the chemistry classroom is that one teacher can always be available to provide another set of eyes to scan for potentially dangerous situations. Even if every precaution is followed, there will probably still be the occasional unplanned scenario that results in student injury or equipment damage. This threat is why both teachers in the chemistry classroom must be intimately familiar with emergency procedures. See Figure 7.5 for important safety information related to co-teaching chemistry.

Figure 7.5. Safety Tips for Co-teaching Chemistry

1. Safety is paramount in every chemistry classroom.
2. Prior to the beginning of the school year, co-teachers must discuss with each other, and agree on, safety procedures and emergency procedures for the conduct of the class.
3. All safety equipment in the classroom must be tested and in place prior to the beginning of the school year. Each co-teacher must know how to use each piece of safety equipment.
4. Part of the initial week of the course must be devoted to lessons on safety.
5. Students (and parents) must sign and return safety agreements if required by the school district.
6. Co-teachers should discuss safety issues for each lab or demonstration with each other and with students prior to the lab being conducted.
7. Care should be exercised in the assignment of lab partners, taking IEP accommodations and the strengths and weaknesses of each student into account.
8. At least one co-teacher should remain vigilant at all times throughout the lab to provide a set of eyes to monitor potentially unsafe student behavior. (Both teachers should not be simultaneously working with student groups.)
9. At least once per quarter, teachers should review safety procedures with students and check safety equipment for location and proper operation.
10. Diligence, diligence, diligence with respect to safety in the chemistry classroom!

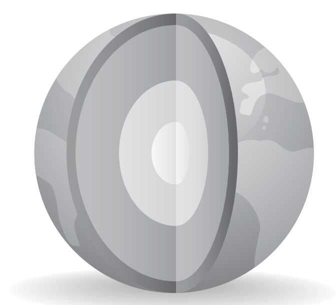
Note: The best source for safety information is the *School Chemistry Laboratory Safety Guide*, which is available online from the Center for Disease Control.

Field Trips

There are rarely field trips in the typical high school chemistry course, if only due to the challenge of covering all the material within the school year. However, there may be a special opportunity to visit a nearby lab or manufacturing facility to provide enrichment. Standard field trip procedures should be followed.

Teacher Perspective

Some of the most useful resources to help a special education teacher grasp basic chemistry concepts are the actual textbooks and accompanying laboratory manuals. Many of the current textbooks in use have integrated technology resources that can help the new teacher quickly grasp concepts. There are also mini-labs now often scattered throughout the textbook, along with inquiry activities that can be performed at home. Although these activities are aimed at students, the new teacher can use these opportunities to "get ahead of the curve" in terms of understanding the material. As with each of the lab sciences, it is critical for both teachers to perform all experiments prior to class to gain understanding of not only what to expect, but also the potential pitfalls for students with special needs in the classroom.



Earth Science

Background

The first United States high school courses containing Earth science material began around 1900 and were taught as physical geography. Although the focus varied, most courses included the study of soils, landforms, weather, water, and climate. Gradually these courses became known as Earth science and included topics on all aspects of Earth (geology, tectonics, weather processes), water (fresh and sea), and the atmosphere. Most courses now also include astronomy and ecology components. In some school districts, Earth science is the first science course taught in high school, followed by some combination of biology, chemistry, and physics.

One developing trend is to shift to a sequence of courses in which a hybrid form of Earth science, called geosystems, is taught to upperclassmen (usually 12th graders) who have completed other science courses such as biology, chemistry, and physics and have a deeper set of mathematical and computer tools with which to work. The rationale is that the geosystems course can integrate previous knowledge and skills from the other disciplines to allow the student to develop a broader, more nuanced understanding of the world around us. Geosystems courses often emphasize the use of technology to gain access to real-time data and multimedia sources (e.g., using the internet to videoconference with professionals). Other technological tools frequently used are geographic information systems (GIS), image processing and remote sensing software, and the Global Positioning System (GPS). Geosystems courses are sometimes inclusive and co-taught. At this time, however, most jurisdictions continue to teach Earth science as an introductory ninth-grade course.

Standards and Curriculum

Most of the national science standards for Earth science are contained in the Earth and Space Science section of the content standards of the 1996 National Science Education Standards. The intent is to build on the information presented in levels K–4 and 5–8. At the high school level, the content areas are energy in the Earth system, geochemical cycles, the origin and evolution of the Earth system, and the origin and evolution of the universe. Most current Earth science textbooks enable the user to meet most, if not all, of the specific content requirements of the Earth and space standards. Although the majority of topics covered in an Earth science course will be derived from the Earth and space section of the standards, there are several important topics from some of the other seven standards that should be included. For example, the Science and Technology standards contain specific content topics that are applicable. And in the Science in Personal and Social Perspective standards, there are content areas related to natural resources, environmental quality, and natural and human-induced hazards that should be covered in an Earth science (or geosystems) course. Of course, the overriding concern of most teachers, general education or special education, is that students be prepared for the topics covered in any state-mandated end-of-year test.

Specific Challenges

Vocabulary challenges are one very immediate concern for the Earth science co-teaching team. Words such as *tectonics*, *igneous*, *Mesozoic*, and *transpiration* pose significant problems for many students, even if they have been exposed to some of these terms in K–8. Each chapter of an Earth science textbook is filled with words and terms unfamiliar to most students, both in terms of meaning and spelling. Other words with which students may have some prior understanding, such as *basin*, have different meanings in an Earth science class. For students who are struggling with English, the challenge is particularly daunting.

The sheer magnitude of the material covered in an Earth science class can be overwhelming for some students, and even more so for those who are poor readers. Most textbooks approach 600 pages or more, with few extraneous topics in the mix. Attempting to present this much information on so many disparate topics (everything about Earth, its composition, history, and the universe surrounding it) is a problem unless the teachers adhere closely to the timelines of a well-constructed syllabus.

The immense timescales involved in Earth science can be difficult to understand for many students. This is an area in which labs involving direct experimentation generally cannot assist learning. The problem is stated very well in the National Standards: "The challenge of helping students learn the content … will be to present understandable evidence from sources that range over immense timescales—and from studies of the Earth's interior to observations from outer space. Many students are capable of doing this kind of thinking, but as many as half will need concrete examples and considerable help in following the multistep logic necessary to develop the understanding …" (NRC 1996, p. 188).

Some of the topics in Earth science are abstract, and many students in grades 9 and 10 may not have achieved the level of cognitive skill to quickly grasp such concepts. In the astronomy sections of the course, students are required to move beyond the study of objects in our solar system, which have been the primary focus in grades K–8. Now they must comprehend extremely large distances, time spans far beyond their normal mind set, and topics such as nuclear fusion.

Strategies for Success

The good news for both teachers in the co-taught Earth science class is that most students find the topics covered to be fascinating and truly fun. Teachers should build on this innate curiosity of students about many of the lessons (e.g., astronomy, volcanoes, and the environment) to engage students in creative projects that allow personal expression and excitement. Hands-on activities and labs involving rocks and minerals, posters and wall charts showing geologic maps and timelines, and internet investigations of current weather phenomena (such as flooding, hurricanes, droughts, and tornadoes) can build student interest.

Earth science is also a course in which student learning can be improved by the judicious selection of video and media presentations. The challenge for Earth science teachers is the sheer quantity of quality videos from which to select for student viewing. There are obviously topics, such as volcanoes, that can best be captured in a visual presentation. Photographs of most Earth science phenomena are often the optimum method for achieving student learning. On the other hand, the course can obviously not be centered on students watching videos or surfing the internet for "cool" information.

If a planetarium is available, it is advisable to use this facility to maximize student learning when teaching the astronomy section of the course. It is also useful if both co-teachers become familiar with the sky at night and the specific astronomical events that take place throughout a typical school year. For example, if a particular planet will make an approach closer to Earth than at any time in the past 25 years, students should be challenged to go outside at night to observe and report to the class what they have seen.

Some teachers have found structured debates to be useful when teaching Earth science. A student-researched debate on climate change, for example, can generate considerable student enthusiasm.

To tackle the vocabulary challenge, many teachers use graphic organizers, word puzzles, flash cards, and a wide array of techniques to allow students not only to gain understanding, but to retain the key words and concepts required for examinations.

Perhaps the best source for co-teachers to stimulate student involvement in Earth science is the daily news. Because so many environmental concerns are issues being discussed in local, national, and international news on a nearly daily basis, there are continuous opportunities to use these current events as assignments or as a basis to begin classroom discussion of relevant topics.

Safety Concerns

Safety issues are typically not a significant factor in an Earth science course—at least compared to other science classes, such as chemistry. However, students must be trained to observe basic laboratory safety procedures prior to any lab being conducted.

Field Trips

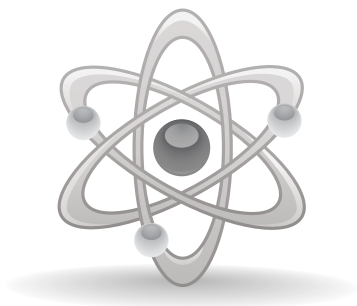
Earth science students can benefit greatly from well-planned field trips to observe firsthand many of the topics discussed in the classroom; for example, how better to study erosion than to take a class to study a nearby stream? Many areas have local geologic features that provide superb hands-on activities. Such field trips do not have to be distant and certainly not overnight. Most schools have features in the local area that can be used to illustrate several Earth science topics.

Teacher Perspective

As opposed to several other core science courses, Earth science is not seriously dependent on the mathematics skills of the students. Because all work can be done with the skills covered in eighth-grade mathematics, successful completion of algebra is not required. For this reason, Earth science can be an ideal ninth-grade science course. It contains material that most students find fascinating and interesting because it focuses directly on the world around us. The course also lends itself to assignments focusing on projects, which can be of great benefit to students who have different learning styles. Some teachers have devised a portfolio-driven Earth science curriculum to take advantage of this opportunity.

Of course, it is impossible to ignore that most states now have an end-of-course, high-stakes test at the completion of the school year. Teachers cannot ignore this mandatory aspect of the course and must include different types of assessments that will strengthen and prepare students to succeed on these examinations.

Chapter 7



Physics

Background

Although physics is most frequently taught in grade 11 or 12, many special education students take an introductory physics class during 9th or 10th grade. This course typically focuses on basic concepts and does not demand the same level of mathematics skill as in standard introductory physics. The textbooks are often the *Active Physics* series by Arthur Eisenkraft, though other introductory physics textbooks, such as *Conceptual Physics* by Paul Hewitt, may be used.

Standards and Curriculum

Most of the national standards for a typical high school physics class are found under Physical Science and Science and Technology, though each of the other six have some topics typically found in a physics course. The unifying theme is learning by inquiry with an emphasis on understanding as opposed to simply knowing. The topics directly applicable to a high school physics course involve motion and forces, conservation of energy, and the interaction of energy and matter. States and local school districts have used these broad guidelines to develop more detailed programs of study for physics courses. Both the physics teacher and the special education teacher should be familiar with the applicable mandated requirements for the course, but in reality, it is usually the responsibility of the physics teacher to ensure that the curriculum being used meets all requirements. Due to varying local and state regulations, there may or may not be a mandatory end-of-year test in physics for the students in your class. Obviously, this is a critical issue in determining not only the focus of the course, but how it will be taught. If there is high-stakes testing in physics, it is essential to ensure that each student in the class is prepared to successfully complete this hurdle, in addition to doing well in every other aspect of the class.

Specific Challenges

One of the unique features of physics as a science is that so many seemingly unrelated topics must be covered. Motion, forces, gravity, electricity, light, sound, heat, and even nuclear energy are often topics contained in a typical physics class. Many special education teachers are initially discouraged by the sheer magnitude and breadth of material to be mastered. Upon closer examination, most teachers quickly realize that each of these topics touch upon everyday experiences, and that it is easy both to engage students in learning this material and to learn it yourself.

Another challenge is the presence, and use, of mathematics throughout the typical physics course. How many times have special education teachers been heard using the student refrain, "I'm not good at math!" to attempt to avoid assignment to co-teach a physics course? The reality is, the mathematics used in most co-taught physics classes is mostly arithmetic, simple proportions, and introductory algebra (e.g., simple equations). However, if the special education teacher assigned to co-teach physics is not comfortable with these basic mathematical skills (and the use of a scientific calculator), one of his or her first priorities must be to rapidly gain competency in this area.

Vocabulary requirements are not as much of a factor in physics as in most other science courses, but there are terms unique to physics that must be mastered (e.g., *momentum*, *kinetic*, *voltage*). Many of the techniques used to have students master the extensive vocabulary issues in biology, chemistry, and Earth science can be applied in physics.

Strategies for Success

One of the most effective means of developing excitement for physics is to present activities that immediately allow students to become actively involved. Rather than simply presenting motion data to the students, we take them outside during the second week of school to gather their own data based on classmates (and their teachers) walking, skipping, jogging, running, and sprinting 100 m on our track. A colleague does the same on a measured distance in the parking lot. Students then use that data for the next several weeks to analyze motion while learning how to do word problems and perform graphical analysis of that information both manually and by computer. In a technology segment, students walk to a local intersection to observe traffic patterns and how computer systems monitor and control traffic through that intersection. When studying electrical circuits, students build their own series and parallel circuits using aluminum foil to create wiring and holiday bulbs as resistances. The key is to develop as many activities as possible that allow students to experience physics as part of the learning process. We have found that all students, but particularly special education students, benefit greatly from such hands-on activities as opposed to only classroom lectures and demonstrations.

Word problems are an integral part of nearly every physics class. For many special education students, this aspect of learning presents a serious challenge. A technique that has proved useful and effective for us is the use of P.I.E.S., which stands for Picture, Information, Equation, Solve. Beginning with the first distance, speed, or time problem of the year, we mandate the use of P.I.E.S. by all students as a means to successfully complete what, for many students, has been a nemesis throughout their education to date. Specifically, we have the students write down the problem. For example, Katerina is walking at 3 m/s; what distance will she travel in 20 s? The first step is to draw a picture depicting the situation—that is, a stick figure of a girl walking. The second step is for the student to "mine" the given information to locate important data. We even have the students circle this information and then place that information on their pictures with the correct symbol. In the problem above, v = 3 m/s and t = 20 s, so what does d equal? This last information, d, is just as important as the other numerical data, because it leads the student to find the correct equation to use to solve the problem. Understanding that the variables v, t, and d are involved helps lead the student to the correct equation, $d = vt$, which is written next to the information. Finally, the student substitutes the information into the equation to solve the problem. The answer is written with the correct units and is then circled. We have found that using P.I.E.S. for every word problem enables each of our students, whether general or special education, to develop a very useful skill set, not only for use throughout the physics course, but in other areas of their curriculum. Both the science teacher and the special education teacher take turns presenting problems and then monitoring student use of P.I.E.S. See Figure 7.6 for a detailed explanation of P.I.E.S.

Another strategy for success is the use of computer simulations to reinforce understanding of physics concepts. Although our preference is for students to perform as many hands-on labs as possible, it is often beneficial to build on those lab experiences with computer simulations. There are now numerous programs available to perform these simulations, including free online physics applets for a variety of applications. It is important when using computer programs to ensure that both teachers are comfortable with how the program works and what procedures to follow to maximize student learning. What usually does not work is just sitting students in front of a given program with instructions to use it.

We are wary of the frequent use of videos in a co-taught physics class. Although there is a wealth of useful information available in the form of videos, it is best used as an introduction or as reinforcement. Because there are so many opportunities in physics for students to learn by doing, why have them simply see a process when they can actually do it? Obviously, when cost considerations preclude schools from purchasing necessary equipment to perform certain experiments, a video of that experiment may be a useful, but suboptimal, alternative. However, nearly all introductory physics labs and demonstrations can be conducted with minimal equipment. For example, we do essentially all of our electrostatics labs using transparent tape, fur, glass rods, and metersticks.

Safety Concerns

Although there are few chemicals used in physics labs, there are safety precautions that must be implemented. Motion labs involve moving parts, pendulum experiments have moving masses at eye level, and electrical labs often involve voltages and currents—sometimes at shocking levels (Van de Graaff generators). Physics labs may also involve the use of expensive equipment requiring particular care so

Figure 7.6. P.I.E.S.—A Strategy for Solving Word Problems

P.I.E.S. is a strategy intended to provide a systematic way to solve word problems. When faced with a story problem, many students will automatically shut down. With P.I.E.S., the student has an immediate plan of action, and can at least get started on the problem by making a visual representation of it. Just having a place to start can drive students on through the next steps and eventually to completion with a successfully solved problem.

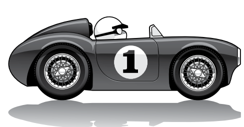
P stands for **P**icture. The students draw representations of the story. No art ability is required; in fact, we often demonstrate this part of the strategy with crude stick figure pictures to show that the quality of the picture is not what matters.

I stands for **I**nformation. The students "mine" the word problem for important information (as in dig through the words to find the gold nuggets) and identify what variable it belongs with (see example below). Students who find this difficult are encouraged to circle or highlight the keywords in the problem as they read it. The variable that is unknown is to be identified with a question mark.

E stands for **E**quation. The students are now able to search a menu of given equations to find which one can be used to solve the problem based on the information that they have identified. They MUST write it down in equation form.

S stands for **S**olve. When the information is identified and the equation is selected, the students insert the information directly below the associated variable in the equation to solve the problem. Students must show every mathematical step; doing so will help the teacher discover if and where the student has weak math skills. If the solution is incorrect, the teacher can find where the mistake was made. We also insist that the answer be circled to allow us to see their final solution—and for the student to express satisfaction at having solved a word problem.

Example:
Sam drove at 45 mph from 1:30 p.m. until 3:30 p.m. How far did he drive?

P 

I v = 45 mph, t = 2 hrs., d = ?

E $d = vt$

$d = 45(2)$

S d = 90 miles

When a story problem is given as an assessment, points can be given for the completion of each step. Such a problem could be worth 10 points with 2 points for each step, 1 point for assigning the correct units, and 1 point for circling the answer. Students who would have been tempted to skip or guess at an answer for this kind of problem in a multiple-choice test are more likely to go for the points and make an effort to solve the problem with P.I.E.S.

they are not damaged. In all cases, these considerations must be paramount for both co-teachers when planning and conducting the lab. The classic warning “It is better to be safe than sorry” has applicability in every team-taught physics class.

Field Trips

Although there may be some benefit in taking field trips in physics, our experience has been that most concepts can be learned in and around the school itself. As we mention earlier, we are strong proponents of taking students outside the classroom to gain hands-on learning in numerous activities, such as examining different types of mirrors and lenses focusing rays from the sun. If there are opportunities in the local area to visit working labs, a museum, or an observatory, it may be useful to conduct a field trip.

Teacher Perspective

We are strong proponents of actively involving students not only in learning physics, but also in demonstrating what they have learned. We rarely assess learning in physics using multiple-choice instruments because we find that we can learn so much more about what students know, and do not know, by having tests that enable them to show all their work. We generously award partial credit on problems if the student shows work, even so little as drawing a picture, to illustrate what is known. In a combined physics class, each teacher is continually circulating among the students to ensure safety, involvement, and learning and to provide assistance when needed.

Science Electives

Many larger high schools are able to offer a wide array of science electives, including astronomy, anatomy, and oceanography, in addition to various Advanced Placement (AP) courses. Most of these courses are rarely co-taught, but as we will discuss in the following chapter, the science teacher may find it both useful and mandatory to work closely with a special education teacher when one or more students with special needs are members of the class. It is highly probable that there will be at least one student with special needs in a science elective class, so it is imperative that the case manager and the science teacher be in contact to maximize learning and achievement for such students.

Figure 7.7. Sample Failure Warning Letter to Parents

(date)

Dear Mr. and Mrs. ____,

We want to inform you that your son/daughter, _______________, is in danger of failing ________________ for this school year. His/her cumulative grade point average for the first two quarters was 66.4%, and his/her current grade as we approach the end of this third quarter is 52.4%. If the school year were to end today, ____________ would not pass the course. We have spoken to ___________ about his/her situation and explained to him/her the need to complete all class work and labs, better prepare for quizzes and tests, and pass the final examination. He/she has placed himself/herself in a difficult situation, and we are concerned. The good news is that he/she still has time to recover and pass the course.

Both of us are available to assist ____________ every day after school. He/she does not need to make an appointment. One of us will always be here for at least one hour after the end of the school day. All ______________ has to do is to show up for assistance. We are eager to help him/her in any way, but it is essential that he/she understand his/her role in improving his/her performance.

___________________ is not offered in summer school, so if _____________ does not successfully complete this course, he/she will have limited options. We suggest that you discuss with ___________'s counselor what to do about getting him/her the necessary science credits he/she needs to graduate if he/she is not successful in this course. Two successfully completed science courses are needed for a modified diploma, and three are needed for a standard diploma.

Please feel free to contact either of us at our e-mail addresses listed below at any time. We are confident that, with your support and encouragement, __________ can show the necessary improvement to succeed in our course.

Sincerely,

______________________ and ____________________

E-mail: _____________________________ and _____________________________________

Specific High School Administrative Issues

Most students now proceed through the elementary and middle school years without risk of failing a course or graduating without a diploma. High school, however, differs, because there are specific state requirements for a student to graduate. Many states provide different types of diplomas based on the courses completed by the student. It is critical, therefore, for high school co-teachers to be continuously aware of the progress of each student toward a diploma. Does student X need to complete the course to graduate? How many successfully completed science courses are required for each type of diploma? Has the student passed each of the state-mandated tests in science necessary to graduate? These are questions that must be addressed by the co-teachers as they monitor grades and student performance throughout the year. It is not sufficient to consider these issues for the first time a few weeks before completion of the course. If a student is experiencing difficulty early in the school year (for example, at the end of the first quarter), it is appropriate for co-teachers to discuss with each other what can be done, both by the teachers and by the student, to improve performance. Once agreement is reached, at least one of the teachers should have a conference with the student, the parents, the case manager, and the guidance counselor to attempt to achieve improvement.

This type of analysis of student performance and appropriate response obviously should continue throughout the school year. However, if the student continues to be in danger of failing the course (and possibly not being eligible to graduate as a consequence), co-teachers must recognize this situation sufficiently early in the school year to be able to notify all concerned and, more important, to provide a possible path for successful completion of the course. We have this analysis of each student early in the second semester (or third quarter) of the school year. If a student is in danger of failing, we not only have conferences, but we also send a formal letter of notification to the parent (copies are sent to the guidance counselor and case manager). See Figure 7.7 (p. 107) for a sample letter.

We also take every opportunity during the school year to recognize solid performance. Although it may not seem appropriate for the age group, we put gold stars on exceptional student work. These may be high school students, but parents report to us that their students proudly bring home work with gold stars and want it placed on the refrigerator door much as when they were in first grade. We also try to find every opportunity to recognize some of our students with special needs as often as possible, with such awards as Student of the Quarter or other schoolwide programs. We also frequently give out small treats in class for behavior, participation, answers, or overall good work. Again, teens seem to respond just as positively to this recognition as their middle and elementary counterparts.

Conclusion

Co-teaching at the high school level differs from elementary or middle school in several ways. Perhaps the most sobering aspect is that you, as a co-teacher, may have the last opportunity to shape the student for the real world beyond high school. Accordingly, you are teaching not only science, but life skills such as responsibility. This challenge will require a combination of compassion and empathy mixed with tough love. In science, you will be preparing students for advanced courses at the university level or jobs which may require science knowledge in the workforce or the military. Because of the prevalence of high-stakes testing in subject areas during high school, much of your work may also be directed toward ensuring that your students are prepared for these examinations. There are few more rewarding moments in teaching than former students returning to greet their co-teachers.

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