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Work in Progress: Guiding Chemical Engineering Instructors Toward Quick AI-generated Instructional Resources

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Abstract

The letters "AI" elicit various responses from faculty members, ranging from a pessimistic fear of how it may be abused by students to optimistic views of it improving the quality of student work and beyond. Many see potential value in generative artificial intelligence (gAI) but have seen enough issues with hallucinations and other shortcomings of gAI to be discouraged. For others, the increasing number of choices of gAIs available makes it difficult to determine how to proceed to make gAI useful in chemical engineering teaching and learning. In addition, while institutions may enact policies around gAI, faculty are rarely provided with guidance for effectively utilizing gAI to facilitate course preparation and to address student learning outcomes.

This work-in-progress report describes preliminary results from a project implemented at the University of Mississippi Department of Chemical Engineering intended to provide guidance to faculty on how to efficiently use gAI to generate student-facing resources in a short period of time based on observations of student misconceptions. Using a simple process (referred to as **DRIVE**) of **D**efine (a target learning outcome), **R**eason (identify a suitable approach to achieving those outcomes), **I**nnovate (by using AI to synthesize a resource), **V**alidate (ensure the resource is correct and useful), and **E**valuate (whether the resource impacts learning). A maximum of 1 hour per topic (and typically much less time) is spent with AI to develop a resource to address a specific student learning challenge. The process typically results in a resource that, upon validation, can be immediately deployed to an LMS for use by students and then evaluated for effectiveness. The paper will describe some of the examples developed to date and provide introductory guidance for those seeking to use common commercial AIs as part of their instructional development process.

Introduction

There is a great deal of discussion and research accompanying the emergence of generative artificial intelligence tools (gAI) over the past few years in the context of higher education. Much of that work focuses on the impact on student behavior and learning [1], [2]. Responses to perceived threats and identified opportunities with gAI have frequently focused on student use of gAI, whether as an aid to complete traditional course activities or as a primary tool to learn appropriate use of gAI tools.

This project takes a different approach than others (with some exceptions [3]) by seeking to find ways to enable faculty to use proven pedagogical methods that take significant lengths of time to implement a way to substantially cut development time by utilizing gAI tools. One of those effective pedagogical approaches is that of guided inquiry [4], applied to chemical engineering by several faculty members [5].

Background

Guided inquiry is a form of inductive learning [6]. Most instruction takes place deductively, starting from a foundational principle (like a mass balance expressing the 1st Law of Thermodynamics). Students are expected to "understand" the principle, simplify its mathematical expression, and apply it to specific situations. An inductive approach, however, mirrors the discovery process that underlies the principle. Instead of starting from the result, students explore or experiment to build up a sense of relationships and connections for specific cases and use their set of observations to postulate the summative principle or relationship.

Guided inquiry is a specific approach to that inductive learning process. In guided inquiry, students begin by observing a scenario, and then they predict behaviors and outcomes using their current knowledge. Resources are provided to students to experiment (physically or virtually) and seek the actual outcome for the scenario. After exploration, they evaluate their prediction and consider why they predicted incorrectly (or correctly). This approach further encourages classroom collaboration for discussion and further predictions in related scenarios. The process can be repeated with multiple sets of prediction/experiment/evaluation cycles covering several related intended learning outcomes.

Perhaps the biggest challenge of guided inquiry is the experimental stage. Physical experimentation is challenging for lecture classes and often impractical in larger classroom settings. Virtual experimentation removes most barriers, but developing a useful simulation that is broadly accessible requires a specific set of skills and significant time investment to create a useful simulation. This project leverages certain emergent capabilities of gAI to remove barriers to implement guided inquiry. This project demonstrates how gAI can generate useful simulations and a complete assignment draft for implementing guided inquiry.

Method

There are many gAI platforms that can be used for software development. To enable focus for this project, we limited consideration of platforms to those that were broadly available and utilized within academia. Furthermore, we wanted a platform that most readily enabled transfer into a learning management system (LMS) such as Blackboard Ultra. To that end, most of our work to date has been performed on Google Gemini and on OpenAI's ChatGPT. Generative AI is used because it reduces the development time for creating a simulation-based guided inquiry activity to under one hour, compared to weeks or months in the author's experience.

This project began shortly after Google released its “Canvas” toolkit within Gemini [7]. Gemini Canvas is an AI specifically trained to develop web-based JavaScript applications embedded in HTML and may be enabled at the Gemini prompt as shown in Figure 1. The gAI prompt is used to guide design and revision of the application, and the result is presented in Gemini as a switched display where the user can rapidly move between the inline editable JavaScript code and the running software as shown in Figure 2.

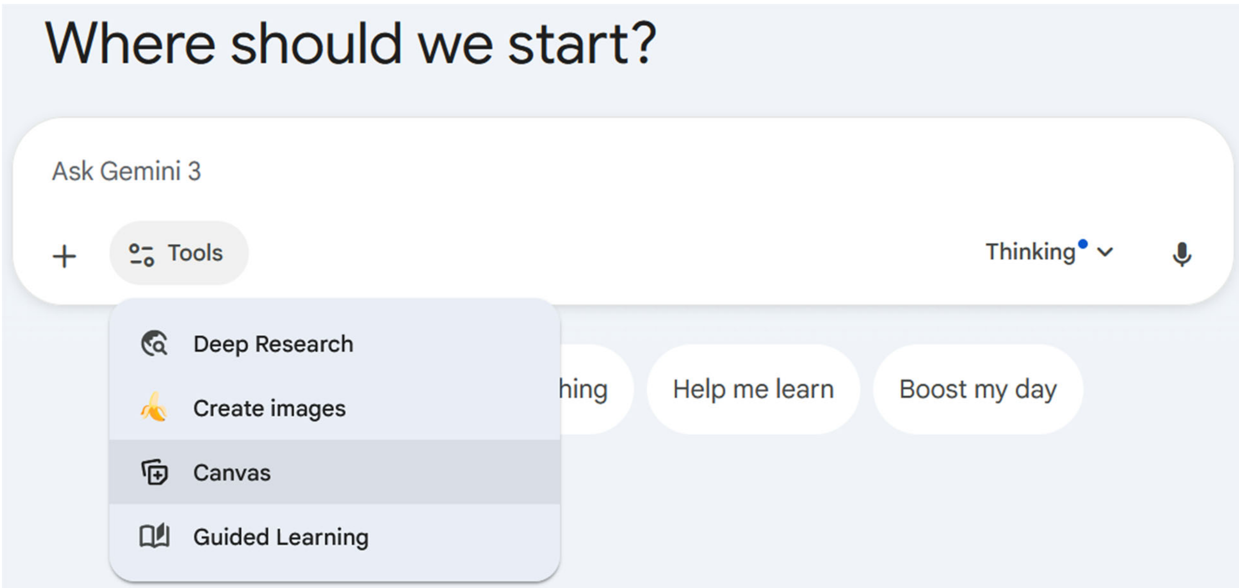

Figure 1. Initial prompt in Gemini with available tools. Enabling Canvas accesses specialized training in generating JavaScript applications.

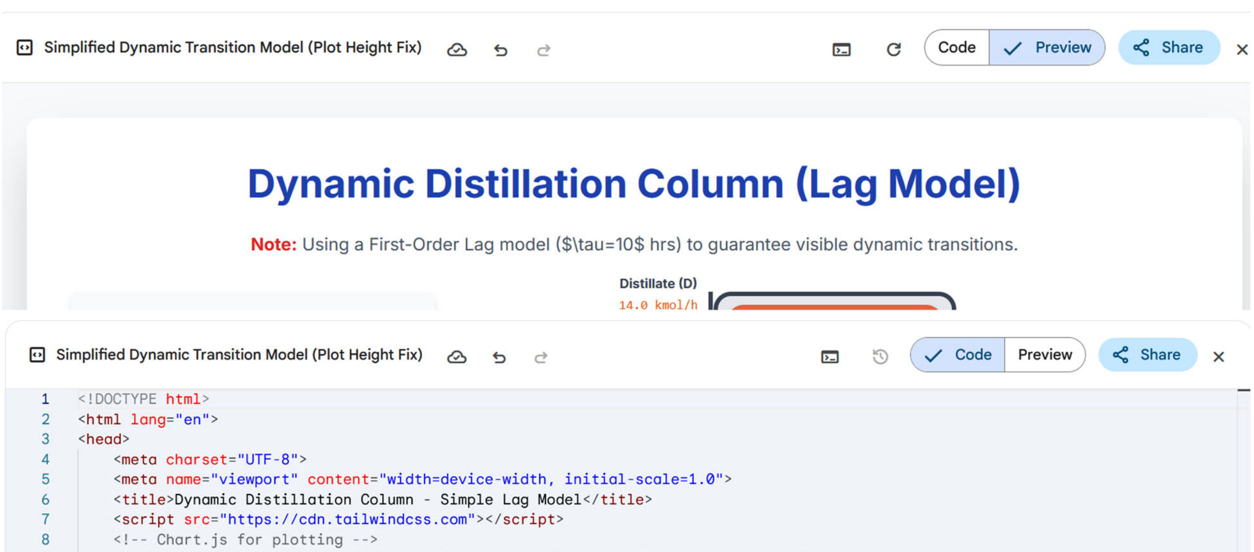

Figure 2. Top image with Preview (working JavaScript application) selected, bottom image with Code view selected. These alternative views allow for rapid testing of user changes and to inspect the methods the gAI used in implementing the mathematical, scientific, and engineering calculations.

To create a simulation application, we recommend the following approach based on our experience since beginning the project during Spring 2025. For convenience, we refer to this process as **DRIVE**.

1. **D**efine learning outcomes
2. **R**eason through potential instructional approaches
3. **I**nnovate by using gAI to synthesize a resource and a draft of accompanying activities or other instructional materials
4. **V**alidate the products to ensure the resources are accurate and aligned with intended learning outcomes
5. **E**valuate learning impacts. This step has not been completed such that results can be shared at this time for this project.

The context of our initial use of this process has been a course teaching material balances to Sophomores majoring in Chemical Engineering. All use of gAI in this course to develop course materials was disclosed by the instructor, and no assessment of student work utilized gAI.

During Fall 2025, we applied the **DRIVE** methodology in a material balances course (Ch E 307) by scheduling a weekly 30-minute meeting amongst the authors (two faculty members and the course undergraduate teaching assistant who was one year removed from the course) to identify outcomes students were struggling with achieving or were likely to find challenging. Each of the authors was then charged with spending no more than one hour before the following class meeting developing a gAI product that could potentially improve student performance with respect to the targeted outcome. We would meet again after the next class meeting to review our work and (if the course instructor had implemented an intervention) discuss observations.

Initially, the three co-authors considered a wide range of gAI products including quizzes, animations, and tutorials in addition to the guided inquiry simulations. Products beyond guided inquiry using simulations are outside the scope of this work.

To address the project goal of providing faculty guidance on using gAI as a means of implementing proven effective pedagogies, we narrowed our focus to the simulation-centric work and documented not only the product but also the process (primarily prompts) used to obtain the product. For this work-in-progress, evaluation of effectiveness is outside the scope of this report.

Examples

During week 8 of the Fall 2025 term, the team identified challenges encountered by students in working with standard volumetric flow rates of gases. Our discussion suggested that students did not readily see how standard flows related to typical expressions of flow or why we would want to use them. Proceeding through the DRIVE process, we **D**efined the desired learning outcomes as a group such that the final learning outcomes were:

1. Compare standard volumetric flow rate and other measures of flow rate.
2. Explain how temperature and pressure affect gas volume and flowrates.
3. Explain why standard volumetric flowrates are useful

We then **R**easoned through paths to achieving the objectives by brainstorming, with one team member selecting an approach demonstrating how temperature and pressure and mass flows impact volumetric measures of gas flow rates.

To **I**nnovate, the initial prompt given to Gemini with the Canvas option selected was:

```
Generate an app that simulates the relationship amongst mass flow,
actual volumetric flow, and standard volumetric flow. Inputs would be
sliders representing a range of mass flows, a corresponding range of
actual volumetric flows, and the equivalent standard volumetric flow.
The app title should indicate that only gas phase flows are considered.
If any one of these inputs change, the other sliders should dynamically
adjust. The values of all three should be represented graphically as
well. There should be two additional inputs for temperature and for
pressure. When these values change, the other inputs values should
adjust, but temperature and pressure inputs are independent of the
other variables. All values should be labeled with a consistent set of
units. Actual volumetric flows should assume ideal gas. Standard
volumetric flow is defined as an equivalent flow of gas at standard
temperature and pressure.
```

There were three additional prompts given to fix appearance and to pair limits on values used by the sliders. Note that while we used additional prompts, most of these changes could have also been made by minor changes to the well-commented code generated by gAI. The final application is shown in Figure 3.

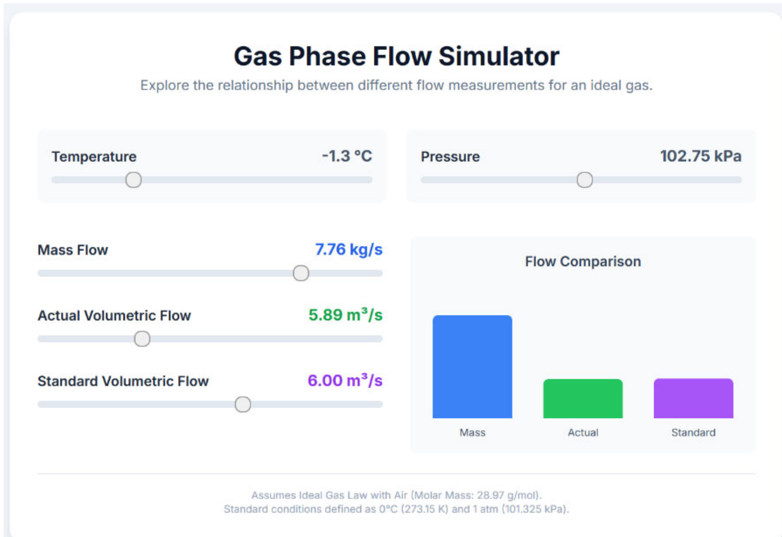

Figure 3. Screen capture of simulator to allow rapid comparison of measures of flow rate as functions of temperature, pressure, and mass flow.

To place this into Blackboard Ultra, a new "Document" was created. The first element on the page was created as an HTML block. We copied the complete gAI generated code (JavaScript embedded into HTML) and pasted it into the Blackboard HTML block. The app was fully operational in both instructor and student modes without further editing.

After **V**alidating the app for minimum qualitative accuracy, the AI was then prompted to generate an accompanying inquiry activity. Since that free account had its daily allocation of inquiries exhausted, another user account was prompted:

```
For the simulator created at (link to shared app generation query),
create a guided inquiry activity that will help students understand
what standard volumetric flowrates are.
```

The separate instance of the gAI could not utilize the link, so the co-author described the simulator.

```
The simulator allows you to vary mass flow, actual volumetric flow, and
standard volumetric flow for a gas treated as ideal. Additionally, you
can vary temperature and pressure. The three flow rate variables are
updated upon changes to any of the other variables, and are graphically
displayed in a bar chart.
```

The resulting guided inquiry activity is given in Figure 4.

Guided Inquiry: What is a "Standard" Flowrate?

This activity will guide you through an exploration of gas flowrates using the simulator. By changing variables and observing the results, you'll develop a strong understanding of mass flow, actual volumetric flow, and the crucial concept of **standard volumetric flow**.

Learning Objectives:

- Define and differentiate between mass flowrate, actual volumetric flowrate, and standard volumetric flowrate.
- Explain how temperature and pressure affect gas volume and flowrates.
- Articulate why standard volumetric flowrate is an essential tool for comparing gas quantities under different conditions.

Part 1: First Observations & Predictions

Get to know the simulator. You can adjust five variables: **mass flow**, **actual volumetric flow**, **standard volumetric flow** **temperature**, and **pressure**. Notice how the three flowrates are linked—changing one often changes the others.

1. **Initial Setup:** Set the **mass flowrate** to 10 kg/s. Use the default values for temperature and pressure.
    - What are the initial values for **actual volumetric flowrate** and **standard volumetric flowrate**? Are they the same or different?
2. **Making Predictions:** Discuss with a partner:
    - What do you think is the difference between how much *space* the gas takes up (volume) and how much *stuff* is in it (mass)?
    - Why do you think one flowrate is called "actual" and the other is called "standard"? What might "standard imply?

Part 2: The Effect of Temperature & Pressure

Let's investigate how the gas conditions affect its flow.

1. **Set a Baseline:** Start by setting a constant **mass flowrate** of 8 kg/s. Note the starting values for all variables. You mass flowrate represents a fixed amount of gas molecules moving through the pipe each second.
2. **Investigate Temperature:**
    - **Prediction:** If you heat the gas (increase temperature) but keep the mass flow and pressure constant, wha do you think will happen to the space it occupies (its volume)? Will the **actual volumetric flowrate** increas decrease, or stay the same? What about the **standard volumetric flowrate**?
    - **Experiment:** Slowly increase the **temperature**. Watch the bar chart and the numbers.
        - What happens to the **actual volumetric flowrate**?
        - What happens to the **mass flowrate** and **standard volumetric flowrate**?
    - **Explain:** Why did the actual volumetric flowrate change? Think about how gas particles behave when they get hotter. Why did the other two flowrates *not* change?
3. **Investigate Pressure:**
    - **Prediction:** Reset to your baseline (8 kg/s). If you squeeze the gas (increase pressure) but keep the mass flow and temperature constant, what will happen to its volume? Will the **actual volumetric flowrate** increase, decrease, or stay the same?
    - **Experiment:** Slowly increase the **pressure**.
        - What happens to the **actual volumetric flowrate**?
        - Did the **mass flowrate** or **standard volumetric flowrate** change?
    - **Explain:** Why did compressing the gas change its actual volume? Why is it useful to have a flow measurement that *doesn't* change when the pressure changes?

Part 3: Finding the "Standard"

What makes the standard volumetric flowrate "standard"? Let's find out.

1. Your goal is to find the exact temperature and pressure where the **actual volumetric flowrate** is *equal* to the **standard volumetric flowrate**.
2. **Experiment:** Adjust the **temperature** and **pressure** until the two bars on the chart are the same height.
3. **Analysis:**
    - At what temperature and pressure are the two volumetric flowrates equal?
    - These are the **Standard Conditions** (like a universal baseline) for this simulator. Why do you think scientist and engineers need a baseline for comparing gas measurements?

Part 4: Putting It All Together

Answer the following questions to summarize your findings.

1. In your own words, define:
    - **Actual Volumetric Flowrate:** The volume of gas that is *actually* passing a point right now, at its *current* temperature and pressure.
    - **Standard Volumetric Flowrate:** The volume that the same gas *would* occupy if it were at a standard temperature and pressure.
2. **Scenario:** An engineer is measuring the natural gas flow to a factory in Minnesota in the winter (-10°C) and to a factory in Texas in the summer (35°C).
    - Which measurement—**actual** or **standard** volumetric flowrate—would be better to use to ensure both factories are receiving the same amount of fuel (i.e., the same number of gas molecules)? Why?
    - What would be misleading about comparing their **actual** volumetric flowrates?
3. **Conclusion:** Explain why standard volumetric flowrate is so important. How does it allow for a fair, "apples-to-apples" comparison of gas quantities anywhere in the world, regardless of local weather conditions?

Figure 4. Guided inquiry activity generated by Gemini, including graphics and formatting.

This inquiry activity was read closely and determined by the team to be acceptable. Note that the learning objectives were not provided to the gAI but still substantially replicated ones that the authors had discussed. The gAI's guided inquiry was copied and pasted into a regular text block in the same Blackboard document containing the simulation file.

A total of thirty minutes was invested in developing both the simulation and the activity and moving it into the LMS. While this assignment was not made during this term (because another instructor was teaching the targeted course and had another plan) and hence has not been **E**valuated for effectiveness, it does represent a potentially simple, effective approach to rapid innovation and holds an expectation of effectiveness based on prior art.

A second example was developed when vapor-liquid equilibrium topics were covered in the course. We **D**efined learning outcomes to aid students in reading VLE diagrams (outcome 1), visualize how segment lengths were proportional to phase distributions (outcome 2), and enable exploration of temperature and pressure effects (outcome 3). The following prompt was given after a discussion **R**easoning through potential solutions to **I**nnovate a product:

```
Generate a simulation that visualizes saturation in a closed piston
cylinder with a heating element that contains benzene and toluene. The
user can set the temperature, pressure, an initial vapor fraction with
sliders. The user can also set the overall composition of the system as
a mole fraction of Benzene with a slider. The color of the vapor phase
darkens as concentration in the vapor phase increases. In addition to
the schematic of the contents of the piston cylinder, show a Txy and a
Pxy diagram with a paths from the initial condition point for the
overall system to the final equilibrium points representing the vapor
and liquid states. As the vapor fraction increases, the vapor coloring
in the schematic should darken.
```

The application shown in Figure 5 was generated.

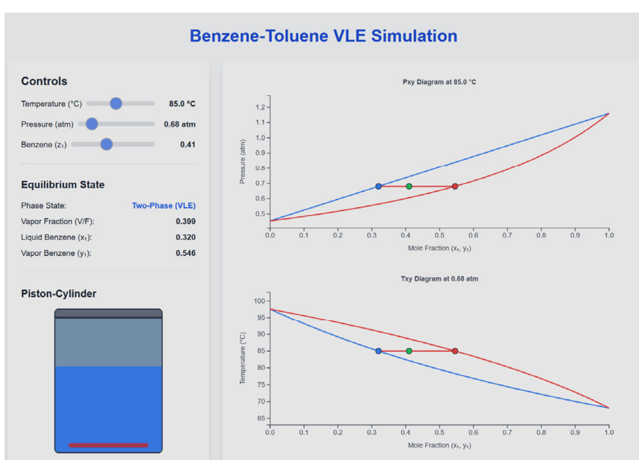

Figure 5. VLE Simulation Application developed with Google Gemini.

To generate the accompanying inquiry activity within the same session, the following prompt was given:

```
Create a guided inquiry activity to accompany this simulation. Learning
outcomes should include identification of saturation conditions,
application of Gibbs phase rule, exploring T and P effects on phase
distribution, and an exploration of successive flash operations.
```

Note that learning outcomes often shifted between the initial planning and the finalization of the simulation, and this was a good example of that transition. The first part of the activity is shown in Figure 6.

Benzene-Toluene VLE: A Guided Inquiry

This activity uses a dynamic simulation to explore the principles of vapor-liquid equilibrium (VLE) for an ideal binary mixture of benzene and toluene.

Learning Outcomes

By the end of this activity, you should be able to:

1. Identify saturation conditions (bubble point and dew point) on phase diagrams.
2. Apply the Gibbs Phase Rule to subcooled liquid, superheated vapor, and two-phase regions.
3. Predict the effect of changing temperature (T), pressure (P), and overall composition (z) on the phase distribution (V/F) and equilibrium compositions (x, y).
4. Describe how a simple multi-stage "flash" operation can be used to separate a mixture.

Key Concepts

- **Raoult's Law (Ideal Solution):** Assumes the vapor pressure of a component in a mixture is its mole fraction in the liquid (x_i) times the pure component vapor pressure (P_i^{sat}).
  - Partial Pressure: $P_i = x_i P_i^{sat}$
  - Total Pressure: $P_{total} = \sum P_i$
- **Bubble Point:** The temperature (at constant P) or pressure (at constant T) where the *first bubble* of vapor forms from a liquid.
- **Dew Point:** The temperature (at constant P) or pressure (at constant T) where the *first drop* of liquid forms from a vapor.
- **Gibbs Phase Rule:** $F = C - P + 2$
  - F: Degrees of Freedom (number of intensive variables you can change independently)
  - C: Number of Components
  - P: Number of Phases

Part 1: Getting Familiar with the Simulation

Set the simulation to the following initial state:

- **Temperature (T):** 90.0 °C
- **Pressure (P):** 1.00 atm
- **Benzene (z_1):** 0.50

1. **Observe the Interface:**
   - **Controls:** Identify the three sliders (T, P, z_1).
   - **Readouts:** What is the "Phase State"? What are the values for "Vapor Fraction (V/F)", "Liquid Benzene (x_1)", and "Vapor Benzene (y_1)"?
   - **Schematic:** How does the "Piston-Cylinder" visually represent the V/F value?
   - **Diagrams:** You see two diagrams: Pxy (Pressure vs. Composition) and Txy (Temperature vs. Composition). The blue line is the **bubble-point line**, and the red line is the **dew-point line**.
2. **Initial State Analysis:**
   - At T=90°C, P=1.0 atm, and z_1=0.5, what is the state of the system?
   - On the Pxy and Txy diagrams, find the **green dot**. This represents your overall system (T, P, z_1). Is it in the subcooled liquid, two-phase, or superheated vapor region?
   - Since the system is two-phase, a red **tie-line** connects the equilibrium liquid composition (blue dot) and vapor composition (red dot).
   - What are the equilibrium compositions?
     - Liquid (x_1): ______
     - Vapor (y_1): ______
   - Which component (Benzene or Toluene) is more volatile (evaporates more easily)? How can you tell this from the x_1 and y_1 values?

Part 2: Finding Saturation Conditions

2a: Bubble and Dew Point at Constant Temperature

1. Set **T = 90°C** and **z_1 = 0.5**.
2. Set **P = 2.0 atm**.
   - What is the Phase State? _________________
   - What is the Vapor Fraction (V/F)? _____
3. Slowly **decrease the pressure** slider. Watch the "Phase State" and "V/F" readouts.
4. At what exact pressure does the *first bubble* of vapor appear (i.e., V/F just becomes > 0)? This is the **bubble-point pressure**.
   - P_{bub} = _____ atm
5. Continue to **decrease the pressure**.
6. At what exact pressure does the *last drop* of liquid disappear (i.e., V/F becomes 1.0)? This is the **dew-point pressure**.
   - P_{dew} = _____ atm
7. **Check your work:** Look at the Pxy diagram. Your measured P_{bub} and P_{dew} should be the pressures where the green dot (at z_1=0.5) intersects the blue bubble line and red dew line.

2b: Bubble and Dew Point at Constant Pressure

1. Set **P = 1.0 atm** and **z_1 = 0.5**.
2. Set **T = 80°C**.
   - What is the Phase State? _________________
3. Slowly **increase the temperature** slider.
4. At what temperature does the *first bubble* of vapor appear? This is the **bubble-point temperature**.
   - T_{bub} = _____ °C
5. Continue to **increase the temperature**.
6. At what temperature does the *last drop* of liquid disappear? This is the **dew-point temperature**.
   - T_{dew} = _____ °C
7. **Check your work:** Look at the Txy diagram. Do your measured T_{bub} and T_{dew} match the intersections on the Txy plot?

Figure 6. Guided inquiry activity generated by Google Gemini to accompany VLE Simulation app.

Note that during the **V**alidation process, we noted the learning outcomes had shifted from our designations, but not in a way that made them less useful. For this activity, the length was such that it would likely need to be subdivided into multiple activities (some elements before class, some in class as one possibility) due to the number of virtual explorations (five “parts” with multiple sub-parts) generated. Again, no **E**valuation of student impact was attempted.

Ongoing Work

Only a few of the gAI products were used in the material balance course at the University of Mississippi in Fall 2025. Both of the professors involved in this paper plan to individually implement guided inquiry with gAI developed simulations and assignments during Spring 2026 as part of their courses in energy balances and in fluid mechanics. One of the key elements we will examine is how to most efficiently construct a prompt for AI to develop a simulation. Once IRB oversight is in place, we will also be looking at the final step of the process, **E**valuation of effectiveness, for dissemination rather than the restricted internal review currently conducted.

Conclusions

This paper describes a work-in-progress for preparing guidance for faculty to utilize gAI to rapidly develop simulation-based interventions to improve student achievement of learning outcomes in chemical engineering and other engineering courses. Preliminary results have demonstrated that it is practical to develop web applications and accompanying assignments in less than one hour to generate products similar to prior art that have an expectation of effective improvement of student outcomes, specifically guided inquiry with simulation.

Acknowledgement

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References

[1] Chen, C. V., & Ratanalert, S. (2025, June), *Development of an MEB Novice Chatbot to Improve Chemical Engineering Critical Thinking* Paper presented at 2025 ASEE Annual Conference & Exposition , Montreal, Quebec, Canada . 10.18260/1-2--56281

[2] Monje, V., & Li, J., & Ford Versypt, A. N., & Sanchez-Pena, M. L. (2025, June), *BOARD # 46: Work-in-progress: Evidence-based scope and selection of threshold concepts for the design of computational notebooks in undergraduate statistics courses for chemical engineering* Paper presented at 2025 ASEE Annual Conference & Exposition , Montreal, Quebec, Canada . 10.18260/1-2--55841

[3] Bilgin, B., & Chen, C. V., & Velegol, S. B. (2025, June), *Generative AI in Chemical Engineering Education: Rebuilding Thermodynamics, Material and Energy Balances and Kinetics Courses with AI and Chemical Engineering Students' Perception of AI* Paper presented at 2025 ASEE Annual Conference & Exposition , Montreal, Quebec, Canada . 10.18260/1-2--56640

[4] Hake, R.R., “Interactive-Engagement vs. Traditional Methods: A Six-Thousand-Student Survey of Mechanics Test Data for Introductory Physics Courses,” American J. Physics, 66(1), 64 (1998)

[5] Vigeant, M., Prince, M. & Nottis, K., "Development of Concept Questions and Inquiry-Based Activities in Thermodynamics and Heat Transfer: An Example for Equilibrium vs. Steady State", *Chemical Eng. Ed.*, 45(3), 211 (2011).
[6] Michael J. Prince and Richard M. Felder. Inductive Teaching and Learning Methods: Definitions, Comparisons, and Research Bases. J. Engr. Education, 95(2), 123–138 (2006).
[7] https://workspaceupdates.googleblog.com/2025/03/introducing-canvas-for-the-gemini-app.html, accessed January 19, 2026