Infusing Entrepreneurially Minded Learning into First-Year Chemistry for Engineers through Fun Fridays

Dr. Kamila M Deavers, Marian University

Dr. Kamila Deavers is an environmental chemist and educator dedicated to advancing student learning in general chemistry through engaging, real-world instruction. Her teaching integrates environmental, public health, and engineering contexts to help students connect core chemical concepts to meaningful applications. She creates an active, student-centered classroom that emphasizes inquiry, critical thinking, and curiosity, often incorporating creative approaches such as music and problem-based learning to deepen engagement. In addition to her teaching, she involves undergraduate students in community-based research projects addressing local environmental challenges. Her work reflects a strong commitment to innovative chemistry education and to support students in exploring science beyond the classroom.

Dr. Najmus Saqib, Purdue University

Dr. Najmus Saqib is a Senior Lecturer in the School of Mechanical Engineering at Purdue University, joining in Fall 2025, with teaching experience in his field since 2017. He earned his Ph.D. in Mechanical Engineering from Colorado School of Mines, where his research pioneered the use of quantitative operando infrared spectroscopy to study lithium-sulfur and lithium-ion battery electrolytes. His current interests include developing diagnostic tools for electrochemical energy storage and advancing the Scholarship of Teaching and Learning in Engineering Education. Prior to joining Purdue, he was a founding faculty member and program coordinator for Mechanical Engineering at the University of Indianapolis, where he led curriculum development and a successful initial ABET accreditation. He is dedicated to innovative, student-centered teaching, incorporating real-world problem solving and entrepreneurial-minded learning, and is deeply committed to mentoring students in their academic and professional growth.

Infusing Entrepreneurially Minded Learning into First-Year Chemistry for Engineers through Fun Fridays

Abstract

This evidence-based complete paper documents the infusion of Entrepreneurially Minded Learning (EML) in a General Chemistry course. EML emphasizes educating the "whole person" by supplementing traditional theory with nontechnical concepts related to curiosity, connections, and creating value (the three Cs). Integrating the EML framework has been a strong focus in curriculum changes in many engineering programs, both old and new, across the United States. Many of these changes have been infused into multidisciplinary courses that impact all engineering disciplines, including first-year engineering coursework. However, a significant, if not a major, share of typical first-year engineering courses are taught by instructors from other STEM fields. Mathematics, Physics, and Chemistry are perhaps the most obvious. EML is relevant to all these fields. General Chemistry classes are often overwhelming and stressful for first-year students because they are content-heavy and require the use of many fundamental STEM principles. Students usually memorize the exact procedure for a calculation, step by step, but do not think about how the concepts could apply beyond the specific problem. Teaching students how to think outside of the box about problems and how to apply their knowledge beyond the chemistry classroom is an important aspect of EML. This paper describes the development of a series of "Fun Fridays" activities for a General Chemistry classroom to help students develop an entrepreneurial mindset for approaching chemistry problems. These in-class activities involve solving chemistry problems in myriad real-life scenarios, while leveraging one or more of the three Cs of EML. Instead of focusing on the solution steps, the problems encourage students to think outside of the box and apply their chemistry knowledge in a broader context. Surveys were conducted at the middle and end of the semester to gauge student perceptions of the "Fun Fridays" activities. Qualitative and quantitative results from the surveys are presented in this paper. Incorporating these problems in General Chemistry increased student engagement in the classroom and helped them view chemistry in a broader societal context. Students were excited about Fridays' activities and felt less stressed in the classroom. They left the classroom with confidence that they were able to solve different types of problems and apply the concepts they learned in general chemistry beyond the classroom. High levels of engagement in introductory chemistry courses may contribute to increased retention of all STEM majors, including first-year engineering students.

Introduction

Entrepreneurially Minded Learning (EML) is an educational framework that aims to develop students' ability to think critically, make connections, and create value within and beyond their discipline. Rooted in the Kern Entrepreneurial Engineering Network (KEEN) philosophy, EML seeks to complement technical skills with the development of curiosity, connections, and creating value – the three Cs – to prepare students for complex, real-world challenges [1]. While originally conceptualized for engineering education, EML's principles have been widely recognized as applicable across STEM disciplines, offering opportunities to foster creativity, innovation, and interdisciplinary problem-solving in a variety of educational settings [2,3].

First-year engineering students often face a transition from high school to the demands of college-level coursework. Many first-year engineering programs emphasize foundational STEM courses, such as Mathematics, Physics, and Chemistry, taught by faculty outside traditional engineering departments [4]. These courses are critical for student success, yet they are frequently perceived as challenging, content-heavy, and disconnected from real-world applications [5]. General Chemistry, in particular, is often viewed as a high-stakes course where students focus on rote memorization and procedural problem-solving without fully understanding the broader implications of their knowledge [6].

Prior studies have demonstrated the effectiveness of EML in capstone design courses, multidisciplinary engineering classes, and co-curricular activities [7,8]. However, fewer studies have explored the implementation of EML in foundational courses that serve as prerequisites for all STEM majors. This paper builds upon existing research by extending EML into a first-year general education setting, specifically within a General Chemistry classroom. By integrating EML into General Chemistry, this study, undertaken at Marian University, aims to enhance student engagement, reduce classroom anxiety, and improve retention among first-year engineering students and other STEM majors.

To address these challenges, this study integrates EML principles into the General Chemistry classroom through the development of "Fun Fridays", a series of engaging, real-life problem-solving activities. These activities are designed to help students connect chemistry concepts to societal challenges, foster curiosity, and instill confidence in their ability to tackle complex, interdisciplinary problems. By framing problems within real-life contexts, students are encouraged to think beyond the classroom and explore the relevance of chemistry in their future careers and the broader world. While this study focuses on General Chemistry, the methods and outcomes have implications for other STEM disciplines and general education courses, highlighting the broad applicability of EML principles.

Project Approach

This study was conducted at a primarily undergraduate institution with small class sizes. The General Chemistry course included a mix of first-year engineering students and other STEM majors. Class sizes ranged from 25 to 30 students, facilitating interactive activities and discussions. The study spanned two semesters and involved weekly "Fun Fridays" activities, designed to incorporate EML principles into the curriculum.

The “Fun Fridays” activities were developed to align with the three Cs of EML: curiosity, connections, and creating value. Each Fun Friday activity was intentionally aligned with current course learning objectives (e.g., stoichiometry, thermochemistry). Activities were scheduled to coincide with relevant topics, reinforcing and extending traditional problem-solving skills through applied, real-world contexts. Each activity involved solving a chemistry-related problem grounded in a real-life scenario, such as environmental issues, health care, or plain fun applications of chemistry. Examples included:

1. James Bond (Stoichiometry and Gas Laws)
2. Up (Gas Laws and Buoyancy)
3. Hair Remediation (Unit Conversions)
4. Saline Solution (Solution Chemistry)
5. Affogato Dream (Thermochemistry)

The activities listed above are included in the Appendix at the end of this paper and are also available on Engineering Unleashed (https://engineeringunleashed.com/).

The problems were intentionally written to encourage students to explore the broader societal implications of their work. Activities were designed to foster collaboration, critical thinking, and communication skills, key components of an entrepreneurial mindset. Each problem aligns with the topics currently being covered in class while embedding fun real-world and pop-culture applications to spark curiosity and engagement. The development process begins with brainstorming scenarios that are relatable and thought-provoking, taking a few days to refine. During this time, relevant data and sources are researched, and the problem is iteratively adjusted to ensure that it is both challenging and accessible. Some calculations are simplified to account for students’ limited knowledge of complex processes, while others adhere closely to real-world procedures. The goal is to strike a balance between realism and feasibility, creating problems that are approachable yet stimulating. Problems often integrate multiple concepts, encouraging students to think critically, make connections, and view their surroundings through the lens of chemistry. For instance, students often struggle to connect abstract concepts with tangible, everyday phenomena. To address this, Fun Friday problems are designed to merge various ideas into a single scenario. This approach not only reinforces their understanding but also inspires them to see the relevance of chemistry in the world around them.

The study reported herein is limited to a single institution with small class sizes, which may not be fully representative of larger or more diverse educational settings. Additionally, the focus on General Chemistry may limit the generalizability of specific activity examples to other STEM disciplines. However, the overarching principles of EML and the “Fun Fridays” framework are broadly applicable and can be adapted to a variety of courses and contexts.

Classroom Approach

During the semester, each Friday was dedicated to a “Fun Fridays” activity. Each Friday began with a simple ritual: the question, “What day is today?” The answer is always the same: “It’s Friday, which means it’s a Fun Friday!” This sets the tone for a unique and engaging session of Fun Friday activities. With a 50-minute class period, the time devoted to these activities is adjusted based on the complexity of the problem, typically spanning 20-30 minutes. Each session starts with an enthusiastic introduction to the problem, which is then broken down, step-by-step, with clear reasoning provided for every calculation. Students work in small groups to collaboratively solve problems, with the instructor facilitating rather than leading solutions. In some cases, guided walkthroughs are provided after initial attempts to reinforce key concepts. To cultivate an inviting and relaxed atmosphere, background music related to the theme of the problem is played. This small but thoughtful detail enhances the classroom environment, making students feel more engaged and energized.

Some calculations are conducted under a time constraint, particularly those related to high-stakes scenarios, such as problems concerning medical applications. By incorporating a timer, students gain experience working under pressure, simulating real-world conditions that often require quick decision-making and problem-solving. These elements are intentionally designed to build both competence and confidence in applying chemistry principles beyond the classroom.

Methods

This study was conducted at a primarily undergraduate institution during the Fall 2024 and Spring 2025 semesters in a General Chemistry course enrolling first-year engineering students and other STEM majors. Class sizes ranged from 25 to 30 students, with a total of 55 respondents to the mid-semester survey and 58 respondents to the end-of-semester survey across both semesters. The instructional setting emphasized interactive engagement and collaborative learning.

To evaluate the effectiveness of the “Fun Fridays” approach, two anonymous student surveys were administered via Qualtrics: a mid-semester survey and an end-of-semester survey. The mid-semester survey served as a formative assessment tool to gather real-time feedback and inform instructional adjustments, while the end-of-semester survey functioned as a summative assessment of student perceptions.

Both surveys included a combination of Likert-scale and open-ended questions. Likert-scale items (1 = Strongly Disagree to 5 = Strongly Agree) assessed student perceptions of engagement, relevance to real-world applications, conceptual understanding, curiosity, and stress levels. The end-of-semester survey included additional items related to perceived impact on problem-solving skills and overall course performance.

Quantitative data from the Likert-scale items were analyzed using descriptive statistics, with mean responses calculated for each question. *Qualitative responses* from open-ended questions were analyzed using an inductive thematic approach. Student comments were reviewed and coded to identify recurring themes related to engagement, conceptual understanding, real-world connections, and classroom experience. Mid-semester qualitative feedback was also used to inform iterative improvements to the implementation of “Fun Fridays” during the semester.

This study is limited by its reliance on self-reported student perceptions, which may not directly reflect measurable learning gains. Additionally, the study was conducted at a single institution with relatively small class sizes, which may limit generalizability. Future work will explore the impact of this approach on student performance and conceptual understanding through direct assessment measures.

Results and Discussion

Qualitative and Quantitative Student Feedback

Likert Scale Survey Questions

Select your level of agreement with the following statements:
(1 - Strongly Disagree, 2 - Disagree, 3 - Neutral, 4 - Agree, 5 - Strongly Agree)

Mid-Semester

A) I enjoy the Fun Friday activities.
B) The Fun Friday activities help me better understand course concepts.
C) The Fun Friday activities represent real-life scenarios that we may encounter as professionals in our fields.

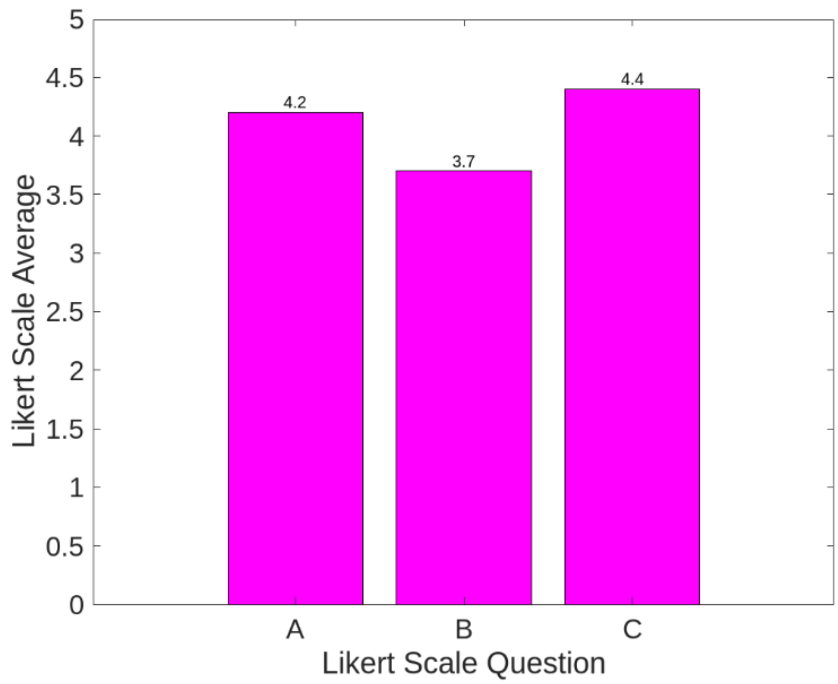

Figure 1: Average results of Likert scale mid-semester survey questions. Data was collected during the Fall 2024 and Spring 2025 semesters with 55 respondents.

End-of-Semester

A) Fun Fridays helped me enjoy my chemistry course.
B) Fun Fridays helped me connect how I may apply chemistry concepts while working in my field.
C) Participating in the Fun Friday activities improved my overall course grade.
D) The Fun Friday activities sparked my curiosity to seek out knowledge beyond the classroom.
E) The Fun Friday activities helped me to develop a problem-solving mindset beyond just learning the concepts.
F) The Fun Friday activities helped me reduce my stress levels in the chemistry classroom.

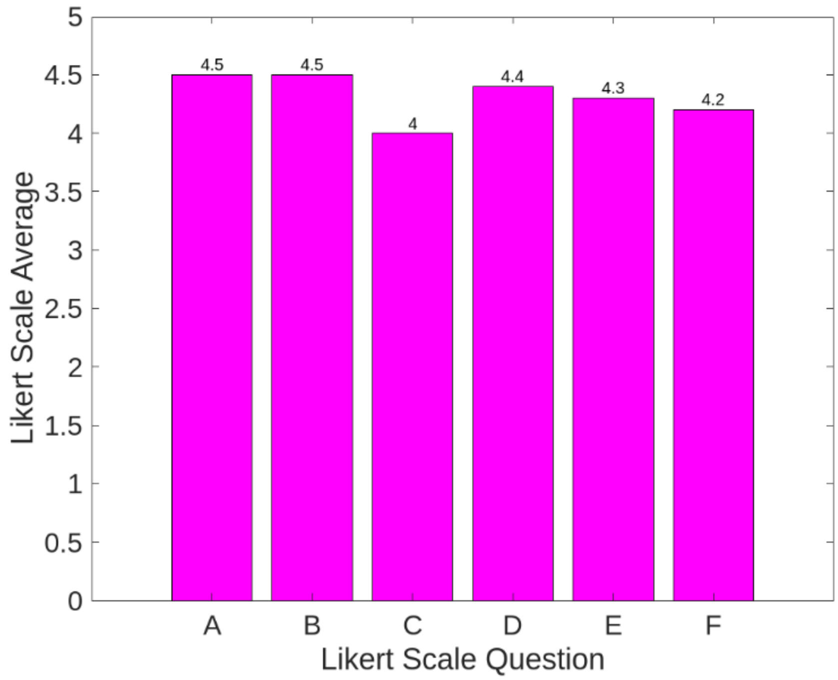

Figure 2: Average results of Likert scale end-of-semester survey questions. Data was collected during the Fall 2024 and Spring 2025 semesters with 58 respondents.

Short Answer Survey Questions

Mid-Semester (samples responses follow)

1. Please explain if/how the activities help you better understand course concepts.
2. Is there a concept that you would like the instructor to incorporate on a future Fun Friday activity this semester?

- "The Fun Friday activities shows that the calculations have a wide variety of real-world applications. It makes the concepts more interesting and reveals the myriad of occupations that utilize chemistry."
- "They help me understand the materials and how they are applied in the real world so it gives it a purpose."
- "It makes you think and make connections."
- "It just shows me that sometimes I can use chemistry in real life."

End-of-Semester (samples responses follow)

1. Did you have a favorite Fun Friday activity? If so, which one and why?
2. Please explain if/how the activities improved your overall course grade.
3. Is there a concept that you would like the instructor to incorporate on a Fun Friday activity next year?

- "I liked all the calculations, but my favorite was the one where we got to do a calculation and got to have ice-cream. I really liked this one because the calculation was an application and we got to enjoy something sweet."

- “The oil spill hair fun Friday, it was interesting to see that what we are learning is used in real life and that our hair could be used to soak up oil spills in the ocean.”
- “I liked the one where we calculated how many balloons were needed to lift the Up house, because that was a favorite childhood movie of mine.”
- “By engaging with real life scenarios, I was able to further understand the material that was being explained and how it could be applied in a practical as opposed to a theoretical way.”
- “These activities helped me to apply what we were doing in class to examples that were not homework problems. Being able to ask questions and class and being guided through these was very helpful.”
- “The activities improved my overall course grade because when one understands the concept and can apply it they can then apply it to future problems”.

Discussion of Survey Results

The quantitative survey results summarized in Figure 1 and Figure 2 were overwhelmingly positive. In both surveys, students agreed that the activities were enjoyable and helped them connect theoretical course concepts to practical scenarios. They noted that the activities sparked their curiosity and helped develop a problem-solving mindset. As an added benefit, student respondents noted that they felt less stressed in the classroom as a result of the “Fun Fridays” activities. Notably, the mid-semester rating for “Fun Fridays help me better understand course concepts” (3.67/5.00) was lower than other items. This suggests that while students initially found the activities engaging, the connection to core content was not immediately clear. This insight informed instructional adjustments, including more explicit linking of activities to course concepts and additional guided problem-solving.

The results from the open-ended questions indicate that many students valued the integration of theoretical concepts with practical applications. Real-life scenarios not only deepened their understanding of chemistry but also highlighted its relevance to everyday life and future career paths. Students consistently reported high levels of engagement and expressed appreciation for the collaborative nature of the activities, which involved working closely with peers and the instructor. These interactions fostered a sense of community within the classroom and strengthened their connection to the broader field of chemistry.

The activities encouraged critical thinking, application of multiple concepts, and the ability to navigate complex calculations of increasing difficulty. While the majority of students found this approach both stimulating and confidence-building, a subset of participants did note that the challenges occasionally felt overwhelming. Despite this, the overall relaxed and interactive atmosphere of the “Fun Fridays” sessions was widely praised for alleviating stress in what is traditionally perceived as a rigorous and content-heavy course.

The findings suggest that the “Fun Fridays” framework appears to support diverse learning needs of students by promoting engagement, fostering curiosity, and enhancing the ability to apply chemistry concepts beyond the classroom. These results underscore the potential of such pedagogical innovations to improve retention and success rates among STEM majors, particularly first-year engineering students.

The challenges identified in the mid-semester survey comments led to several adjustments and improvements to how the activities were conducted to enhance the effectiveness and accessibility of the “Fun Fridays” activities. Complex calculations were broken down into step-by-step procedures, with key highlights provided to guide students through the problem-solving process. Greater emphasis was placed on fostering classroom discussions and encouraging collaborative problem-solving among students. Stronger group work was promoted, underscoring the value of teamwork in tackling complex problems more efficiently than when working individually. For students struggling with specific concepts, the instructor provided additional guidance by walking through the problems on the board, ensuring that foundational understanding was reinforced while maintaining the overall “Fun Fridays” experience.

The relaxed and engaging atmosphere of the sessions was preserved, with lively background music and informal discussions creating an environment conducive to exploration and creativity. Each problem highlighted essential skills relevant to STEM fields, helping students connect the activities to their broader academic and professional goals. Suggestions from students were incorporated into the design of subsequent activities, either directly or through similar themes.

Notable examples of successful activities included the “James Bond” activity, which integrated multiple challenging concepts into a familiar and entertaining context. Students found the activity approachable because of its connection to the iconic character, making it both engaging and memorable. Another example was the “Up” calculation, focused on the gas laws and inspired by the popular animated movie. Although this problem required a brief lecture on buoyancy – beyond the scope of the standard General Chemistry curriculum – students appreciated the simplicity of the calculation and its connection to a well-loved film. These activities demonstrated how relatable and context-rich scenarios can make even difficult topics more accessible and enjoyable for students.

Conclusions

The implementation of “Fun Fridays” in a General Chemistry classroom shows promise as a pedagogical strategy for enhancing student engagement, reducing stress, and fostering an entrepreneurial mindset in first-year STEM students. By integrating the principles of Entrepreneurially Minded Learning (EML), these activities encouraged students to connect abstract chemistry concepts with practical, real-world applications, sparking curiosity and promoting critical thinking.

Students responded positively to the structured yet relaxed environment of “Fun Fridays,” where a combination of collaborative problem-solving, engaging real-life scenarios, and thoughtful instructional design helped alleviate the pressures of a traditionally content-heavy lecture course. The inclusion of relatable, interdisciplinary problems reinforced their understanding of chemistry while simultaneously preparing them for challenges they may encounter in professional STEM environments. This dual focus on technical competence and broader applicability aligns well with the goals of EML, emphasizing curiosity, connections, and creating value.

Survey data and student feedback consistently highlighted the value of “Fun Fridays” in making chemistry more approachable and relevant. Activities like the “James Bond” and “Up” scenarios demonstrated how leveraging pop culture and creative contexts can make even complex concepts more engaging and memorable. Moreover, the intentional inclusion of teamwork, time-sensitive challenges, and step-by-step problem-solving modeled essential skills for future engineers and scientists.

The broader implications of this approach extend beyond General Chemistry. The principles and methods described in this study can be adapted for use in other STEM disciplines and general education courses, particularly those foundational to engineering curricula. By incorporating real-life scenarios, collaborative problem-solving, and an entrepreneurial mindset into early coursework, educators can help students develop confidence, curiosity, and a sense of purpose within their chosen fields.

Future work could expand the scope of this study by exploring the effectiveness of “Fun Fridays” in larger classroom settings or at institutions with more diverse student populations. Additional research could also examine the long-term impact of EML-infused activities on student retention, performance in upper-level courses, and career readiness. This study relies on self-reported student perceptions, which may not directly correlate with measurable learning gains. Future work will compare student performance on exam questions related to Fun Friday topics across semesters with and without implementation, as well as explore longitudinal impacts on retention and conceptual understanding. While preliminary results are promising, further study is needed to evaluate long-term learning outcomes.

Resources

A “Card” – i.e., an information repository – has been created for this paper on the Engineering Unleashed website [9]. This card contains all the instructional materials mentioned in this paper, including those developed “in-house” such as the rubrics, etc. These materials can be freely downloaded, reviewed, adopted, and if desired, modified by anyone for use in their courses under the Creative Commons CC BY-NC license.

References

[1] D. Rae, and D. E. Melton, “Developing an entrepreneurial mindset in US engineering education: an international view of the KEEN project,” *The Journal of Engineering Entrepreneurship*, vol. 7, no. 3, 2017.
[2] M. Besterfield-Sacre, S. Zappe, A. Shartrand, and K. Hochstedt. “Faculty and Student Perceptions of the Content of Entrepreneurship Courses in Engineering Education,” *Advances in Engineering Education*, vol. 5, no. 1, 2016.
[3] D. E. Goldberg, M. Somerville, and C. Whitney, *A Whole New Engineer: The Coming Revolution in Engineering Education*. Douglas, MI: ThreeJoy Associates, 2019.
[4] M. W. Ohland, S. D. Sheppard, G. Lichtenstein, O. Eris, D. Chachra, and R. Layton, "Persistence, engagement, and migration in engineering programs," *Journal of Engineering Education*, vol. 97, no. 3, 2008.
[5] M. M. Cooper, N. Grove, S. C. Underwood, and C. Klymkowsky, “Lost in Lewis structures: An investigation of student difficulties in developing representational competence,” *Journal of Chemical Education*, vol. 89, no. 7, 2002.
[6] K. Bain, and M. H. Towns, “A review of research on the teaching and learning of chemical kinetics,” *Chemistry Education Research and Practice*, vol. 17, no. 2, pp. 192-207, 2016.
[7] T. Standish-Kuon, and M. P. Rice, “Introducing engineering and science students to entrepreneurship: Models and influential factors at six American universities,” *Journal of Engineering Education*, vol. 91, no. 1, 2002.
[8] T. Shenk, N. Saqib, M. S. Kleine, A. Gogineni, A. R. McLanahan, and S. M. Gillespie, “Engaging the Undergraduate Thermodynamics Classroom Using Mini-Adventures in the Entrepreneurial Mindset,” *ASEE Annual Conference & Exposition*, 2024.
[9] Deavers, K., & Saqib, N. (2025, February 7). "Fun Fridays: EML in the General Chemistry Classroom". Engineering Unleashed. Retrieved from https://engineeringunleashed.com/card/4719.

Appendices

<u>James Bond’s Golden Pen</u>

Dr. Kamila Deavers

A Montblanc Octopussy tie-in advertisement features a yellow-gold Montblanc Meisterstuck fountain pen. photo © Prop Store

https://collider.com/pierce-brosnan-james-bond-movies-ranked/

Most of us have heard about James Bond’s movies. The legendary Sean Connery, the amazing Pierce Brosnan, and most recently Daniel Craig. We are not getting into a debate about who was the best actor but into the ACTION! James Bond is able to escape from any possible trap using his handy tools and innovations, besides being just awesome. In the film Octopussy (1983) and Golden Eye (1995), 007 is equipped with a golden pen filled with sulfuric acid. We have to give Bond credit for using a golden pen, because gold is one of the few metals that are not soluble in sulfuric acid, unless you add nitric acid. What is hard not to point out is that the amount of sulfuric acid in the pen would not be sufficient to dissolve the iron bars in the prison cell. It would be possible, though, with enough acid and the right-sized pen — that is where we come in to help!

Let’s get the numbers together and design the right-sized pen for James Bond!

1. We can assume Bond has concentrated sulfuric acid, which is 98% (m/m) H_2SO_4. We need to know the concentration of the acid. Recalculate this for molarity, M [mol/L]. D_{H2SO4} = 1.84 g/cm^3 (Sigma Aldrich).

2. Bond is in a prison cell with iron bars — these are no longer used; we now use steel or iron/steel doors, but let's go with the iron bars to fit the story. How many grams of iron are in the bars? We will focus on one bar to be dissolved by acid. Prison bars are approx. 7/8 of an inch thick (express with 3 sig figs).

   Dimensions: 3.00 ft height.   1ft = 12 in

   Calculate the volume of the bar.   V = $\pi r^2 h$

   D_{Fe} = 7.86 g/mL

   Calculate the mass of Fe.

3. What would be the chemical reaction of sulfuric acid and iron? What will you produce?

4. You now know the reaction and stoichiometry. You can calculate how many moles of acid it would take to dissolve the iron bar. Calculate the volume [cm^3] of acid. How much hydrogen gas would be produced for an explosion to accompany the hard work dissolving the bars? Calculate the moles and volume of hydrogen gas.
   Recall: pV = nRT (P = 1.00 atm. T= 20 °C, R = 0.08206 atm-L/mol-K).

5. We now know the volume of acid needed. Now we need it to fit into a pen or an object similar to one. Remember it needs to be fancy for James Bond. He cannot walk with a backpack around!

   The general dimensions of the pen are 130-140 mm (height)
   You can use the volume of acid and calculate the diameter of the pen.
   Use the volume of the cylinder to simplify the design.
   V = $\pi r^2 h$

It might be a HUGE pen. Any suggestions for a different object the acid could be stored in that would go with Bond's outfit? Remember, he is a spy so nothing obvious!

Sources:

ps://www.sigmaaldrich.com/US/en/sds/ALDRICH/339741?userType=undefined

https://www.truphaeinc.com/blogs/guides/average-length-of-pen - :~:text=What is the average length, a portion of gel pens.

https://fscimage.fishersci.com/msds/11490.htm

Up – Sky High Vacation

Dr. Kamila Deavers


https://www.buzzfeed.com/jessicaprobus/the-story-of-the-house-that-inspired-up-is-just-as-adorable

Have you ever had the idea of floating away on an adventure in a house carried by balloons? Isn't it magical – just you, your house, and the sky? And yes, it would be amazing to go on vacation with no packing involved – just your house and everything in it! Like in the movie Up!

Here is the catch: to make this dream a reality, you have to figure out how many balloons and how much helium it would take to lift a house into the sky.

The **Ideal Gas Law** and a bit of physics are perfect for solving this puzzle.

A little bit of physics – Archimedes' principle:

- An object submerged in fluid is buoyed up by a force equal to the weight of the fluid it displaces
- Air has a density of 0.0807 lb/ft^3
- Helium is less dense than air. Helium has a density of 0.0114 lb/ft^3
- The lighter fluid (helium) is "held up" by a buoyant force in a more dense (air) fluid.
- The difference in the up and down force is 0.0693 lb/ft^3 **(1.15 kg/m^3)**

THEREFORE, each cubic meter of helium could lift 1.15 kg.

Ready to dive into the calculation?

Let's figure out how many balloons we'd need to float off like Carl and Russell!

We need to figure out how much helium (volume and number of moles) it takes to lift the house.

1. House weight (kg)

The average house weight can vary between 80,000 and 160,000 pounds, excluding foundation and contents (WasteremovalUSA).

A two-story house weighs 275 lb/ft^2 and a three-story house weights 350 lb/ft^2.

2. Helium Lifting Capacity – buoyancy – Volume of Helium

Density difference is 1.15 kg/m^3

3. Moles of Helium Needed Using the Gas Law (T = 20 °C, p = 0.95 atm at 1500 ft above sea level). Recall, pV = nRT, where R = 0.08206 $\frac{atm\ L}{mol\ K}$

4. Convert Moles of Helium to Volume (STP condition)

T = 0 °C

p = 1.00 atm (atmospheric pressure)

1 mol = 22.4 L

5. Number of balloons

Let's use 12-inch round balloons, which are super popular for decorations and float beautifully with helium.

For one balloon, V = $\frac{4}{3}\pi r^3$ 12 in – diameter

6. Time to fill balloons. How many tanks of helium? And the cost of the adventure?

Helium tanks come in different sizes, but let's go with a standard 8.24 m^3 tank from MMBalloons. 1 tank = $410.

We have a pretty epic setup for a sky-high vacation! Where would you fly off to?

Here's where the reality of ballooning comes in! Since helium balloons lose their buoyancy over time, you've got about **8-12 hours** of floating time before your house starts to descend.

7. How far you could travel in those precious hours?

The house would essentially act like a balloon, drifting with the wind.

Wind speeds vary depending on altitude, but let's use an average ground-level wind speed of **20 km/h**

Distance = speed x time

You might want to have a landing plan — or a way to refill those balloons!

Another option? Yes, HYDROGEN! But, oh, the humanity!

<u>Hair Remediation/Donation</u>

Dr. Kamila Deavers

Hair structure:

- Keratin – protein in the hair
- Structural fibrous protein

Hair protects our body:

- It helps to keep the sun's harmful rays from reaching our scalp
- Eyelashes and eyebrows keep dust, dirt, and sweat out of our eye
- Hairs in our nose and ears help to keep out germs and other foreign objects
- Body hair helps to regulate body temperature

Oily hair is an amazing feature!!!

- It does not swell up as a sponge
- Oil coats the entire hair surface, because of the sheer volume
- When you wash your hair, your scalp gets the signal to produce more sebum (oil)
- Sebum is for scalp hydration and protects the hair
- It is our body's defense system and UNAVOIDABLE!
- Washing hair often correlates to higher oil production (build up on your scalp)

  HOW?
- It is hydrophobic (dislikes water) – cuticle content
- The structure – scales and a rough surface create a large surface area to adhere oil
- The process is called adsorption (do not confuse it with absorption)
- Hair molecules cling to hair fibers

Why are we talking about hair?

- Hair has better absorption of crude oil comparable to other sorbents such as polypropylene cotton or cellulose [1]
- In 1989, an Alabama-based hair stylist Philip McCrory first designed a prototype device that used hair to collect oil
- NASA tested the technology with positive results
- Oil spill in Philippines, 2023
  - Oil tanker capsized releasing oil slick
  - Residents were donating hair to clean the spill
  - According to Matter of Trust Organization, 40,000 hair mats have been made

You can calculate the amount of hair mass you have and how much oil can be absorbed by it!

Hair Thickness	Average Density	Average Absorbance Rate
0.03 mm (Thin) 0.03 mm - 0.05 mm (Medium) Above 0.05 mm (Thick)	1.32 $g.cm^{-3}$	5

How much hair do we have on the head? It depends on the hair color.

Average 90,000 – 150,000 hairs on head

Type of Hair	Number of hairs
Blond hair	150,000
Brown & Black hair	100,000 -110,000
Red hair	90,000

1. Calculate hair volume with your hair length in cm. Length over 4 inches (10 cm) for environmental donation. Assume the hair structure is a cylinder, V = $\pi r^2 h$.

2. Calculate the mass of hair you have.

3. Calculate the amount of oil absorbed according to your hair mass.

<u>Let's see what it takes to be an Environmental Chemist!</u>

Deep Water Horizon Oil Spill Disaster, 2010

- In the then Gulf of Mexico, USA
- Explosion of oil platform
- 57,500 square miles of oil had been leaked into the then Gulf of Mexico
- Total discharge was 780,000 m^3 of crude oil
- 4,900,000 barrels of oils
- "The largest environmental disaster in history"
- BP used the chemical "Corexit" to clean an oil spill which is proven to be toxic to marine life
- Double disaster with clean-up?!

NOW, we know that we can use hair. We can calculate how many tonnes of hair would be needed to clean the BP oil spill.

You are tasked with a method of using hair to absorb the spilled oil.

How much hair in kg would it take to absorb all the oil?

- 4,900,000 barrels of oils
- 1 barrel = 42 gallons
- 1 gallon = 3.78541 liters
- 1 kg of human hair can absorb 8 liters of oil
- Hair can absorb up to 5 times its weight!

Sources:

1. Pagnucco, R. and M.L. Phillips, *Comparative effectiveness of natural by-products and synthetic sorbents in oil spill booms.* J Environ Manage, 2018. **225**: p. 10-16, ISSN 0301-4797, https://doi.org/10.1016/j.jenvman.2018.07.094.

   (https://www.sciencedirect.com/science/article/pii/S0301479718308570)

- https://matteroftrust.org/research-resources/
- https://science.howstuffworks.com/environmental/green-tech/remediation/hair-clean-up-oil-spills.htm
- https://www.ncbi.nlm.nih.gov/books/NBK546248/ - :~:text=Hair structure&text=The hair root is in, make the hair stand up.
- https://time.com/6262631/philippines-oil-spill-cleanup-hair/
- Augustine Osamor Ifelebuegu, Tuan Vu Anh Nguyen, Peter Ukotije-Ikwut, Zenebu Momoh, Liquid-phase sorption characteristics of human hair as a natural oil spill sorbent, Journal of Environmental Chemical Engineering, Volume 3, Issue 2,2015,Pages 938-943,ISSN 2213-3437, https://doi.org/10.1016/j.jece.2015.02.015
- Jimenez F, Ruifernández JM. Distribution of human hair in follicular units. A mathematical model for estimating the donor size in follicular unit transplantation. Dermatol Surg. 1999 Apr;25(4):294-8. doi: 10.1046/j.1524-4725.1999.08114.x. PMID: 10417585.
- Picture Hair, Source: https://www.freepik.com/premium-ai-image/group-people-with-different-hair-colors-facial-features_176899176.htm
- Picture – CNN, https://www.cnn.com/2022/05/19/world/oil-spills-human-hair-matter-of-trust-spc-scn-intl-c2e/index.html
- Sathinathan, Pavithira & Kiew, Peck Loo. (2021). Regression Analysis for the Adsorption of Oil Using Human Hair as Natural Adsorbent. 10. 10.61762/ijbrvol10iss1art11559.
- https://www.scientificamerican.com/article/the-worlds-simplest-theorem-shows-that-8-000-people-globally-have-the-same-number-of-hairs-on-their-head/

Saline Solution

Dr. Kamila Deavers

You're on a summer shadowing rotation at a hospital pharmacy. Suddenly, a trauma patient rushes in, severely dehydrated and injured. The nurse sprints to the pharmacy, needing a 1000 mL IV drip bag of 0.9% saline solution for IV rehydration — ASAP! A patient is in urgent need of a saline drip, but there's a national shortage of 0.9% NaCl solution! 🏥 😱

No pre-made 0.9% (m/v) saline solution is available. You only have a 0.45% (m/v) saline solution in a 500 mL IV drip bag and a bottle with 99.9% pure sodium chloride (NaCl). It's up to you to mix the right amount of salt in just a couple of minutes.

Data:

0.45% (m/v) saline solution NaCl (aq), $V_{INITIAL}$ = 500mL

V_{FINAL} = 1000 mL, 0.90 % (m/v) saline solution

D_{H20} = 0.9975 g/cm^3 at 23 °C (average room temperature in hospitals)

Let's go through the calculation! HURRY, you have 5 minutes to complete it!

Did you make it in time? If yes, take a well-deserved rest!

<u>**Affogato Italian Dream**</u>

Dr. Kamila Deavers

https://www.recipetineats.com/affogato/

You're on a Vespa cruising along the scenic coastline of Italy, with the ocean breeze on your face and sunshine spilling over the hills. The road leads you into a charming village, where you decide to stop for an espresso at a cozy café. As you sit down, the sounds of peaceful Eros Ramazzotti and Luciano Pavarotti's peaceful melodies fill the air, mingling with the warm, rich scent of freshly brewed espresso. It is a hot day, so you order an Affogato, a decadent combination of rich vanilla ice cream poured over with a shot of hot espresso. When it arrives, you watch the ice cream melting in the espresso and as it slowly swirls into a creamy blend, you start to think as a General Chemistry student, "Could I calculate the moment of perfect harmony between the espresso and vanilla ice cream?" YES, you can!

In this delicious moment – we have two systems exchanging heat:

- The hot espresso and the ice cream
- You know from the 1st Law of Thermochemistry that $E_{universe}$ is constant

  $E_{ice\text{-}cream} + E_{espresso} = 0$

- The systems interact till they reach thermal equilibrium (T_f) where the flavors have blended just right

Ready to calculate the perfect moment when your drink is cool enough to sip and perfectly mixed?

Here's the plan:

- the espresso loses heat as it cools down
- the ice cream gains heat, first melting* and then warming up.
- Using thermochemistry, we can figure out the final temperature T_f when both have reached equilibrium

$+ q_{ice\text{-}cream} = - q_{espresso}$

$Q = mc\triangle T$

$\triangle T = T_{final} - T_{initial}$

******We simplified this process and omitted the melting point phase at constant temperature of ice cream which is General Chemistry II content. If you follow the General Chemistry II procedure, you would need to implement* $\triangle H_{fusion}$ *as part of the melting change (* $q_{ice\text{-}cream} + \Delta H_{fusion} = - q_{espresso}$*)*

Data

- The ice cream scoops, 1 scoop = 113.4 g.
- 2 scoops = 226.8 g.
- Regular ice cream is typically served at -12 °C ($T_{initial}$).
- The heat capacity of a 30 g shot is about 125 J/°C, meaning 4.16 J/g°C.
- To produce high-quality espresso, your brewing water should sit within an ideal temperature range of between 92°C and 96°C ($T_{initial}$) (197 °F and 205 °F), according to the **Specialty Coffee Association**.
- The temperature of the espresso in the cup will be between 160–165 °F (71.1–73.9 °C).

	c_s (J/g°C)
Vanilla Ice-cream	2.74
Espresso	4.16
Water	4.186

You learned something new and enjoyed the chemistry of coffee time!

Cheers!