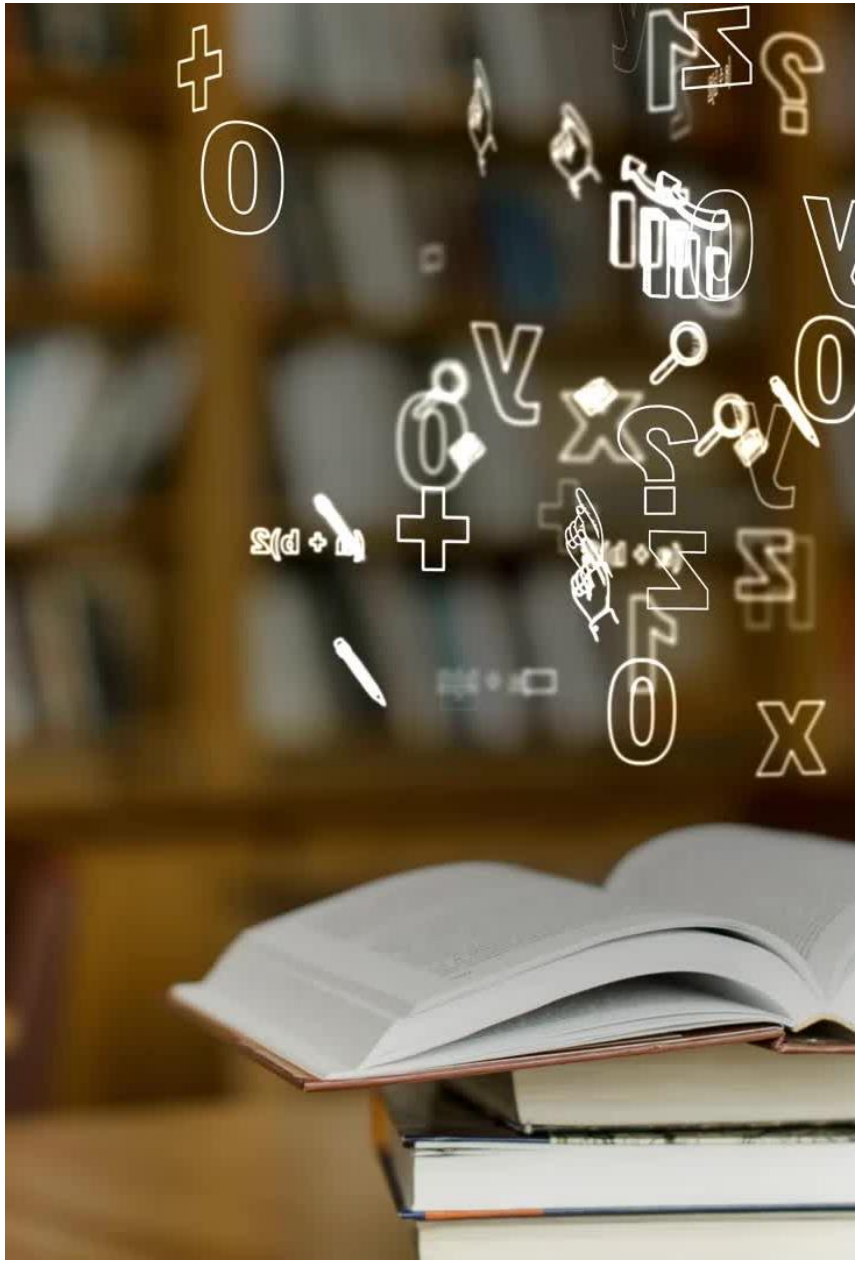
real-world ; retaining knowledge, and cultivating effective reading habits for deep learning

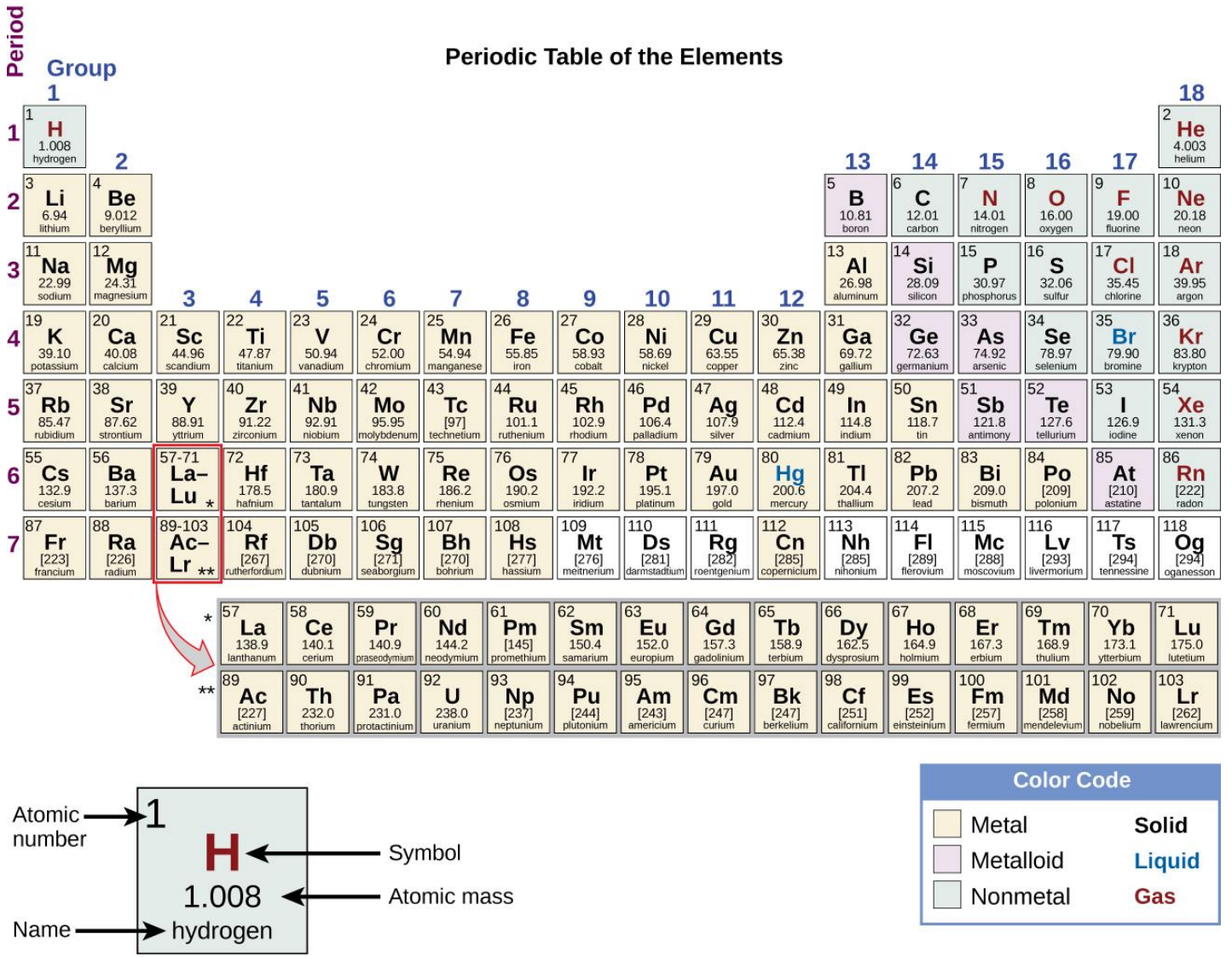


Scholarship of Excellence in Teaching Fellowship 2023 - 2024

Pabitha Gnanamani

Adjunct chemistry faculty

The Alphabets of chemistry



Course: General chemistry I – CHEM 131
Purpose and Goals…..

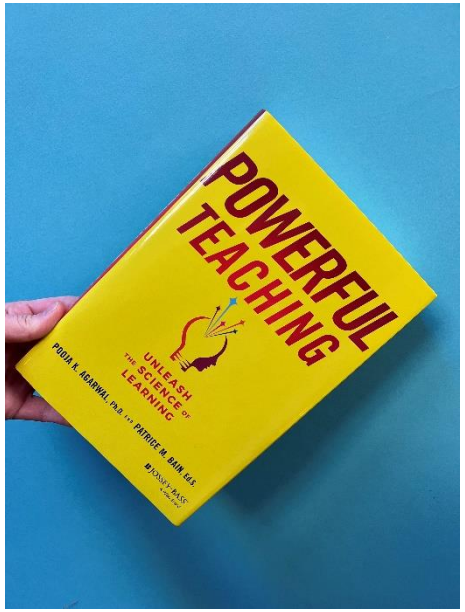
1. **Creating Subject Interest:** Bridging the gap between classroom and the real world

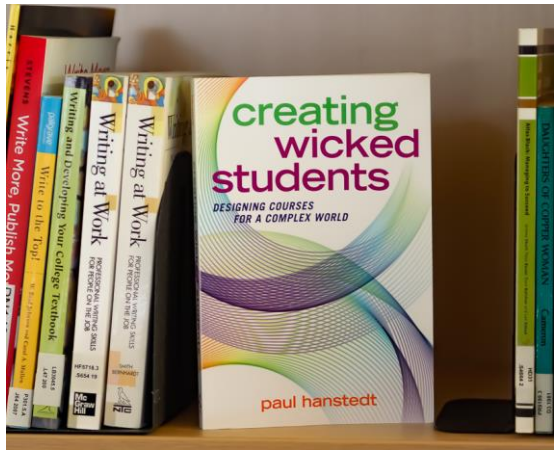
2. **Content retention:** Promoting good study habits through retrieval practices

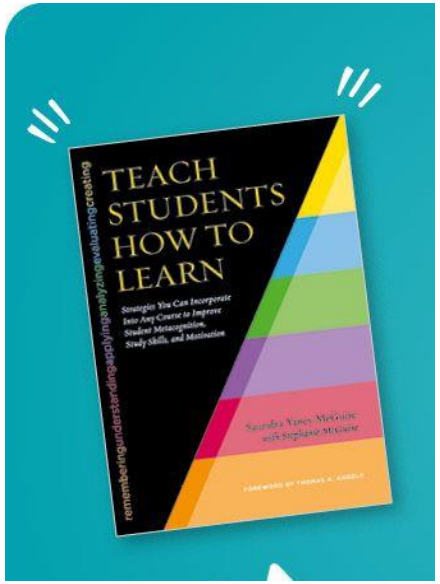
3. **Initiating good reading habits:** A golden key to mastery in chemistry, also would help in content retention

Inspirational Books…

- **Powerful Teaching: Unleash the Science of Learning** by *Pooja Agarwal and Patrice Bain*
- **Teach Students How To Learn: Strategies You Can Incorporate into Any Course to Improve Student Metacognition, Study Skills, and Motivation** by *Saundra Yancy McGuire*
- **Creating Wicked Students** by *Paul Hanstedt*







Words that inspired me from the author of the books….

"Great explanations are only one arm of effective teaching, The other arm involves teaching students how to learn materials on their own without help" – **Teaching students how to learn by Sandra**

"When we think about learning we typically focus on getting information into students' heads. What if instead focus on getting information out of student's heads?" **– Powerful Teaching: Unleash the Science of Learning by Pooja Agarwal and Patrice Bain**

"First of all teaching and learning are two entirely different things. Just because the content has been covered in a course - does not necessarily mean it has been learned by students well enough to last beyond the final exam… **We need to do something with that information that strengthens the neuronal network, connecting the new learning. With only so many hours in a given course in a given semester, a course structure that focuses on** content delivery over application limits the brains' ability to recall that information later on." – **Creating Wicked Students by Paul Hanstedt**

STRATEGIES USED AND IMPLEMENTATION

1. Case Study – fostering Subject Interest and enhancing critical thinking: Case studies offer an excellent opportunity for students to apply theoretical concepts to real-world scenarios.

5 case studies covering all the major concepts of the course.
Resource of Case study: National science teaching association

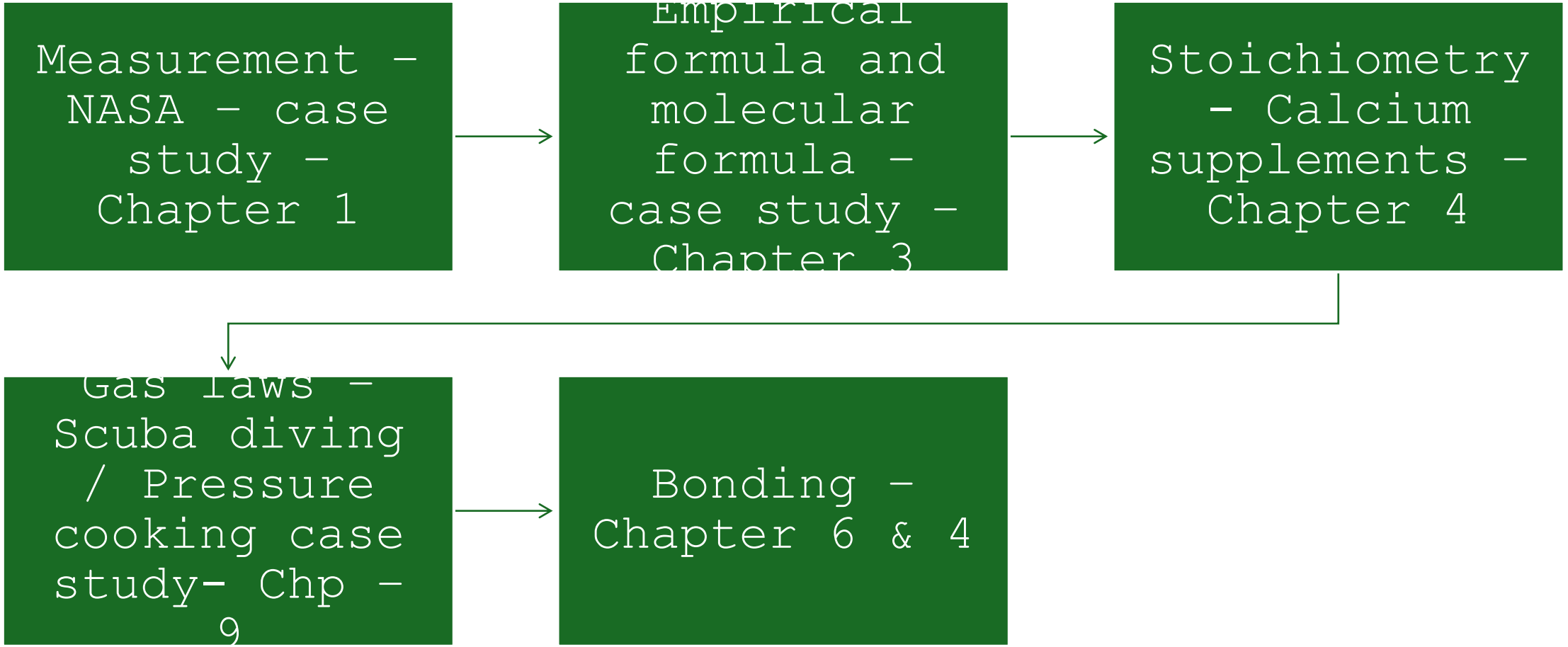
2. Active Reading: Introducing active reading and incorporating concept mapping can significantly enhance students' understanding. *Concept maps facilitate development of higher order thinking skills*

Pre reading assignment with concept mapping before the start of every chapter – 10 reading assignment

3. Retrieval practices: To enhance content retention

Retrieval quizzes – quizzes were conducted a week after every exam. Focusing on the chapters covered for the respect exam.

List of case studies used….

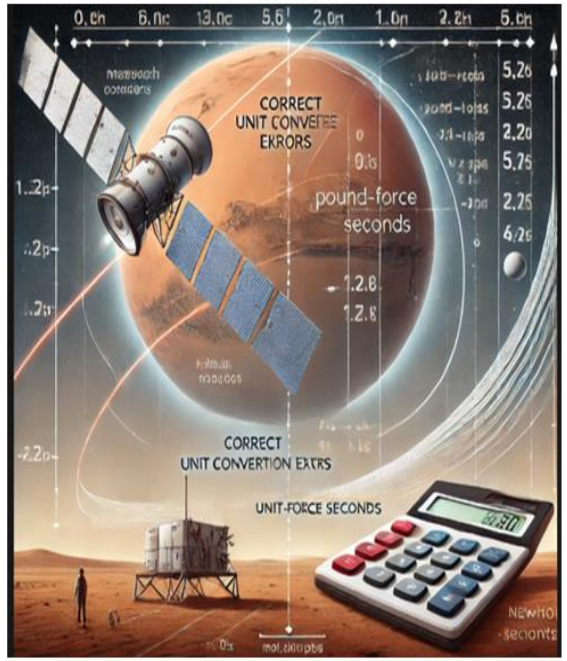


Case Study 1: NASA's Mars Climate Orbiter Failure Due to Measurement and Unit Conversion Errors

Enforcing the importance of Units and unit conversion in the real world….

1. Convert the intended altitude of the Mars Climate Orbiter (150 kilometers) into miles. Use dimensional analysis to solve.
2. Convert the actual altitude the orbiter reached (57 kilometers) into feet.
3. What is the difference in force between pound-force seconds and newton-seconds, and why is it crucial to convert between these units correctly
4. **How could the correct use of unit conversions have prevented the Mars Climate Orbiter from descending too low into Mars' atmosphere?**
5. **Explain why it is critical for all**

Background:



In 1999, NASA's Mars Climate Orbiter, a $125 million spacecraft intended to study Mars' atmosphere, was lost due to a critical mistake involving measurements and unit conversions. The mission's goal was to provide data on the Martian climate, weather patterns, and atmospheric conditions. However, the spacecraft encountered problems when it approached Mars to enter orbit. The navigation team at NASA had intended for the spacecraft to pass within 150 kilometers (93 miles) of the Martian surface. Instead, due to a mix-up in units, the orbiter dipped to an altitude as low as 57 kilometers (35 miles). This brought the spacecraft too close to Mars, causing it to enter the upper atmosphere, where it disintegrated due to the extreme heat and pressure.

Case study 2: The Case of the Sleepless Student:

Calculate the molecular formula and empirical formula of an unknown compound using the students blood work.

Questions to be answered at the end of the case study:

1. What are the empirical and molecular formulas for the unknown substance based on the combustion and decomposition analysis data?
2. What is the possible identity of the substance (the active ingredient in the pill)? How is it used? What is the dosage of the active ingredient taken by Tasha? What reference source(s) did you use and how reliable do you think they are? Explain your responses.
3. Why do you think that Tasha lost consciousness?

Patients blood work

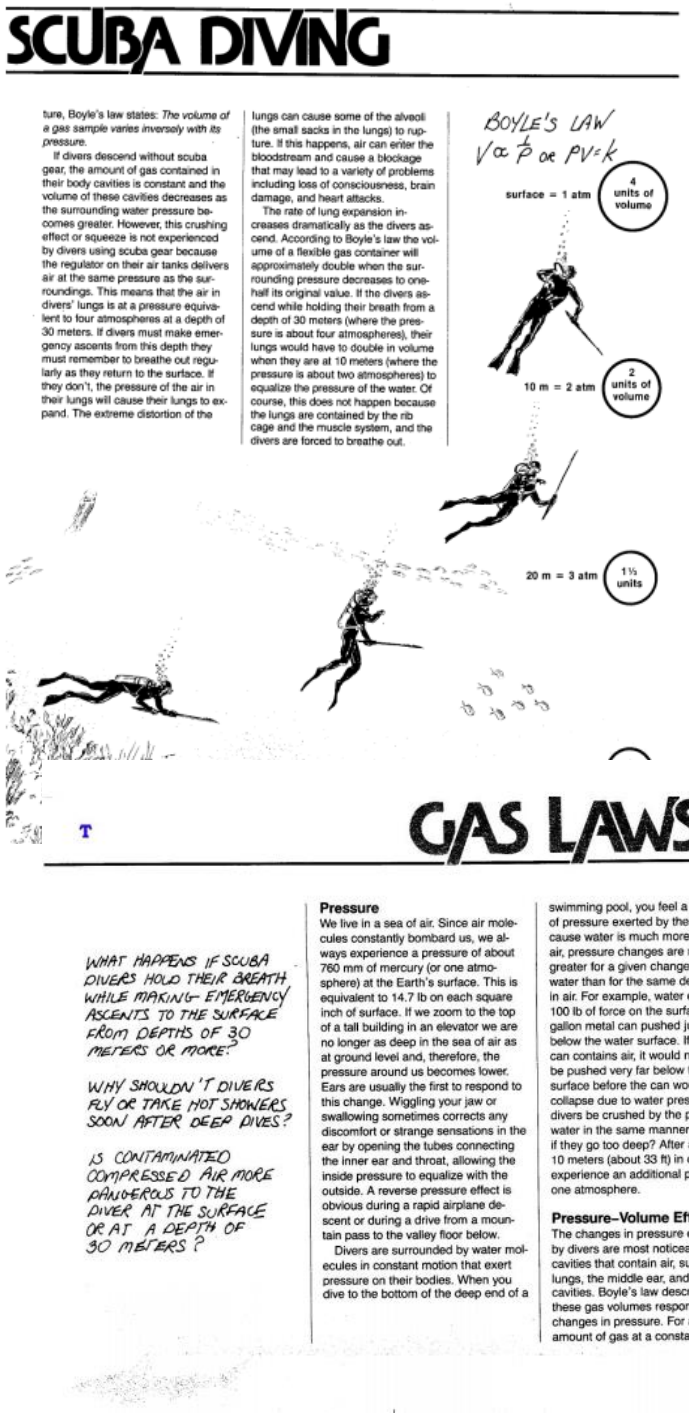
PATIENT: Jones, Tasha		TIME ADMITTED:	4:12 AM	DATE: 10/3/2019
WEIGHT:	110 lbs	AGE: 21	SEX: F	Report submitted
				by S. Phillips
BLOOD SAMPLE:	100 cc			
TESTING STARTED:	8:15 AM			
TEST COMPLETED:	10:47 AM	DATE: 10/3/19		
UNKNOWN SUBSTANCE FOUND				
CONCENTRATION:	200 mg/L blood			
MASS SPEC ELEMENT ANALYSIS:		Carbon		
OF UNKNOWN		Hydrogen		
		Chlorine		
		Nitrogen		
		Oxygen		
COMBUSTION ANALYSIS:		0.010 mg of unknown tested		
OF UNKNOWN				
	PRODUCTS:	CO_2	20.56 mg	
		water vapor	2.81 mg	
DECOMPOSITION ANALYSIS:		0.010 mg of unknown tested		
OF UNKNOWN				
	PRODUCTS:	Cl_2	2.208 mg	
		N_2	0.872 mg	
		O_2	0.997 mg	
MOLECULAR WEIGHT ANALYSIS		321.16 g/mol		

Case study 3: **Gas Laws and Scuba Diving**

Connecting the gas laws learned in understanding the chemistry behind ~~scuba diving safely…~~

Read the accompanying article "Gas Laws & SCUBA Diving". Answer the following questions completely on a separate sheet of paper.

1. Why does diving 30m below sea level affect our bodies more than being in a building 30m above sea level?
2. What parts of a diver's body are most affected by pressure changes?
3. Why don't SCUBA diver's lungs collapse as they descend?
4. What would happen to a diver who does not exhale while surfacing from a 30 m dive?
5. Explain in terms of Boyle's Law.



SCUBA DIVING

ture, Boyle's law states: *The volume of a gas sample varies inversely with its pressure.*

If divers descend without scuba gear, the amount of gas contained in their body cavities is constant and the volume of these cavities decreases as the surrounding water pressure becomes greater. However, this crushing effect or squeeze is not experienced by divers using scuba gear because the regulator on their air tanks delivers air at the same pressure as the surroundings. This means that the air in divers' lungs is at a pressure equivalent to four atmospheres at a depth of 30 meters. If divers must make emergency ascents from this depth they must remember to breathe out regularly as they return to the surface. If they don't, the pressure of the air in their lungs will cause their lungs to expand. The extreme distortion of the lungs can cause some of the alveoli (the small sacks in the lungs) to rupture. If this happens, air can enter the bloodstream and cause a blockage that may lead to a variety of problems including loss of consciousness, brain damage, and heart attacks.

The rate of lung expansion increases dramatically as the divers ascend. According to Boyle's law the volume of a flexible gas container will approximately double when the surrounding pressure decreases to one-half its original value. If the divers ascend while holding their breath from a depth of 30 meters (where the pressure is about four atmospheres), their lungs would have to double in volume when they are at 10 meters (where the pressure is about two atmospheres) to equalize the pressure of the water. Of course, this does not happen because the lungs are contained by the rib cage and the muscle system, and the divers are forced to breathe out.

BOYLE'S LAW
$V \propto \frac{1}{P}$ or $PV = k$

surface = 1 atm — 4 units of volume

10 m = 2 atm — 2 units of volume

20 m = 3 atm — 1⅓ units

GAS LAWS &

WHAT HAPPENS IF SCUBA DIVERS HOLD THEIR BREATH WHILE MAKING EMERGENCY ASCENTS TO THE SURFACE FROM DEPTHS OF 30 METERS OR MORE?

WHY SHOULDN'T DIVERS FLY OR TAKE HOT SHOWERS SOON AFTER DEEP DIVES?

IS CONTAMINATED COMPRESSED AIR MORE DANGEROUS TO THE DIVER AT THE SURFACE OR AT A DEPTH OF 30 METERS?

Pressure

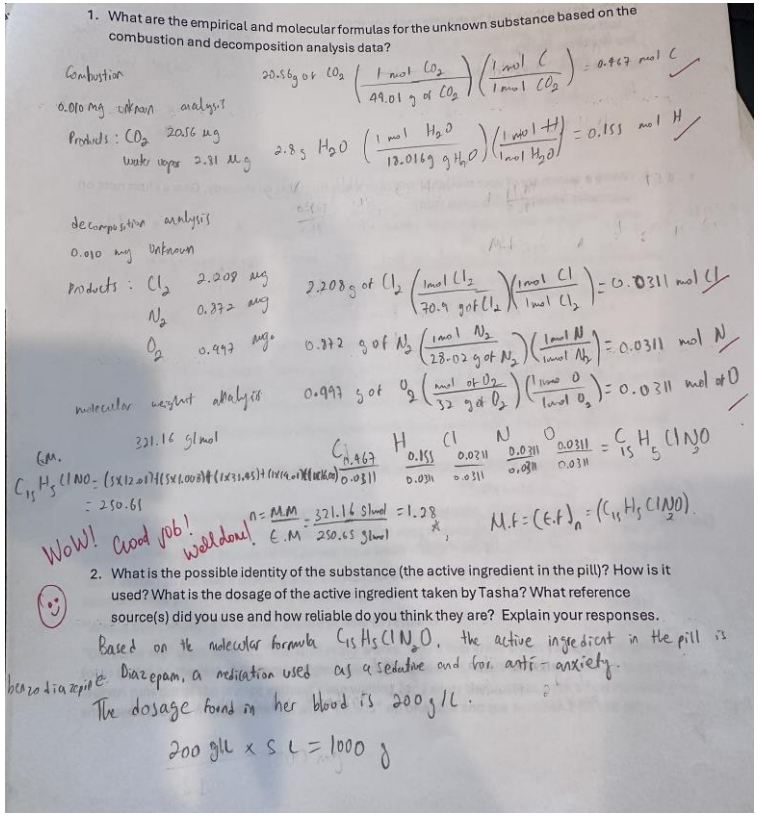
We live in a sea of air. Since air molecules constantly bombard us, we always experience a pressure of about 760 mm of mercury (or one atmosphere) at the Earth's surface. This is equivalent to 14.7 lb on each square inch of surface. If we zoom to the top of a tall building in an elevator we are no longer as deep in the sea of air as at ground level and, therefore, the pressure around us becomes lower. Ears are usually the first to respond to this change. Wiggling your jaw or swallowing sometimes corrects any discomfort or strange sensations in the ear by opening the tubes connecting the inner ear and throat, allowing the inside pressure to equalize with the outside. A reverse pressure effect is obvious during a rapid airplane descent or during a drive from a mountain pass to the valley floor below.

Divers are surrounded by water molecules in constant motion that exert pressure on their bodies. When you dive to the bottom of the deep end of a swimming pool, you feel a great deal of pressure exerted by the water. Because water is much more dense than air, pressure changes are much greater for a given change in depth in water than for the same depth change in air. For example, water exerts over 100 lb of force on the surface of a one-gallon metal can pushed just one foot below the water surface. If the metal can contains air, it would not have to be pushed very far below the water surface before the can would start to collapse due to water pressure. Can divers be crushed by the pressure of water in the same manner as the can if they go too deep? After all, for every 10 meters (about 33 ft) in depth, divers experience an additional pressure of one atmosphere.

Pressure–Volume Effects

The changes in pressure experienced by divers are most noticeable on body cavities that contain air, such as the lungs, the middle ear, and the sinus cavities. Boyle's law describes how these gas volumes respond to changes in pressure. For a constant amount of gas at a constant tempera-

Students work – case study….



1. What are the empirical and molecular formulas for the unknown substance based on the combustion and decomposition analysis data?

Combustion

0.010 mg unknown analyzed

Products: CO_2 20.56 mg

water vapor 2.81 mg

20.56 g of CO_2 $\left(\frac{1\ mol\ CO_2}{49.01\ g\ of\ CO_2}\right)\left(\frac{1\ mol\ C}{1\ mol\ CO_2}\right) = 0.467\ mol\ C$

2.8 g H_2O $\left(\frac{1\ mol\ H_2O}{18.016\ g\ H_2O}\right)\left(\frac{1\ mol\ H}{1\ mol\ H_2O}\right) = 0.155\ mol\ H$

decomposition analysis

0.010 mg unknown

Products: Cl_2 2.208 mg

N_2 0.272 mg

O_2 0.997 mg

2.208 g of Cl_2 $\left(\frac{1\ mol\ Cl_2}{70.9\ g\ of\ Cl_2}\right)\left(\frac{1\ mol\ Cl}{1\ mol\ Cl_2}\right) = 0.0311\ mol\ Cl$

0.272 g of N_2 $\left(\frac{1\ mol\ N_2}{28.02\ g\ of\ N_2}\right)\left(\frac{1\ mol\ N}{1\ mol\ N_2}\right) = 0.0311\ mol\ N$

0.997 g of O_2 $\left(\frac{1\ mol\ of\ O_2}{32\ g\ of\ O_2}\right)\left(\frac{1\ mol\ O}{1\ mol\ O_2}\right) = 0.0311\ mol\ of\ O$

molecular weight analysis

321.16 g/mol

$\frac{C_{0.467}}{0.0311}\ \frac{H_{0.155}}{0.0311}\ \frac{Cl_{0.0311}}{0.0311}\ \frac{N_{0.0311}}{0.0311}\ \frac{O_{0.0311}}{0.0311} = C_{15}H_5ClN_2O$

Em.

$C_{15}H_5ClNO$ = (15×12.01)+(5×1.008)+(1×35.45)+(1×14.01)+(1×16.00) = 250.61

$n = \frac{MM}{E.M} = \frac{321.16\ g/mol}{250.65\ g/mol} = 1.28$; $M.f = (E.f)_n = (C_{15}H_5ClN_2O)_1$

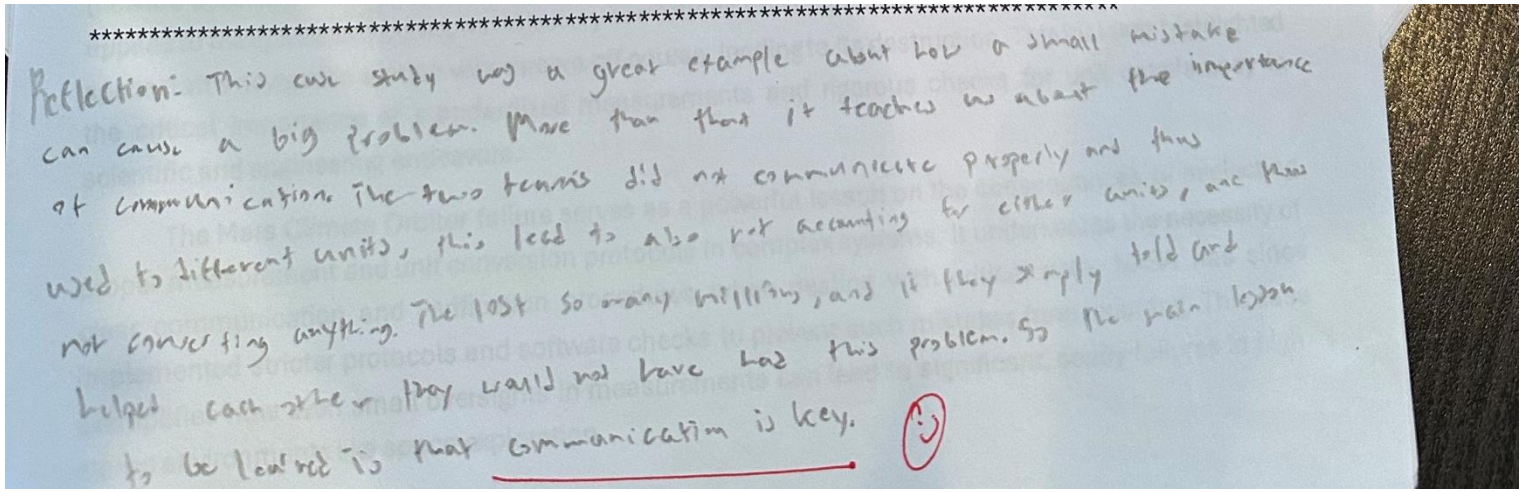
WoW! Good job! Well done!

2. What is the possible identity of the substance (the active ingredient in the pill)? How is it used? What is the dosage of the active ingredient taken by Tasha? What reference source(s) did you use and how reliable do you think they are? Explain your responses.

Based on the molecular formula $C_{15}H_5ClN_2O$, the active ingredient in the pill is benzodiazepine Diazepam, a medication used as a sedative and for anti-anxiety.

The dosage found in her blood is 200 g/L.

200 g/L × 5 L = 1000 g



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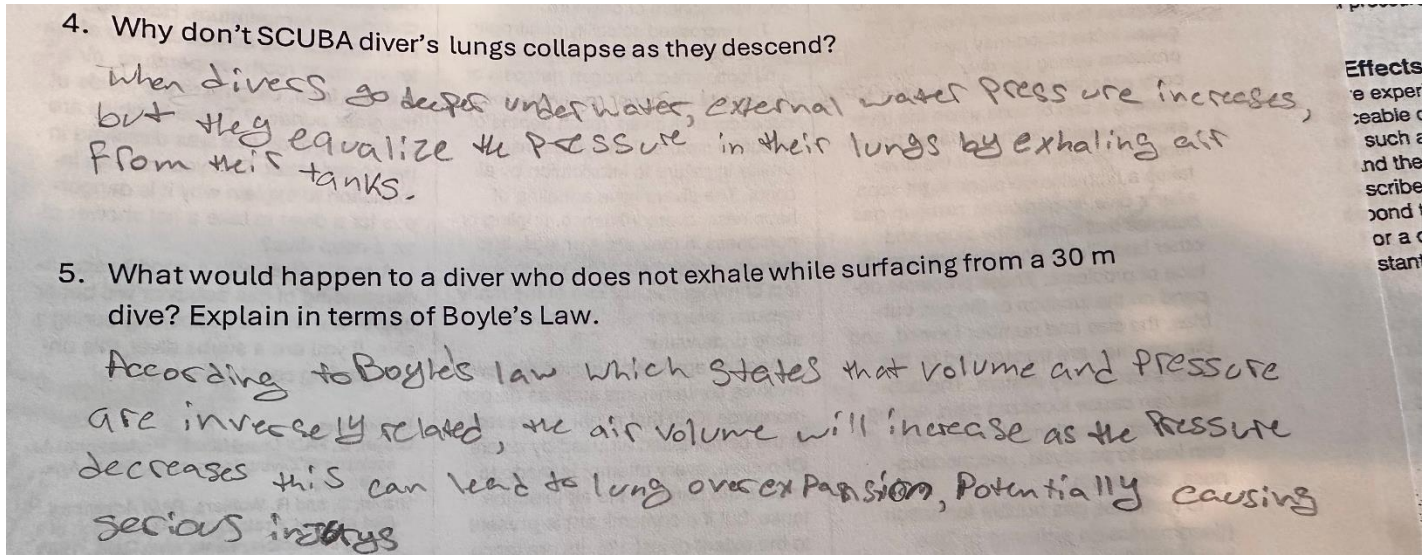
Reflection: This case study was a great example about how a small mistake can cause a big problem. More than that it teaches us about the importance of communication. The two teams did not communicate properly and thus used to different units, this lead to also not accounting for either units, and thus not converting anything. The lost so many millions, and if they simply told each helper exactly what they would not have had this problem. So the main lesson to be learned is that communication is key.



4. Why don't SCUBA diver's lungs collapse as they descend?

When divers go deeper underwater, external water pressure increases, but they equalize the pressure in their lungs by exhaling air from their tanks.

5. What would happen to a diver who does not exhale while surfacing from a 30 m dive? Explain in terms of Boyle's Law.

According to Boyle's law which states that volume and pressure are inversely related, the air volume will increase as the pressure decreases this can lead to lung overexpansion, potentially causing serious injurys

Sample reading assignment - with clear instructions

Dear Class,

Complete the reading assignment as per instructions on your chemistry notebook (handwritten). Take a picture of it and upload a clear picture in here. If you have more than one page make sure to copy paste all the pictures into one single word file and upload a single file. If you need help let me know.

Instruction for the reading assignment: Chapter 2- Open stax book:
1.Go through the headings and boldfaced words. Review summaries and chapter objectives given at the beginning and the end of the chapter. Take notes in your own words. (do not copy)
2.Come up with 5 questions you would like to get answered in this chapter based on the summary and objective and the heading you glanced through.
3.Create a concept Map using those headings and boldfaced words (use the example given below as a template). Trying to make a connection between the Heading, subheading, bold words - based on how you understood them to be connected.
4.Headings or topic that caught your interest and if you tend to read the full content - give a brief description of anything you learned new in this reading assignment.

Sample reading assignment requiring 2 – peer review

Dear Class,

Complete the reading assignment as per instructions on your chemistry notebook **(handwritten).** Take a picture of it and upload a clear picture in here. If you have more than one page make sure to copy paste all the pictures into one single word file and upload a single file. If you need help let me know.

Instruction for the reading assignment: Chapter 9 - Open stax book: Read only the following topics. ignore the other objectives.

9.1 Gas Pressure

9.2 Relating Pressure, Volume, Amount, and Temperature: The Ideal Gas Law

9.3 Stoichiometry of Gaseous Substances, Mixtures, and Reactions

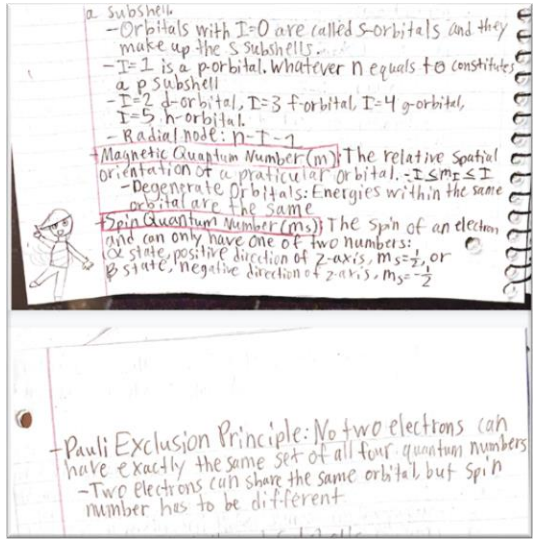
9.5 The Kinetic-Molecular Theory

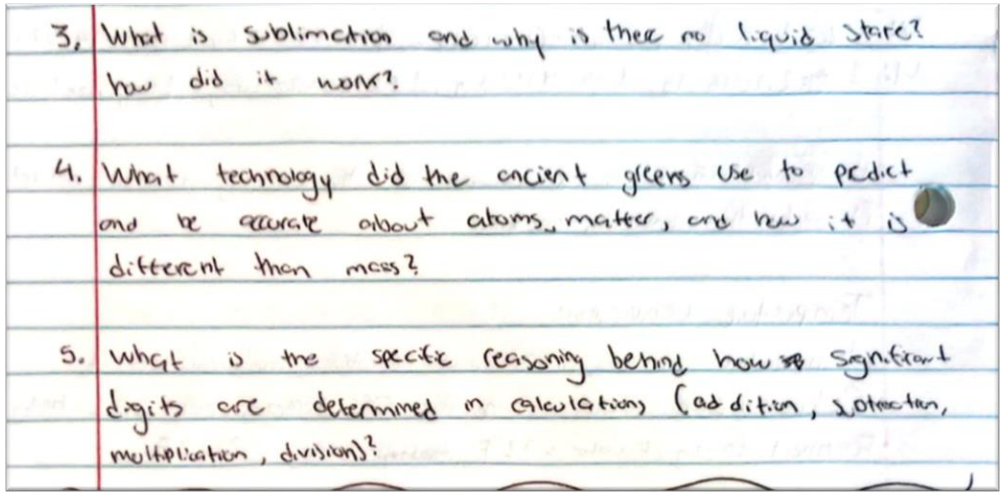
1. Go through the headings and boldfaced words. Review summaries and chapter objectives given at the beginning and the end of the chapter. **Read the heading and take notes.**
2. **Note down the new concepts you will be specifically learning in this chapter.**
3. Think of **what concepts you learned in chapter 2,3 and 4 you will be using in this chapter 9. Give a summary of how and when will you be using those concepts in this chapter.**
4. **Create a concept Map using those headings and boldfaced words** (use the example given below as a template). Trying to make a connection between the Heading, subheading, bold words - based on how you understood them to be connected.
5. This time will be able to see **two of your classmates reading assignment for review.** learn from each other.

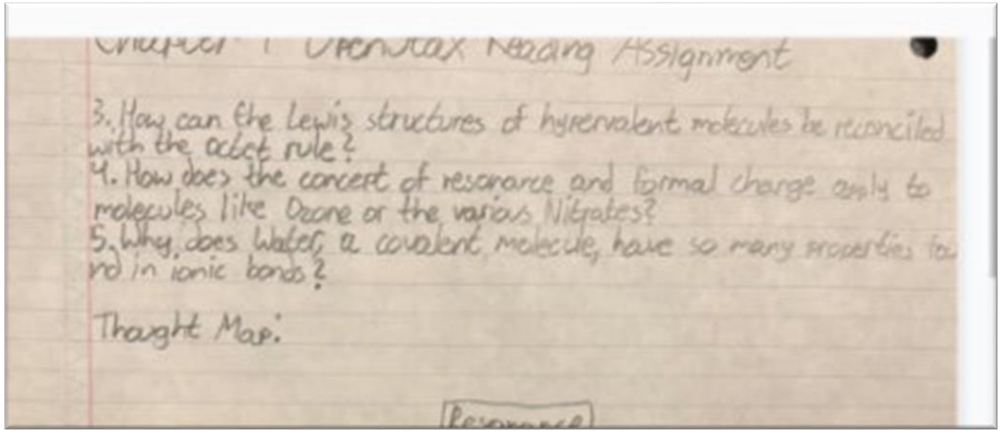
Your reading assignment should have all the first 4 segments to get the full credit. Do

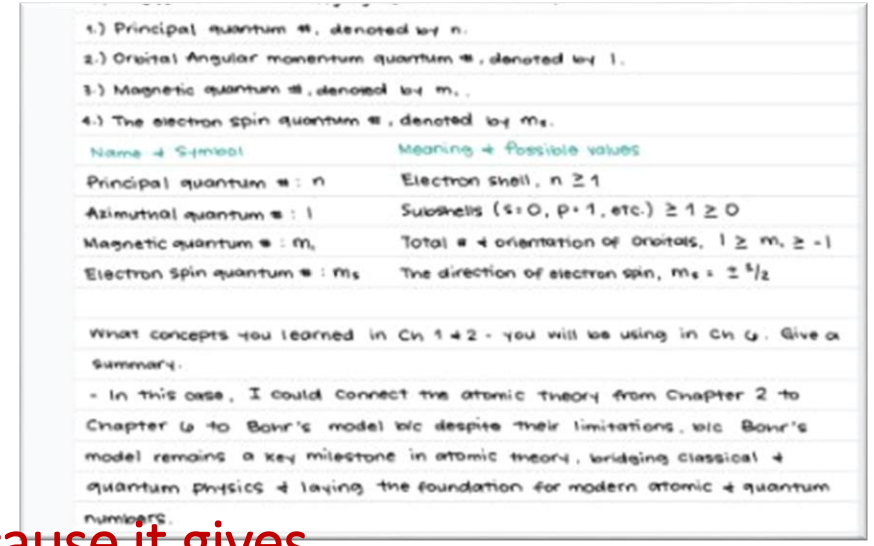
Students work…

Reading assignment and concept mapping….

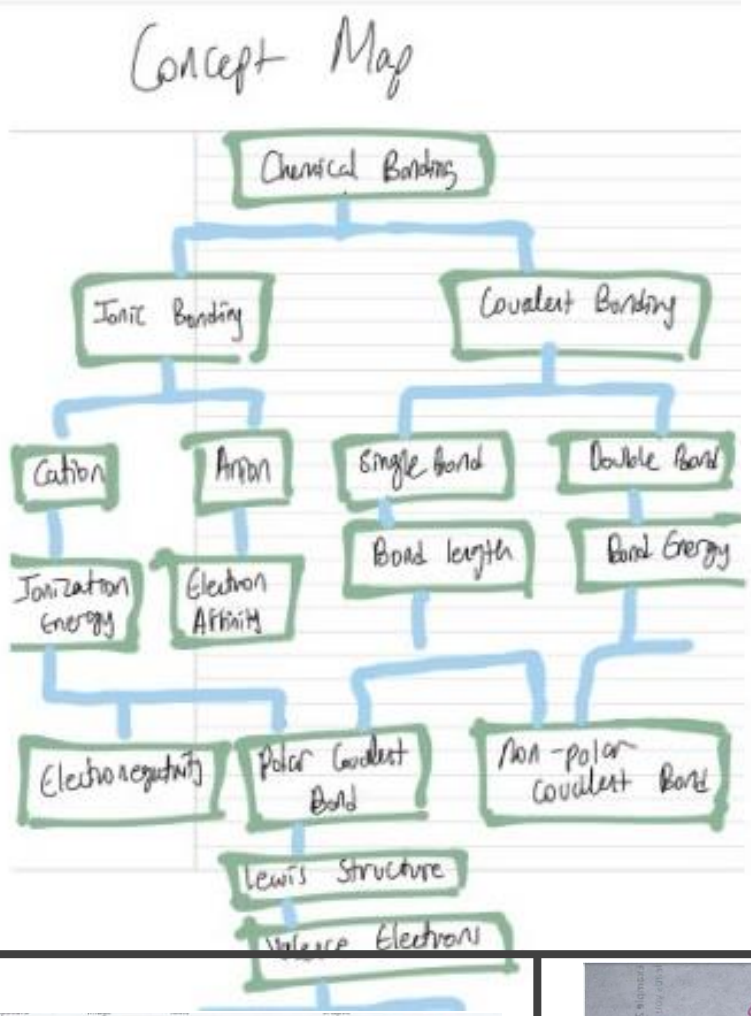


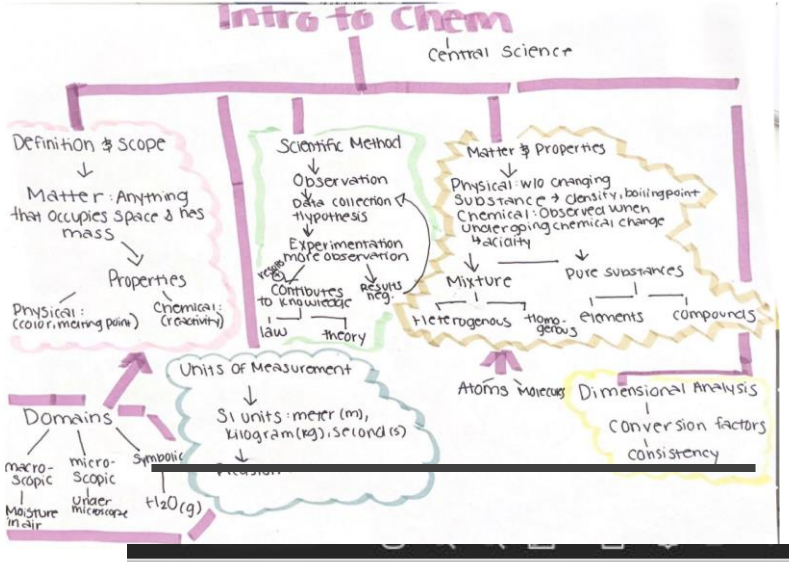


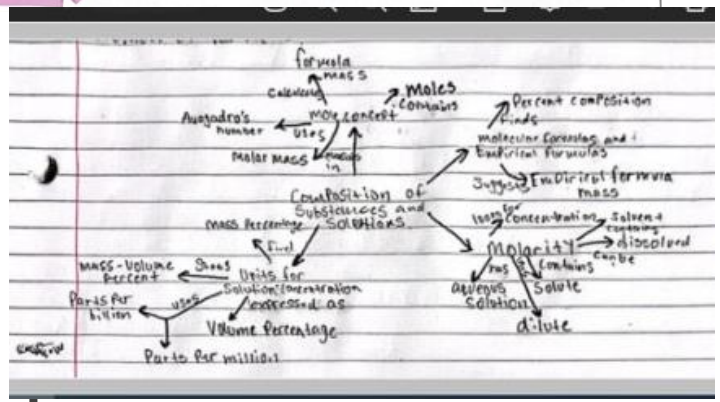


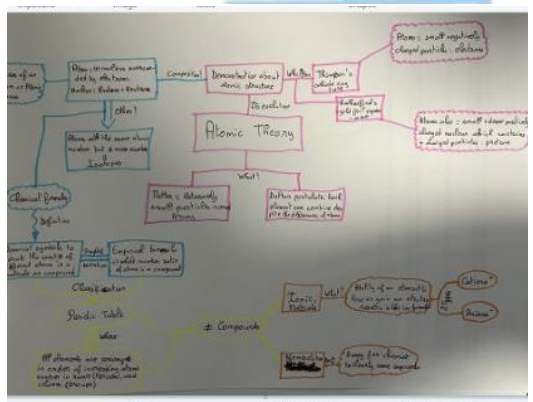


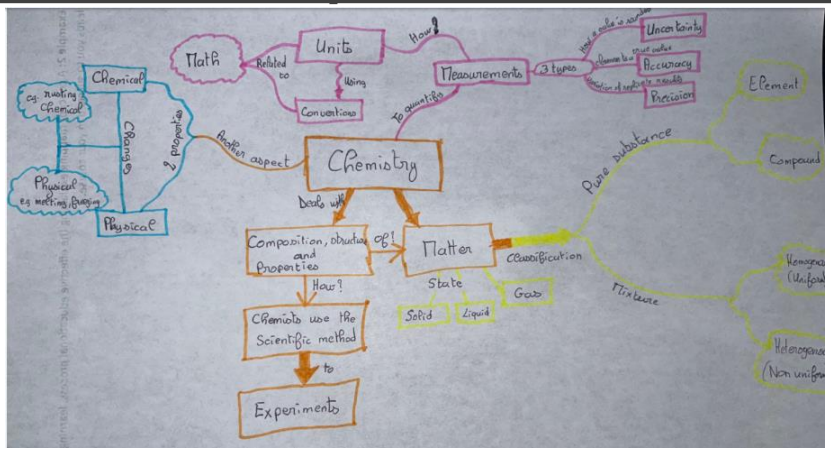
I enjoyed learning about the chapter beforehand because it gives me an overview even if I don't completely understand it. –











Concept maps - facilitate development of higher order thinking skills

Student comment on concept mapping:

I think the concept mapping is good because it helps me visualize the connections between topics. It lets me focus on the main things in the reading and write the important takeaways. It does stress me out a little bit trying to figure out how to fit things on the page.

Assessment ...

Student's comments and Survey results

Grade comparison of Fall 24 and Fall 23

Student survey on case study:

1

Student 1: Case studies help me connect chemistry to real world concepts. Throughout school we always learn about subjects but never implement them into real world problems until it happens. I find them interesting.

2

Student 2: The case studies help me understand why the things that we are doing is important and what mistakes or discoveries were made because of what we are learning about in class. It interests me because then I see what we are doing put into a real-world scenario.

3

Student 3: I like it because it solidifies our understanding of what we just covered in class and allows us to apply it to real world situations compared to numbers by itself.

4

Student 4: It helps me understand how important chemistry is not just for my major but for any real-world applications, which makes it that much more

5

Student 5: It helps me appreciate how far chemistry has come and how useful it is and all we do thanks to it. It is rather interesting and it helps us learn more about different discoveries. I like them.

Student survey on case study….

I think the case studies we've done are pretty interesting and helps me to think of the how chemistry is really everywhere in the real world. Especially being in a nursing major what I enjoyed the most was the Sleepless night case study because it had to do with medicines and the dosages.

I think that connecting chemistry with the real world helps a lot and given that the case studies help a lot. I have a lot of interest in the case studies and enjoy explaining to my friends what I learned in the case studies afterwards.

The case study makes me take the concepts we have learned during class and apply it to problems we are not usually given. It helps better understand the concept and shows how there are many scenarios that certain concepts can be applied to. Reading the case studies is interesting because they include situations that some people might go through.

I enjoy the case studies because I can step away from solely focusing on the elements by themselves and solving equations and instead, I can view how the elements and concepts of chemistry can be applied in real-world scenarios. I am enjoying the Gas Laws case study the most due to the detailed, clear explanations and information about how gas pressure and solubility are affected in water in varying temperatures and altitude levels, and how they affect humans or anyone who travels to depths of the sea (scuba-divers).

Student survey on pre reading assignment…..

- I enjoyed learning about the chapter beforehand because it gives me an overview even if I don't completely understand it.
- I enjoyed writing out the concepts that are discussed in each chapter in my own words to better understand the material. I also enjoyed writing the definitions of the concepts and topics that are discussed and that we also learn in class.
- I do re read my reading assignment notes after lectures and used them before the exam the concept mapping not so much but that is because I feel like I can already remember it after writing it down once and drawing how they are all connected.

Students survey on concept mapping…

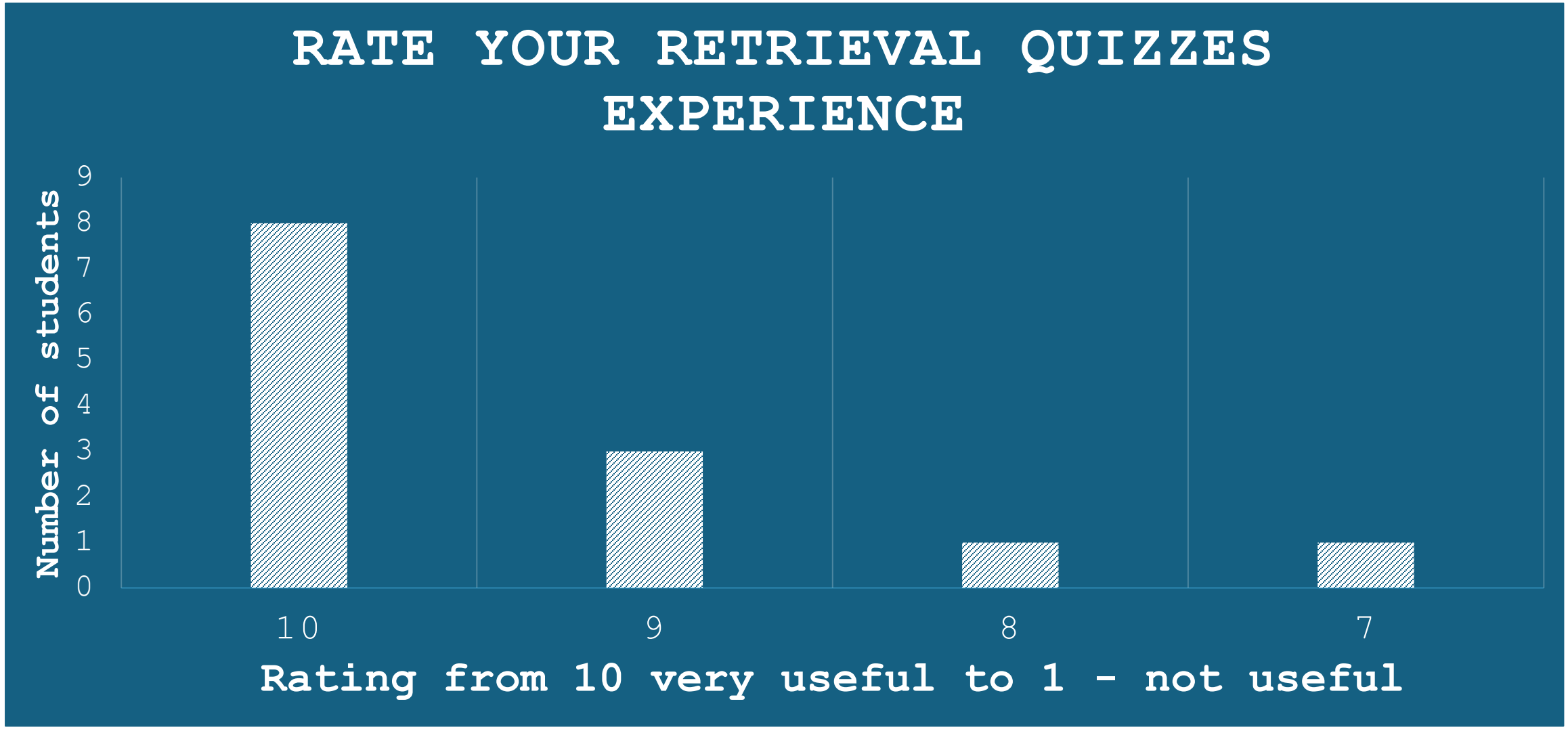
1. I think the concept mapping forces me to focus on the key details and write only the important details to save space since we have to handwrite it on one page. But I don't like them for this same reason because I spend a lot of time trying to make it look organized and clear instead of focusing on understanding what I'm reading.
2. **I liked doing the practice problems while reading the chapter, but I don't like making concept maps. Either way, the concept maps do help me remember what I learned in that section.**
3. I think the concept mapping is good because it helps me visualize the connections between subjects. It lets me focus on the main things in the reading and write the important takeaways. It does stress me out a little bit trying to figure out how to fit things on the page.
4. **I don't necessarily enjoy the reading assignment but I think it's helpful for my studies.**
5. The reading was a bit boring because the words are complicated and I don't

Retrieval quizzes – student survey…

1. It helps me to review than the actual exam.
2. I do enjoy the retrieval quizzes and yes, I think it helps a lot. It helps me understand things that I did not understand before and it helps me go over the topics that we covered at that time.
3. I do like the retrieval quizzes. I do think that after taking the exam if we take the retrieval quiz it give us a chance to look back and see where we need to work on.
4. **I do not really know if I like it or not, but I know that it helps us to understand ourselves more, reflect on our habits, and the way we may or may not do things to be successful in this class.**
5. I do take the retrieval quizzes to help or reinforce not only my grade but the concepts and knowledge of the material that was given on the exam.
6. I did take them. I like that it touches up on some topics I could've missed and that it gives us a chance to fix our mistakes.
7. **I really think the retrieval quizzes are a review of the exam and also**

Survey results end of the semester…

Survey results of Retrieval quizzes…



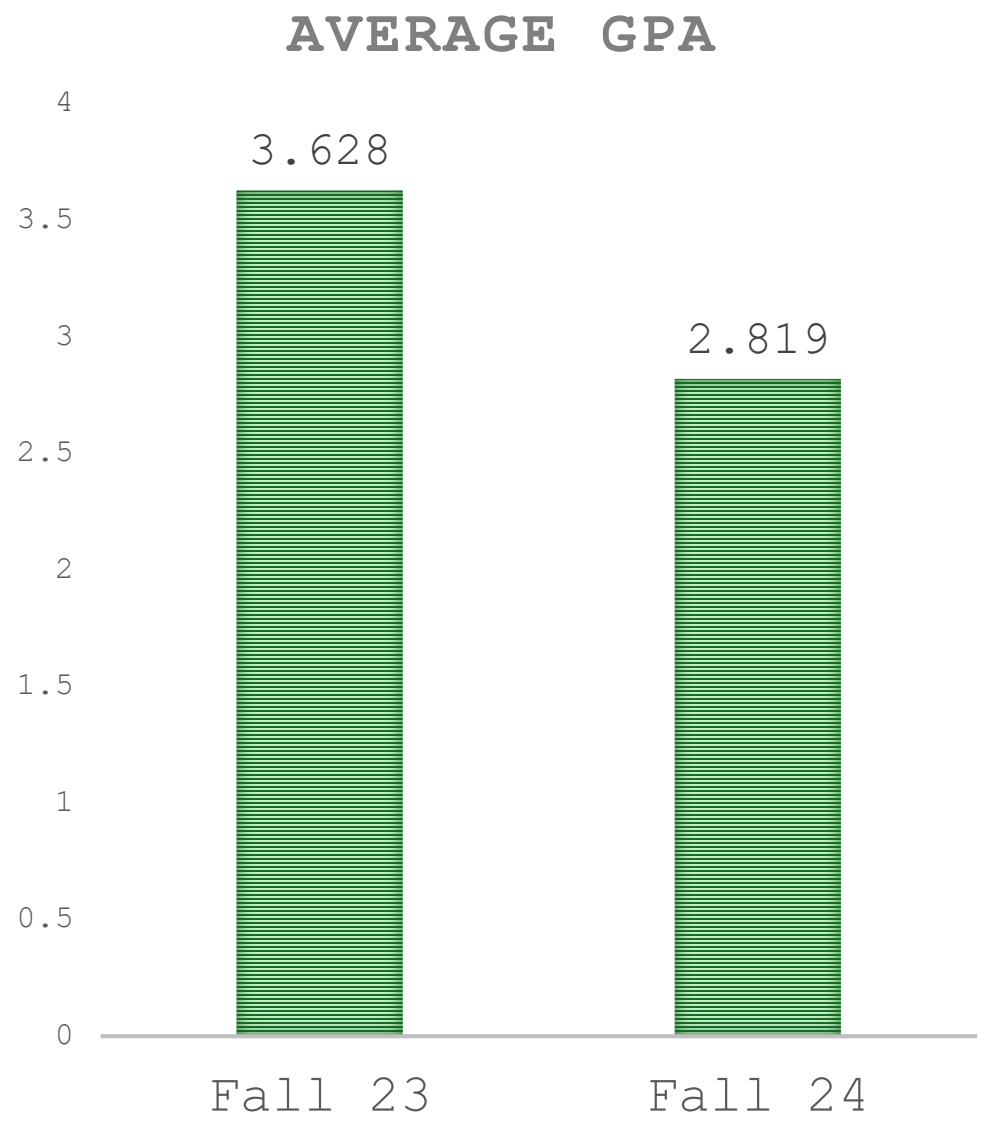
Control group(Fall 23) and the experimental group(Fall 24) analysis

Fall 24

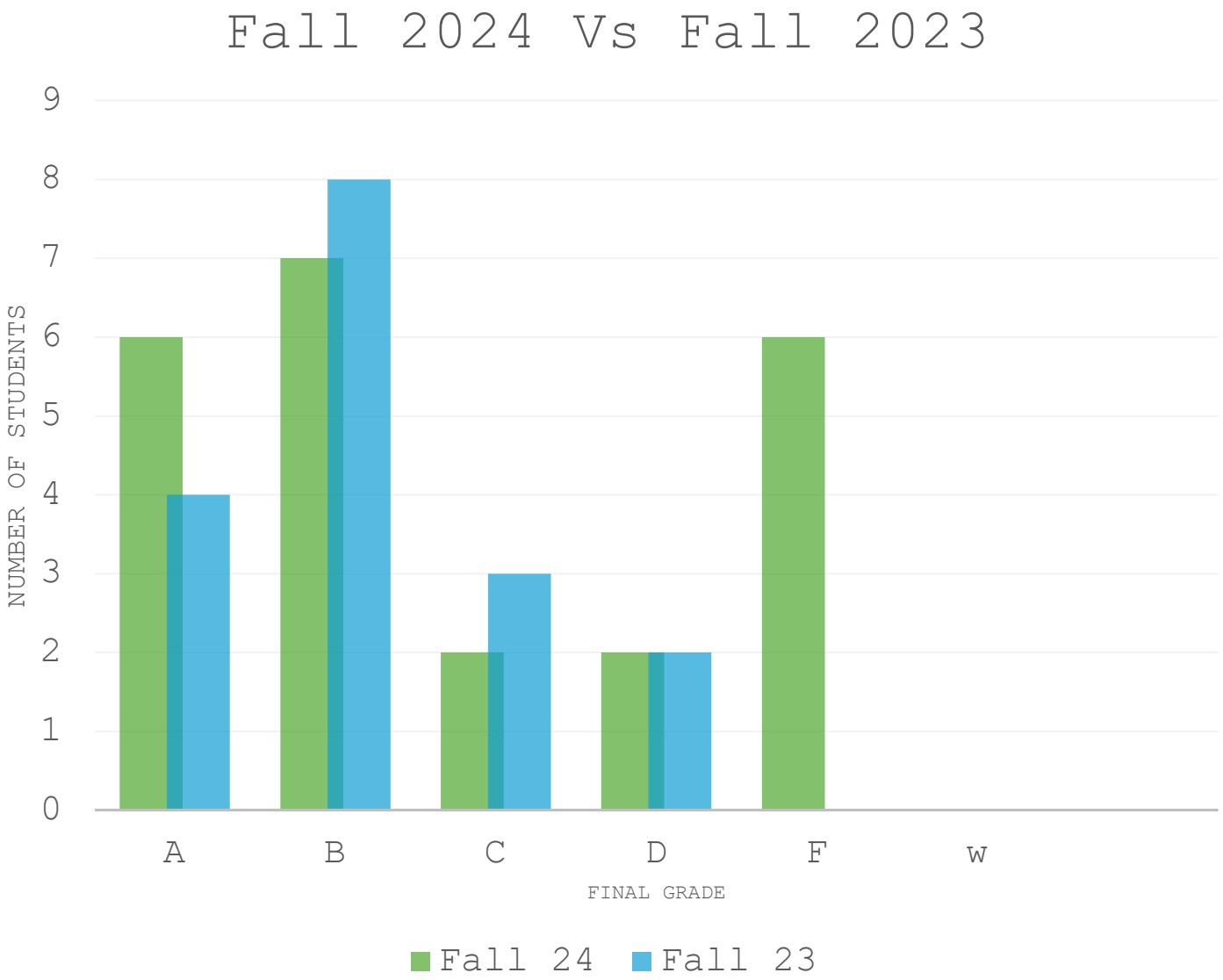
- Total number of student: 23
- 3 - early college student

Fall 23

- Total number of student: 17
- 15 - early college student



Final grade comparison



My learnings…..

1. SET and this one year has made me more organized in my planning.
2. I believe analysis of the student's data is very essential to improving the teaching style.
3. I loved reading informative books and will continue this journey of reading and improving – as for a lifetime.

Future plan….

1. I would like to continue use the same strategies for the up coming semester as well to analyze its impact.
2. However, I would like to fine tune the case study

Thank you

- I thank Joan for her support and guidance for the past one year.
- I thank all my friends in the cohort 2024 for all their support.