



Revolutionizing Chemistry Education: 10 Ways to Use ChatGPT in Your Classroom

Josh Kenney | Thu, 03/02/2023 - 14:30



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If you're a chemistry teacher, you know that teaching this complex subject can be both rewarding and challenging. From balancing chemical equations to understanding the periodic

table, there's a lot for students to learn and for educators to teach. Fortunately, ChatGPT is here to help! As an advanced language model trained by OpenAI, ChatGPT has the potential to revolutionize the way you teach chemistry. In this blog post, we'll explore 10 ways that ChatGPT can make teaching chemistry easier and more engaging for both you and your students. So, whether you're a seasoned chemistry teacher or just starting out, let's dive into the ways ChatGPT can help enhance your classroom experience.

Before continuing, we should inform you that ChatGPT wrote the title and introduction of this post. The rest of the content has been written by humans (Ben Meacham and Josh Kenney), we had a lot of fun interacting with ChatGPT during our research and thought it would be fitting to let it have a voice in this post!

1. Coming up with ideas for labs

Ben - I don't know about you, but many of the lab ideas that I've integrated into my curriculum have not always come directly from me. We hear about lab ideas from colleagues, at conferences, online, and in books. However, what if you're a bit crunched for time and looking to do a lab related to a specific topic and just

can't seem to find one that fits your needs? Fortunately, ChatGPT does a surprisingly good job at generating lab ideas that can be applicable to almost any topic. For example, we are currently learning about enthalpy, entropy, and spontaneity in my




class. Though I have some good enthalpy labs, I don't really have anything that would allow students to perform a reaction and eventually calculate Gibbs free energy of the reaction. So, I went to ChatGPT and asked about this.

Ben: What are some lab ideas for high school chemistry on the topic of colligative properties?

ChatGPT: Here are a few lab ideas for high school chemistry on the topic of colligative properties:

1. **Freezing Point Depression:** This experiment can be used to investigate the effect of adding a solute on the freezing point of a solvent. Students can compare the freezing point of pure water to that of a water-salt solution of known concentration. By measuring the temperature at which the solution freezes, they can calculate the freezing point depression.
2. **Boiling Point Elevation:** Similar to the freezing point depression experiment, this lab can be used to study the effect of adding a solute on the boiling point of a solvent. Students can compare the boiling point of pure water to that of a water-sugar solution of known concentration. By measuring the temperature at which the solution boils, they can calculate the boiling point elevation.
3. **Osmosis:** This lab can be used to study the process of osmosis, which is the movement of solvent molecules through a semipermeable membrane. Students can set up a simple experiment using a potato and different concentrations of salt solutions. By measuring the change in weight of the potato after it has been placed in the solution, they can determine the direction of osmosis and the concentration of the solution.
4. **Vapor Pressure:** This experiment can be used to investigate the effect of adding a solute on the vapor pressure of a solvent. Students can compare the vapor pressure of pure water to that of a water-ethanol solution of known concentration. By measuring the pressure at which the solution vaporizes, they can calculate the vapor pressure lowering.

See the pdf for the full conversation I had with ChatGPT about this including answers to clarification questions I asked.  ChatGTP Generating Lab Ideas (https://www.chemedx.org/sites/www.chemedx.org/files/chatgpt_generating_lab_ideas.pdf)

2. Ask ChatGPT to write lesson plans for you.

Josh - Some schools require teachers to write detailed lesson plans for each class. I had this requirement in a previous teaching position and found it was a burden to keep up with the weekly lesson plan deadlines. Of course, I always have a lesson plan when I teach; an agenda for the class period, a list of demos, the problems we



will solve in class, and the homework for the day, but my plan was less detailed than what was required by my administrators. ChatGPT could've saved me hours of work by writing the lesson plans. I asked ChatGPT for a lesson plan for Electrons and Light and it suggested a similar lesson to what I taught. Not only that, but the lesson plan would undoubtedly satisfy even the most stringent administrators. Just tell ChatGPT the topic, length of the class, the level, and any specific content you'd like to include in the lesson.

Josh: Write a 75-minute lesson plan for high school chemistry in the topic of electrons and light. Include a demonstration that shows light of different color have different energy. Include another demonstration that shows the flame tests of metal ions.

ChatGPT:

Lesson Title: Electrons and Light

Subject: High School Chemistry

Duration: 75 minutes

Objective: By the end of this lesson, students will be able to:

Understand the relationship between electrons and light

Describe the wave-particle duality of light

Explain how the energy of light is related to its frequency and wavelength

Understand how electrons are arranged in an atom

Understand the concept of ground state and excited state of an electron

Perform flame tests on different metal ions and observe the different colors produced

Conclusion (15 minutes): Review the key concepts covered in the lesson, including the wave-particle duality of light, the relationship between energy, frequency, and wavelength of light, electron arrangement in atoms, ground and excited states of electrons, and the use of flame tests to identify metal ions.

Ask the students to reflect on what they have learned and to consider how these concepts might be useful in understanding real-world phenomena, such as the colors of fireworks, the colors of gemstones, and the colors of neon signs.

Assign a short homework assignment to reinforce the concepts covered in the lesson, such as answering a set of questions related to the topics discussed.

Assessment: The teacher can assess students' understanding of the topics covered by asking questions during the lesson, giving a quiz, or assigning a homework assignment. The flame test demonstration can also serve as a form of assessment, as students can be asked to identify the metal ions present based on the colors observed.

3. Generating procedures for labs

Ben - Even if you are inspired to pursue a lab idea generated by ChatGPT, or from somewhere else, what if you don't know exactly what's required to execute the lab properly? Or, what if you're short on time and would like a procedure for a lab to be generated automatically? This is another area for science teachers to use ChatGPT as a great supplemental resource.



Ben: Can you provide an experimental procedure for students to conduct a lab on freezing point depression?


ChatGPT: Sure, here's an experimental procedure for students to conduct a lab on freezing point depression:

Materials: Distilled water, Sodium chloride (NaCl) , Two beakers, Thermometer, Stirring rod, Ice bath, Digital balance

Procedure:

1. Measure and record the mass of two empty, dry beakers using a digital balance.

2. Add 50 mL of distilled water to one beaker and 50 mL of a 1.0 M NaCl solution to the other beaker.
3. Place both beakers in an ice bath and stir gently with a stirring rod until the temperature of each solution reaches the temperature of the ice bath (around 0°C).
4. Insert a thermometer into each beaker and record the initial temperature of the solutions.

See the pdf for the full conversation I had with ChatGPT, the suggested lab and a modified lab based on a follow up question.  [ChatGTP Generating Lab Procedures](https://www.chemedx.org/sites/www.chemedx.org/files/chatgpt_generating_lab_procedures.pdf)

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4. Ask ChatGPT to explain complex concepts from the perspective of different personalities.

Josh - Many chemistry topics are challenging for students to develop a conceptual understanding, and as chemistry teachers, we often use analogies to help make abstract ideas more concrete. As students build knowledge of complex concepts, it is helpful for them to hear about them from different perspectives. Sometimes, the idea will "click" for a particular student when communicated just the right way. I asked ChatGPT to explain the particle-wave duality of light from the perspective of different personalities. All of the explanations are correct, including an entirely different way to communicate the topic with a unique analogy. Put students into small groups and have them read the explanations to each other. The activity is deeply metacognitive because they are thinking about the content of the explanation and if the analogy makes sense. In a fun twist, they can try to guess who did the explaining.

Josh: Can you explain the wave-particle duality of light from the perspective of the following personalities?

- 1) Homer Simpson
- 2) Donald Trump
- 3) Jerry Seinfeld

ChatGPT: Sure, here's an explanation of the wave-particle duality of light from the perspectives of Homer Simpson, Donald Trump, and Jerry Seinfeld:

Homer Simpson: "Wave-particle duality? Oh man, that's a tough one. But I think I get it. It's like when I'm eating a bag of chips - sometimes I'm just eating them one at a time, like particles, but other times I'm shoving them in my mouth all at once, like a big wave. Light does the same thing - sometimes it acts like a particle and sometimes it acts like a wave. It's like when I'm watching TV and the channel keeps changing - you never know what you're gonna get!"

Donald Trump: "The wave-particle duality of light? Tremendous, tremendous concept. I know all about it. It means that light can behave like both a wave and a particle, depending on how you look at it. And you know what? That's just like me - sometimes I'm a tough negotiator, and sometimes I'm a real people person. You never know what you're gonna get with me, either. But let me tell you, when it comes to light, I know more about it than anybody. Believe me."

Jerry Seinfeld: "Wave-particle duality of light? What's the deal with that? It's like, is it a wave, or is it a particle? Pick a side, light! But seriously, folks, the wave-particle duality is a fascinating concept in physics. It means that light can behave like both a wave and a particle, depending on how it's observed. And you know what? That's just like people - sometimes we're in a good mood, and sometimes we're not. But the thing is, we're always the same person. Same with light - it's always light, even if it's acting like a particle or a wave. It's like how I'm always me, even if I'm in a bad mood. But you know what makes me feel better? A good cup of coffee. Now that's something I can get behind."

5. Organizing students into random lab groups

Ben - Sometimes we want to randomly assign our students into groups. While there are plenty of random group generators out there, it would be nice to have the ability to do this within a program that I'm used to, like Excel. So, here is an example of how ChatGPT filled in for my lack of programming knowledge and allowed me to easily regenerate random lab groups for my class whenever I want new groups to be created.



Generating random lab groups.mp4

ChemEd Xchange

03:32

Video 1: Using ChatGPT to generate random lab groups , *ChemEd X Vimeo Channel*, 3/2/2023.

6. Ask ChatGPT for incorrect but convincing explanations to use in student discussions.

Josh - Using errors as a teaching tool provides students with an advanced metacognitive task that may produce a more robust understanding of content.¹ In my chemistry class, I have used **Answer Keys with Wrong Answers** (<https://www.chemedx.org/blog/answer-keys-wrong-answers>), adding a layer of complexity when students check their answers on homework and practice. Although having students evaluate correct and incorrect explanations of content is valuable, creating convincing wrong answers is time-consuming. ChatGPT, on the other hand, can provide numerous plausible explanations of topics in seconds.

Josh: Provide three different explanations for the difference between evaporation and boiling. One explanation should be correct and the other two should be incorrect yet very convincing.

ChatGPT:

Correct explanation:

Evaporation and boiling are both processes that involve the conversion of a liquid to a gas. However, they differ in the amount of energy required and the speed at which they occur. Evaporation occurs at the surface of a liquid and requires only a small amount of energy to convert molecules from the

liquid state to the gas state. Boiling, on the other hand, occurs throughout the entire liquid and requires a significant amount of energy to break the intermolecular bonds that hold the molecules together. As a result, boiling occurs at a higher temperature and is a faster process than evaporation.

Incorrect yet convincing explanation 1:

The difference between evaporation and boiling is that evaporation is a natural process that occurs when a liquid is exposed to air, while boiling requires the addition of heat to the liquid. When a liquid is heated, it starts to boil, and the molecules in the liquid move around more quickly, causing bubbles to form and rise to the surface. Evaporation, on the other hand, occurs without the need for any external energy source and is caused by the natural movement of molecules at the surface of the liquid.

Incorrect yet convincing explanation 2:

The difference between evaporation and boiling is that evaporation is a physical process, while boiling is a chemical process. When a liquid evaporates, the molecules in the liquid absorb energy from the surroundings, causing them to move faster and eventually escape into the air. Boiling, on the other hand, involves the chemical transformation of a liquid into a gas, which requires the breaking of chemical bonds between the molecules in the liquid.

Incorrect yet convincing explanation 3:

The difference between evaporation and boiling is that evaporation is a reversible process, while boiling is irreversible. When a liquid evaporates, the molecules in the liquid escape into the air and can be collected and condensed back into a liquid. Boiling, on the other hand, causes the molecules in the liquid to break apart and form a gas, which cannot be easily condensed back into a liquid without the addition of significant energy. As a result, boiling is considered an irreversible process.

7. Providing teachers with instructions on how to create specific solutions that will be used in a lab

Ben - We make a variety of solutions for labs throughout the year. However, some solutions may require knowledge that you may not currently have. For example, even though I've used a variety of acid/base indicators throughout my career, I don't know the exact procedure for how to properly create each indicator if I need to restock it.

Recently, I was doing a lab with my students that required 1 L of a 2% starch solution. I had some prior knowledge that making starch solutions was a bit different than making a traditional solution. So, I went to ChatGPT to ask about how to make this and was pleasantly surprised to be given the exact instructions I was looking for. Here is a quick video showing what that process looked like.



Asking ChatGPT about how to make a 2% starch solution

ChemEd Xchange

02:48

Video 2: Asking ChatGPT about how to make a 2% starch solution, *ChemEd X Vimeo Channel*, 3/2/2023.

8. Ask ChatGPT to evaluate students' Claim, Evidence, and Reasoning.

Josh - The claim, evidence, and reasoning framework is a way of communicating scientific explanations. Introduced in 2011 by Katherine McNeil and Joseph Krajcik,² it quickly spread throughout K-12 science classrooms. I always include this framework in lab reports and ask students to make sense of the data they collected and analyzed by making a claim backed up by evidence from their data with reasoning that uses scientific principles to connect their claim and evidence. Students need support when first learning to use CER, especially with providing sufficient evidence and claims. ChatGPT is a valuable tool because students can ask it to evaluate the strength of their CER responses. ChatGPT will help identify weaknesses in their responses and allow meaningful practice before needing to write unsupported CER responses on tests or lab reports.

Josh: Evaluate how well I used claim, evidence, reasoning (CER) in the following statement.

The unknown salt contained a potassium ion because it produced a purple flame in the flame test and potassium makes a purple flame.

ChatGPT: You used claim, evidence, reasoning (CER) to some extent in the following statement:

Claim: The unknown salt contained a potassium ion.

Evidence: It produced a purple flame in the flame test and potassium makes a purple flame.

Reasoning: None provided explicitly.

The claim is clearly stated, and the evidence is provided to support it. However, the reasoning is not explicitly stated, and it is not clear how the evidence supports the claim. The statement relies on the reader's assumed knowledge that potassium is the only element that produces a purple flame in the flame test. While this may be true, it is not explicitly stated and could weaken the argument if the reader does not have that knowledge.

To improve the use of CER, you could add explicit reasoning that links the evidence to the claim, such as stating that the purple flame indicates the presence of a metal ion and that potassium is the only known metal ion that produces a purple flame. This would make the argument more explicit and provide a stronger basis for the claim.

Josh: Evaluate how well I used claim, evidence, reasoning (CER) in the following statement.

The unknown salt contained a potassium ion because it produced a purple flame in the flame test. Potassium chloride also produced a purple flame in the flame test, so the unknown must contain a potassium ion.

ChatGPT: You used claim, evidence, reasoning (CER) well in the following statement:

Claim: The unknown salt contained a potassium ion.

Evidence: It produced a purple flame in the flame test.

Reasoning: Potassium chloride also produced a purple flame in the flame test, so the unknown must contain a potassium ion.

The claim is clearly stated, and the evidence is provided to support it. The reasoning links the evidence to the claim logically, by comparing the unknown salt's behavior to that of a known substance with similar characteristics. Overall, the statement demonstrates a logical and structured approach to scientific inquiry using CER.

9. Generating rubrics

Ben - One thing my department grades several times throughout a quarter is students' Claim, Evidence, and Reasoning conclusions after a lab. When we first implemented CER, we went back and forth so many times on how exactly we should score each category. What were the criteria for having "strong" reasoning compared to "weak" reasoning? This is yet another area where ChatGPT can at least get the ball rolling for teachers. The program can easily be used to generate rubrics that fit the needs of whatever criteria you're interested in. What's even better is that it can provide this to you in a table format that can be easily copy and pasted into any document. Having created several rubrics on ChatGPT, I've been surprised by how well the rubrics align with what I was actually trying to distinguish between for each category. Below is an example of a rubric generated by ChatGPT that would be used to score a CER.

Ben: Create a 3 point rubric that can be used to score a CER. Categories should include claim, evidence, and reasoning. Provide this in a table format.

ChatGPT:

Category	3 Points	2 Points	1 Point
Claim	Strong claim: The claim is clearly stated, relevant to the question or problem, and supported by evidence and reasoning.	Adequate claim: The claim is stated, relevant to the question or problem, and supported by some evidence and reasoning, but may lack clarity or specificity.	Weak claim: The claim is unclear, not relevant to the question or problem, and/or not supported by evidence and reasoning.
Evidence	Strong evidence: The evidence is accurate, relevant, and sufficient to support the claim. It includes specific details and/or examples that demonstrate a deep understanding of the topic.	Adequate evidence: The evidence is accurate and relevant, but may be insufficient or lack specific details or examples to fully support the claim.	Weak evidence: The evidence is inaccurate, irrelevant, or insufficient to support the claim.
Reasoning	Strong reasoning: The reasoning connects the claim and evidence in a clear and logical manner, demonstrating a deep understanding of the topic. It considers alternative explanations and counterarguments.	Adequate reasoning: The reasoning connects the claim and evidence, but may lack clarity or logical coherence. It may not fully consider alternative explanations or counterarguments.	Weak reasoning: The reasoning is unclear or illogical, or does not connect the claim and evidence at all.

10. Teach students to use ChatGPT for exam review.

Josh - Self-quizzing is the most effective study strategy in chemistry, yet students often rely on passive methods like flashcards or re-reading notes. Instead of creating time-consuming exam review problem sets, provide students ChatGPT review prompts. Each time they use the prompt, they will get slightly different questions so they can reuse a single prompt repeatedly.

Josh: Create 3 exam review questions for converting the mole.

ChatGPT:

1. What is the definition of a mole, and what is its relationship to Avogadro's number?
2. How many atoms are in 0.5 moles of carbon atoms?
3. If you have 10 grams of sodium chloride (NaCl), what is the number of moles of NaCl in the sample?

Josh: Provide the answers for the exam review questions you just gave me.

ChatGPT:

1. A mole is a unit of measurement that represents an amount of substance containing as many elementary entities (such as atoms, molecules, or ions) as there are atoms in 12 grams of pure carbon-12. Avogadro's number is the number of particles in one mole of a substance, which is approximately 6.022×10^{23} .

2. To calculate the number of atoms in 0.5 moles of carbon, we can use Avogadro's number:

$$0.5 \text{ moles} \times 6.022 \times 10^{23} \text{ atoms/mole} = 3.011 \times 10^{23} \text{ atoms}$$

Therefore, there are 3.011×10^{23} atoms in 0.5 moles of carbon.

To find the number of moles of NaCl in a sample of 10 grams, we need to first determine the molar mass of NaCl.

3. The molar mass of NaCl is 58.44 g/mol (sodium has a molar mass of 22.99 g/mol, and chlorine has a molar mass of 35.45 g/mol).

Next, we can use the formula:

$$\text{moles} = \text{mass/molar mass}$$

$$\text{moles} = 10 \text{ g}/58.44 \text{ g/mol}$$

$$\text{moles} = 0.171 \text{ moles}$$

Therefore, there are 0.171 moles of NaCl in a 10-gram sample.

ChatGPT can serve as a valuable resource for chemistry teachers. However, it is important to keep in mind that ChatGPT is an AI language model. The teacher must review the material generated just like they would with any other source of information. It is important to consider the accuracy of the content and exercise safety when conducting experiments. By using ChatGPT responsibly and in conjunction with other reliable resources, educators can enhance their chemistry instruction. If you haven't already tried it out yourself, you can use it for free at <https://openai.com/blog/chatgpt> (<https://openai.com/blog/chatgpt>).

References

1. Coppola, B. P., & Pontrello, J. K. (2014). Using errors to teach through a two-staged, structured review: Peer-reviewed quizzes and "What's wrong with me?" (link is external) (<https://pubs.acs.org/doi/10.1021/ed500286y>). *Journal of*

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