Diverse Learners

The NGSS, as outlined in Appendix D, holds that all students, when provided with equitable learning opportunities, can learn science:

"The Next Generation Science Standards (NGSS) build on the National Research Council's consensus reports which consistently highlight that, when provided with equitable learning opportunities, students from diverse backgrounds are capable of engaging in scientific practices and constructing meaning in both science classrooms and informal settings."[6]

Some of the strategies and approaches in *A Natural Approach to Chemistry* were adapted from *NGSS for All Students* [7] and provide approaches and strategies for working with:

- English language learners (ELLs)
- Students with disabilities
- Gifted and talented students
- Girls
- Economically disadvantaged students
- Students from major racial and ethnic groups
- Students in alternative education

Briefly, some of these strategies include:

- Second language format and accessible online text tools (alt text and screen readers in several languages)
- An Activity-Before-Concept model using lab investigations prior to text involvement
- An accessible student text with one-concept per page, on target Lexile Levels (Student Book: 1090, LIM: 930), and margin term and vocab callouts to help readers
- Video options for reading text
- Use of real life scenarios, including an emphasis on the chemistry of the human body and natural environment, Student Skill Sheets at basic, on-grade, and advanced levels, and more

The next several sections will give more specific strategies for working with the various students you have in your classroom.

Strategies For Engaging Students Who Are English Language Learners (ELLs)

English language learners face unique challenges in high school chemistry, as they must learn the specialized academic language and concepts of chemistry while simultaneously learning English. They may understand more about science than they can express in English. This can lead teachers to underestimate their progress. However, chemistry classroom can be a rich environment for language learning. When providing ELLs with opportunities to develop their language skills through speaking, listening, reading, and writing, they can excel. Consider incorporating some of the following supports for ELLs:

- Focus on academic language, literacy, and vocabulary. Help ELLs develop their understanding of academic language, including technical terms, chemical symbols, and mathematical notation in context. Provide opportunities for ELLs to practice reading, writing, and speaking about chemistry concepts in English.
- Link background knowledge and culture to learning. Build on ELLs' prior knowledge and experiences, and draw on their cultural background to help them make sense of new concepts.
- Increase comprehensible input and language output. Use a variety of strategies to make sure that ELLs can understand what is being taught, such as using visuals, manipulatives, and providing clear explanations. This can help ELLs visualize abstract concepts and make learning more concrete. For example, you could use diagrams, models, and/or real-world objects to illustrate chemical reactions.

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[6] https://www.nextgenscience.org/resources/ngss-all-students

[7] Lee, O., Miller, E., & Januszyk, R. (Eds.) (2015). NGSS for all students. National Science Teachers Association

- Stimulate higher-order thinking skills and use of learning strategies. Help ELLs develop the skills they need to think critically about chemistry concepts and solve problems. Teach them how to use learning strategies, such as taking notes, summarizing, and asking questions.
- Provide clear and concise instructions. Break down complex instructions into smaller steps and provide visuals or demonstrations to help ELLs understand what they are supposed to do.
- Give ELLs time to process information. Don't expect them to answer questions or participate in discussions immediately. Give them time to think about what they have heard or read before responding.
- Use scaffolding. Provide ELLs with support as they need it, such as providing them with sentence frames or graphic organizers to help them organize their thoughts.
- Work with ELLs individually or in small groups. This will give you the opportunity to provide them with the extra support they need. You can also use this time to check for understanding and answer questions.
- Encourage ELLs to participate in class discussions. This can help them build their confidence and fluency in English. You can also provide them with a list of key terms or phrases to help them participate.
- Provide ELLs with access to resources in their native language. This could include textbooks, dictionaries, or websites.

Strategies For Engaging Students With Disabilities and/or Neurodiversity

Neurodiversity refers to the variety of ways in which the brain functions. It includes differences in neurological development such as autism, Attention Deficit Hyperactivity Disorder (ADHD), dyslexia, and more. Neurodiverse students often learn in different ways than their neurotypical peers. They may need more time to process information, they may need different sensory input, or they may need more structure or flexibility in their learning environment. All students have different learning styles and preferences, and these differences should be taken into account when supporting learning experiences.

Here are some specific examples of how teachers can modify to meet the needs of students with disabilities and/or neurodiversity:

- Modify instruction by employing a range of teaching strategies. Not all students learn in the same way, so it's important to use a variety of teaching strategies to reach all learners. This could include incorporating visual, auditory, and kinesthetic learning activities. Understand the strengths of each student. Take the time to learn about each student's strengths and weaknesses to help tailor your instruction accordingly.
- Scaffold the learning. This means providing students with the support they need to learn new material. This could include providing them with outlines, study guides, or worked examples. It could also involve providing different levels of complexity in assignments or providing a data table if one is not included in the investigation. This can help students to organize their information and to make sense of it.
- Use real-world examples. This can help students connect the abstract concepts of chemistry to something they can relate to.
- Provide clear and concise instructions. Teachers can use visuals, gestures, and voice inflection to help students understand what is being asked. They can also break down tasks into smaller steps. Neurodiverse students often have difficulty processing information in large chunks. Break down lessons into smaller, more manageable steps.
- Modify assessments by providing students with alternative ways to demonstrate their learning, such as through oral presentations or portfolios. They can also give students more time to complete assessments and allow them to use assistive technology, or in some cases, use a method that does not involve technology at all.
- Offer opportunities for peer support. Teachers can create opportunities for students to work together in groups or pairs. Allow students to discuss their ideas before writing individual responses. This can help students to clarify their thinking and to get feedback from their peers.
- Let students answer questions in different ways. This could include allowing them to write their answers with a partner, draw a diagram, or record their answers using voice-to-text technology.
- Highlight the contributions of individuals who think differently. This can help students to see that their unique way of thinking is valuable and that they can be successful in science and engineering.

Strategies For Engaging Gifted and Talented Students

Gifted and talented students in science are those who may have a natural aptitude for the subject and demonstrate exceptional ability in areas such as critical thinking, problem solving, and creativity. They are often curious and ask many questions, and they are eager to learn more about the world around them. However, some students may excel in some areas of chemistry and not others. A variety of formative assessments, given periodically, can help identify those students who want or need more of a challenge with specific core ideas when learning about certain topics. Those identified as "gifted and talented" may fluctuate throughout the year based on the data of those formative assessments. There are a number of ways to support and challenge these students:

- Provide them with opportunities to conduct independent research projects. This allows them to explore their interests in depth and to further develop their problem-solving skills.
- Give them opportunities to work on real-world problems. This can help them to see the relevance of science to their own lives and to develop their critical thinking skills.
- Provide a variety of learning experiences, such as field trips, guest speakers, and hands-on activities. This can help them to stay engaged and motivated in their studies.
- Challenge students to extend their learning by developing steps of a follow-up lab procedure or presenting more than one viewpoint on a topic of discussion.
- Provide them with opportunities to learn at their own pace. They often learn more quickly than their peers. Allow them to move ahead at their own pace, either by providing them with enrichment activities or by allowing them to take more advanced topics.
- Challenge them with complex problems. Advanced students are often bored by simple tasks. Give them challenging problems to solve that will stretch their minds and help them to develop their critical thinking skills.
- Provide them with opportunities to collaborate with other students. This can help them develop their communication and teamwork skills.
- Use technology to enhance their learning. There are many educational technology tools that can be used to support advanced students in chemistry. These tools can be used to provide enrichment activities, to create simulations, and to help students visualize chemical concepts, such as the molecular workbench.

Strategies For Promoting Equitable Participation From Girls or Quiet Voices

Girls and quiet voices are often underrepresented in high school chemistry classes, which can lead them to participate less than others. However, there are a number of things that can be done to encourage more girls and quiet voices to participate in chemistry classes. One is to provide positive role models. This could involve inviting female chemists to speak to students about their careers.

It is important to remember that every quiet student is different. What works for one student may not work for another. The key is to be patient and understanding, and to find ways to make them feel comfortable participating. Here are some suggested supports:

- Make sure they feel comfortable. Girls or quiet students may be hesitant to participate if they feel like they are being put on the spot or judged. Create a safe and supportive environment where students feel comfortable sharing their ideas, even if they are wrong.
- Give them options. Not all girls or quiet students are comfortable speaking up in class. Offer them other ways to participate, such as writing down their answers, drawing pictures, or working in small groups.
- Personalize the learning. Students may be more likely to participate if they feel like the material is relevant to them. Find ways to connect the concepts to their interests or experiences.
- Give them small group assignments. This can help them feel more confident sharing their ideas in a smaller setting.
- Have them lead a discussion or presentation. This can be a great way to give them a chance to share their knowledge and expertise with the class.
- Create opportunities for them to do hands-on experiments. This can be a great way for them to learn and participate without having to speak up in class.
- Use anonymous surveys or polls. This can be a way for them to share their thoughts and ideas without having to put their name on it.

Strategies For Engaging Students with Diverse Backgrounds and Experiences

To engage all students in chemistry, it is important to connect science to their diverse backgrounds experiences. This can be accomplished by eliciting students' ideas and knowledge from their personal and cultural experiences, and then using those ideas to build collective understanding.

Teachers can support these differences by valuing the experiences of all students, regardless of their background. They can do this by:

- Foster an inclusive learning environment. This means creating a space where all students feel welcome and valued, regardless of their background.
- Connect science to students' lives. This is one of the most important ways to engage students in science. When students see how science is relevant to their own lives, they are more likely to be interested and motivated to learn. For example, you could talk about how the science of surface tension affects our respiration (Ch 16), or how the science of fireworks produces the various colors they might see (Ch 5).
- Connect science to students' life experiences. This can be done by using examples from students' everyday lives, or by asking them to share their own experiences with the topic being studied. Students are more likely to be engaged in science if they can see how it relates to their own communities, cultures, and experiences. You can help students to make these connections by asking them to think about how science has affected their own lives or the lives of their families and friends.
- Value students' contributions. All students have something to contribute to the learning process. It is important to create a classroom environment where students feel safe and respected, and where their ideas are valued. When students feel like their voices are heard, they are more likely to be engaged and motivated to learn.
- Start with observations. Asking students to make observations before moving on to analytical questions can help them to build a common understanding of the content. This is especially important for students who come from different backgrounds or who have different levels of prior knowledge. By starting with observations, you can help to ensure that everyone is on the same page.
- Use active learning strategies. Active learning strategies engage students and help them retain information better. Some examples of active learning strategies include group work, role-playing, and problem-based learning.

Strategies For Engaging Students in Alternative Education

Students in alternative education face a number of challenges. They may have experienced trauma or other challenges that have made it difficult for them to learn. They may also have fallen behind academically or have behavioral problems. Additionally, they may feel isolated and different from their peers in traditional schools.

- Be flexible and adaptable. Students in alternative education may have had negative experiences in traditional schools, so it is important to be flexible and adaptable in your teaching methods. This could involve using a variety of teaching styles, or being willing to change your plans if something is not working.
- Build relationships with students. Students in alternative education may need more support and guidance than students in traditional schools. It is important to build relationships with students and get to know them as individuals. This will help you to understand their needs and how to best support them.
- Offer choices and opportunities. Students in alternative education may have lost a sense of control over their lives. It is important to offer them choices and opportunities, whenever possible. This could involve letting them choose their own learning activities or giving them opportunities to take on leadership roles.
- Focus on the positive. Students in alternative education may have a lot of challenges in their lives. It is important to focus on the positive and celebrate their successes, no matter how small. This will help them to stay motivated and believe in themselves.
- Provide individualized support. Students in alternative education may need more individualized support than students in traditional schools. This could involve providing tutoring, mentoring, or other interventions.
- Encourage students to take responsibility for their learning. Students in alternative education may need help learning how to take responsibility for their own learning. This could involve teaching them how to set goals, manage their time, and solve problems.

- Be consistent. It is important to be consistent in your expectations and consequences. This will help students to trust you and know that you are serious about helping them succeed.
- Encourage students to ask for help. Students in alternative education may be reluctant to ask for help. It is important to encourage them to do so, and to make sure that they know that you are there to support them.

A General Example of Differentiating Instruction

Many of you probably use aspects of differentiated instruction already. For example, Monday you may show a demo of a simple chemical reaction from everyday life and ask students to list questions about what they've just seen or to make predictions if you made changes. You assign a short reading or video about reactions that night. Tuesday the class does a lab on simple reactions. Tuesday night you assign some problems on basic chemical changes for the students to complete and Wednesday you review the problems with the class. That means your students were exposed to the concept of chemical reactions in four pedagogically different ways.

- Students listened to your short discussion and watched a short demonstration—this is primary audiovisual learning and linguistic learners tend to respond well.
- Students read about reactions in their student book—also audiovisual and linguistic learning but better for the intrapersonal learners who like working alone.
- Students did a lab investigating the concept of reactions—this involves a group and therefore appeals to intrapersonal learners and kinesthetic learning styles.
- Students did problems on chemical change on their own or in groups—this involves the logical/ mathematical learners and intrapersonal learners.

Group-work brings in the interpersonal learners. A well-differentiated lesson may include two or more different instructional strategies to learn the same content. In this case, by different we mean using strategies that appeal to different learning styles. Listening to a discussion and reading a book are both primarily passive audio-visual and linguistic strategies from the perspective of the student. Doing an investigation with a group to learn the same concept is a completely different strategy that appeals to interpersonal, visual/spatial and kinesthetic learning styles. Using an interactive computer simulation appeals to intrapersonal and logical/mathematical learners. Doing a project or solving puzzles are also different strategies.

Cognitive Levels

Cognitive levels, such as Bloom's Taxonomy, group learning and reasoning skills into levels of increasing sophistication or cognitive demand. The lowest level is gathering and memorizing information, such as vocabulary words and basic concepts. The next level is applying or manipulating information, such as calculating density using mass and volume. The highest level is critically evaluating information, such as answering the question of whether a penny is copper based on data and understanding of density. Synthesizing an explanation for something based on observations is another high-level cognitive function. Each chapter in *A Natural Approach to Chemistry* includes opportunities at all cognitive levels.

Here is a table that summarizes the different cognitive levels and their corresponding examples:

COGNITIVE LEVEL	EXAMPLE
Gathering and Memorizing Information	Remembering vocabulary words, basic concepts, and facts
Applying or Manipulating Information	Using formulas to solve problems, conducting experiments, and creating presentations
Analyzing Information	Breaking down information into its component parts, identifying patterns, and making inferences
Evaluating Information	Judging the quality of information, making decisions, and solving problems
Synthesizing Information	Creating new ideas or products, drawing conclusions, and making generalizations