GNG1103

Engineering Design

Deliverable H

Date: March 29,2020

Team #: F08

Problem Statement

The problem statement is to create an interactive, innovative , user-friendly and cost effective VR learning experience that helps students currently enrolled in Organic Chemistry visually understand chemistry molecules in 3D

Reasons for Prototyping

1. Make a plan for the final Prototype for Design Day
2.Continue to get a deeper understanding of our final prototype
3. Reduce the risk of errors
4. Verify that it is feasible
5. Find mistakes in advance, improve them and incorporate any feedback.

Introduction

The overall environment of the game was completed and consists of a laboratory setting with separate areas to interface with the different parts of the game. In other words it acts as a game 'lobby' to allow for immersive selection of tasks. Within the lab is a beaker that allows the user to transfer to another scene inside the solution. In this second scene the user may collide molecules in various attitudes and with various forces to try to create a successful reaction. This is designed to teach the conditions required for a successful collision. Lastly in the lab there is a trivia game option. This allows the player's learning to be assessed which was an important aspect of the clients needs.

Unfortunately, due to the circumstances testing of the program with the VR headset was not able to be accomplished. This was an important aspect that we could not complete. If we still had access to the hardware we would have tested the various elements of the game to ensure that the actions of the user produced the desired effect. Additionally, it would have been very useful to have people from outside the group to test the game so we could get feedback. This would have been an opportunity to fine-tune the design in preparation for design day. In addition, the comments of users on what they liked would have provided useful talking points to emphasise during design day. It is in the preparation for design day that the balance of the time would have been spent to ensure that all members of the group were equally acquainted with all the disparate elements of the project. This would have been an important step because of the delegating techniques used in creating the game.

Had testing taken place it would have consisted of three main phases. In the first, each component would be tested in isolation to ensure that they worked as intended. Second, the members of the group would try to actually play the game ensuring that all elements worked

together and as intended in a play situation. Lastyl people outside the group would have been recruited to test the game. This would have allowed user-friendliness to be assessed in addition to elucidating any flaws that had thus far gone undetected.

Prototype Screenshots

Our team designed a cover image for our game in unity. This is the first image they will see when entering the game which includes a flask and the name of the game using elements from the periodic table.

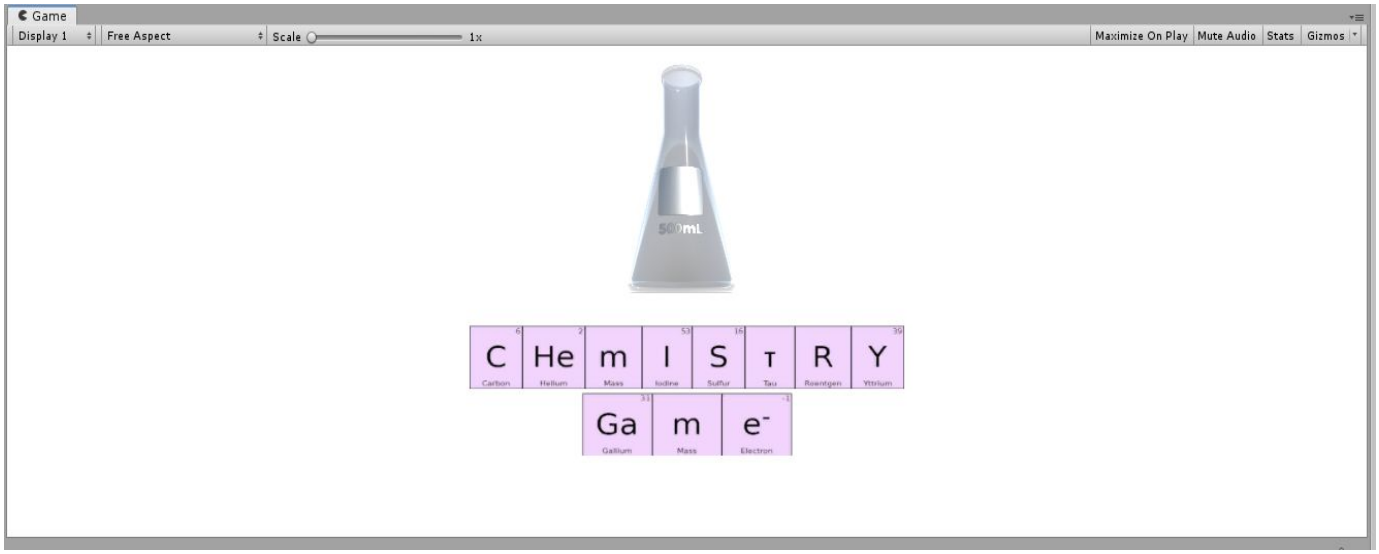


Figure 1.Cover page of the game

Molecules

The following molecules were first made in solid works and later imported to unity. So they could easily be rotated and moved around by the player. They were also made so they could collide and react and form products.

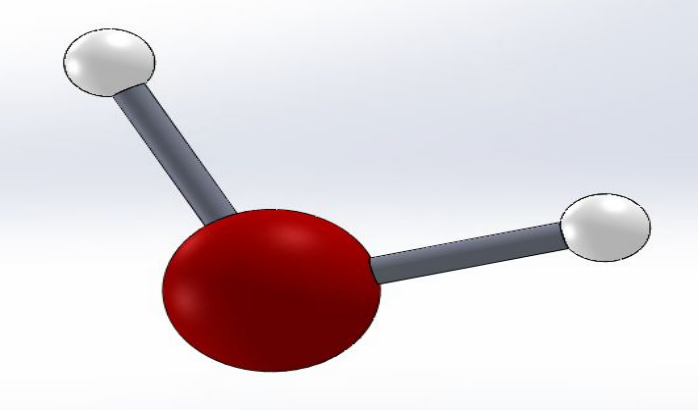


Figure2. H_2O molecule

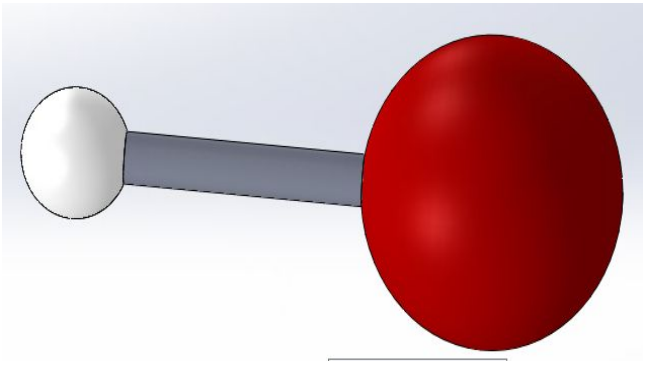
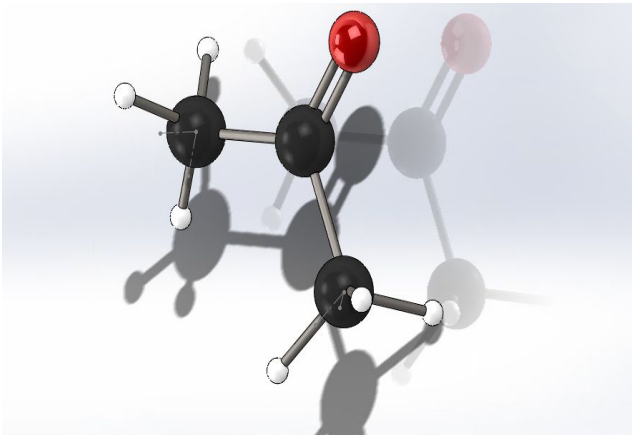


Figure 3. OH molecule



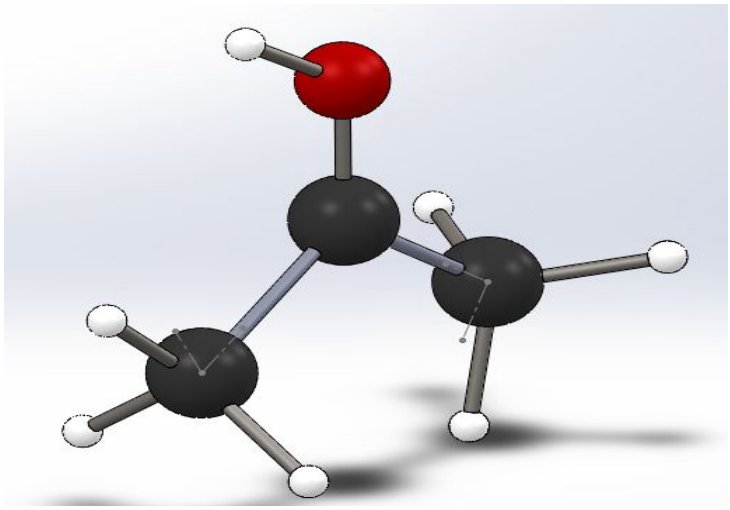


Figure 5. Protonated Acetone Molecule

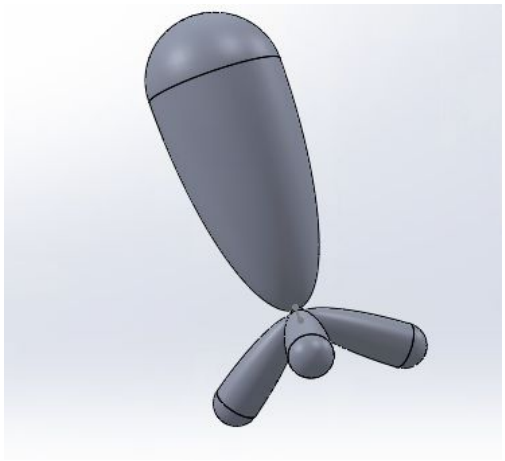


Figure 6. Orbitals Hydroxide Molecule

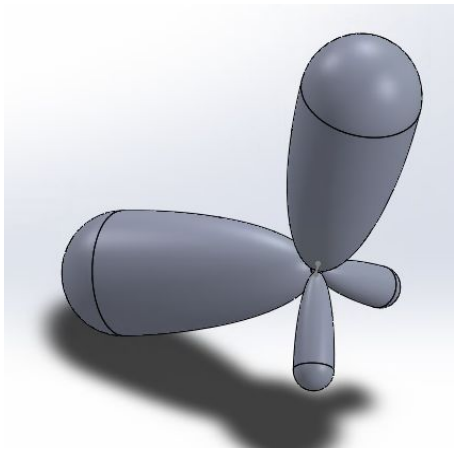


Figure 7. Orbitals H_2O molecule

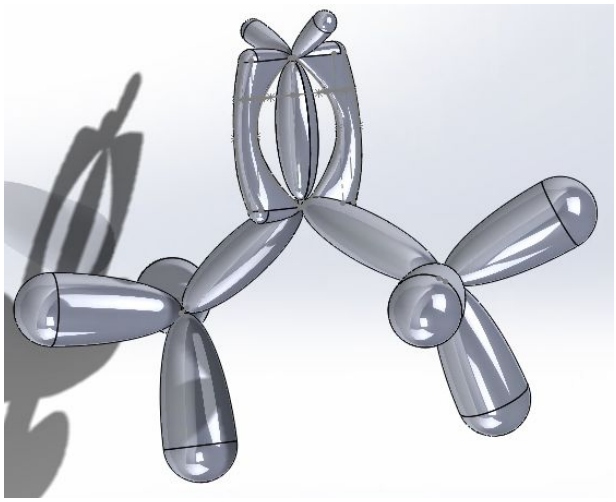


Figure 8. acetone orbitals

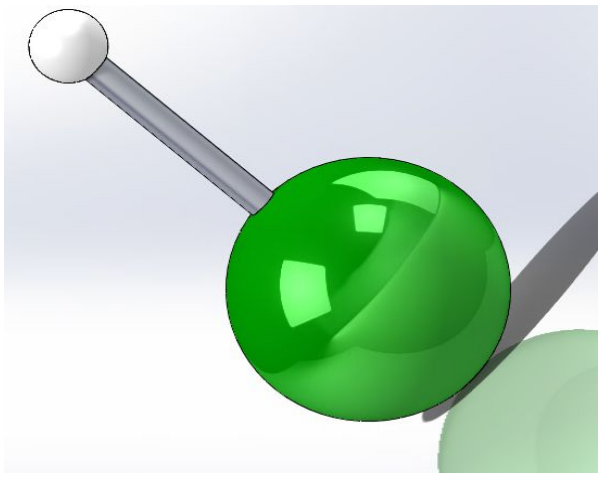


Figure 9. Hydrogen Chloride

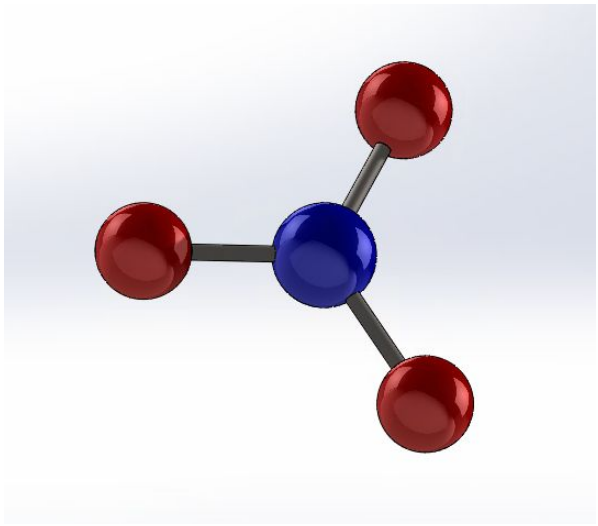


Figure 10. Nitrate Molecule

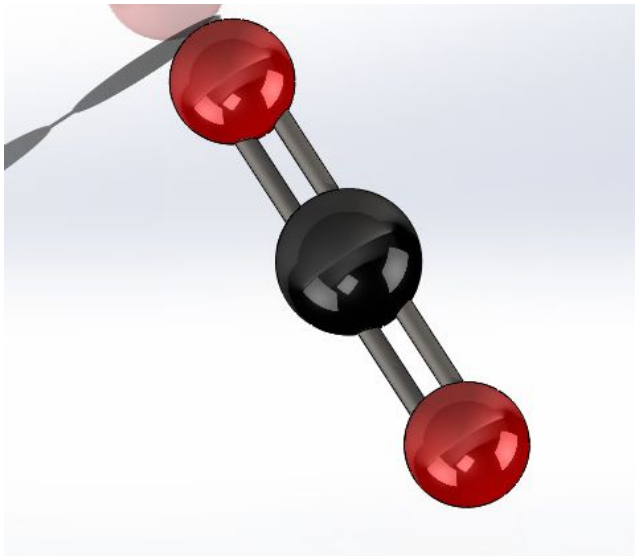


FIgure 11. Carbon DIoxide

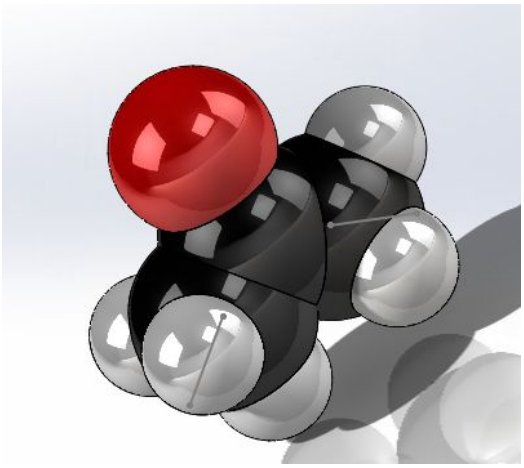


FIgure 12. Space Filling Acetone Molecule

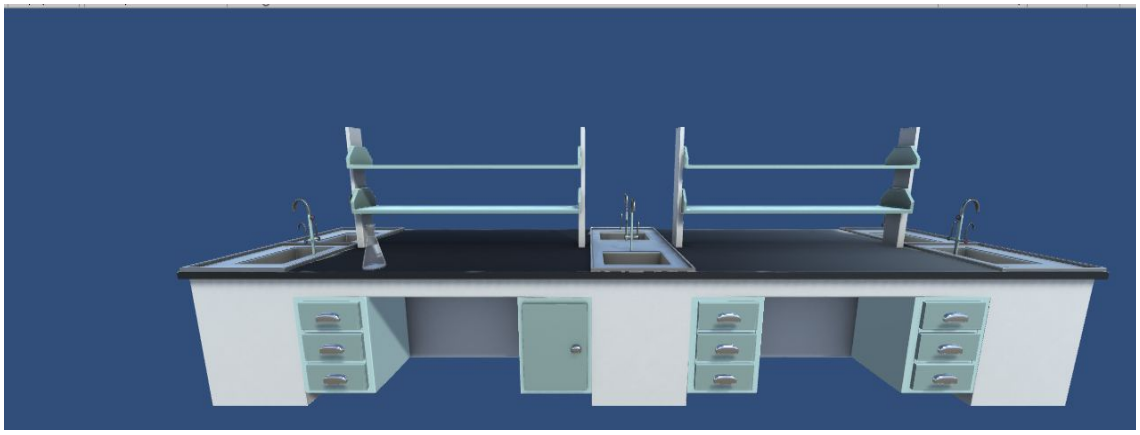
When the user gets into the game the first thing he will see when he approaches the Lab bench is a pop up window with the Learning Objectives. The learning Objectives for Scenario 2 are :

1) To describe the internal movement of the molecules.
2) Select the appropriate model to solve a problem (orbitals,ball and stick, electrostatic)
3) Explain /identify requirements for successful collision(angle of reaction, energy)

Then they will be able to begin the activities by selecting the different Learning Objectives.

Environment and Two different Scenes

Right now the lab scene consists of a lab bench we bought for $8.99 and a Flask we bought for $3.99. The fist scene is a normal lab bench with a blue background where all the learning takes place so there are no distractions. We choose generic colors. The second scene is where the trivia game will happen. We were able to choose the background we wanted and make the lab bench differently so it doesn't look so generic. The second scene is a beaker full of molecules the user can choose to grab a molecule or jump into the beaker and play with reactions and the molecules.



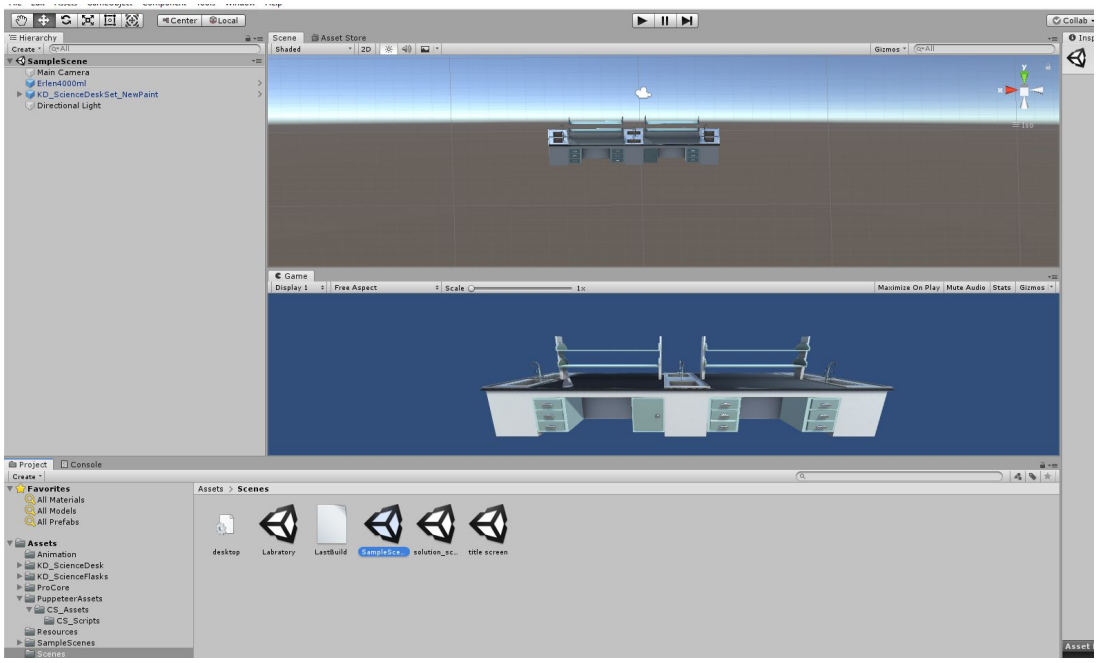


Figure 10 and 11. Lab Scene with the erlenmeyer flask where the reactions will take place

Figure 12. Beaker with solution

Figure 13. Beaker scene Front view vs. Top view

From the beaker one can see that there are several H_2O molecules therefore eliminating the misconception that there is only one molecule in a solution. Then the player would be able to grab any of the H_2O molecules and change the orientation.

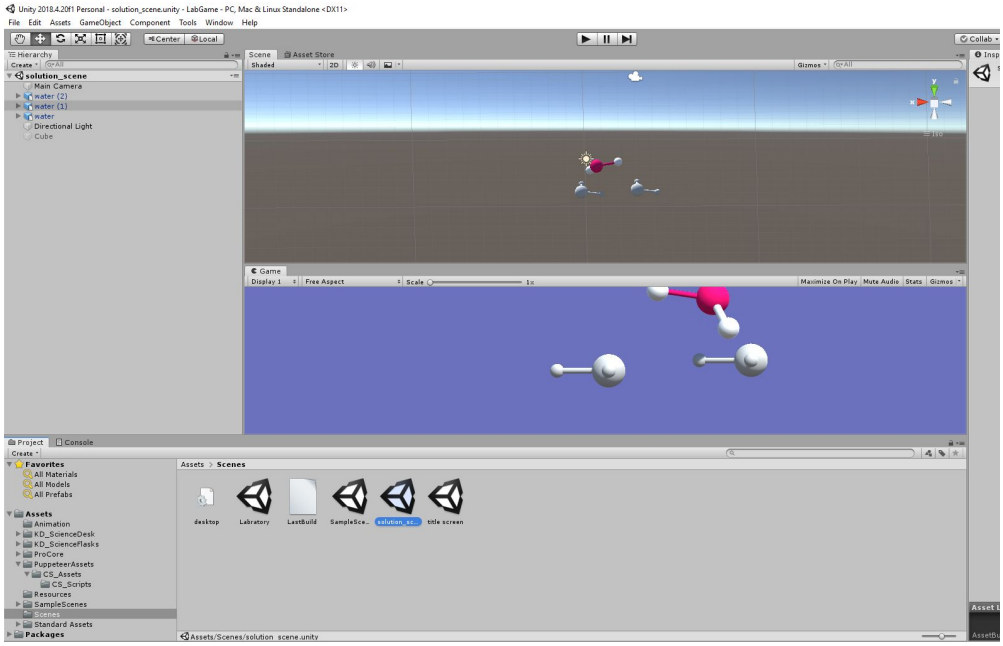


Figure 14. Molecules after the player takes them out of the beaker.

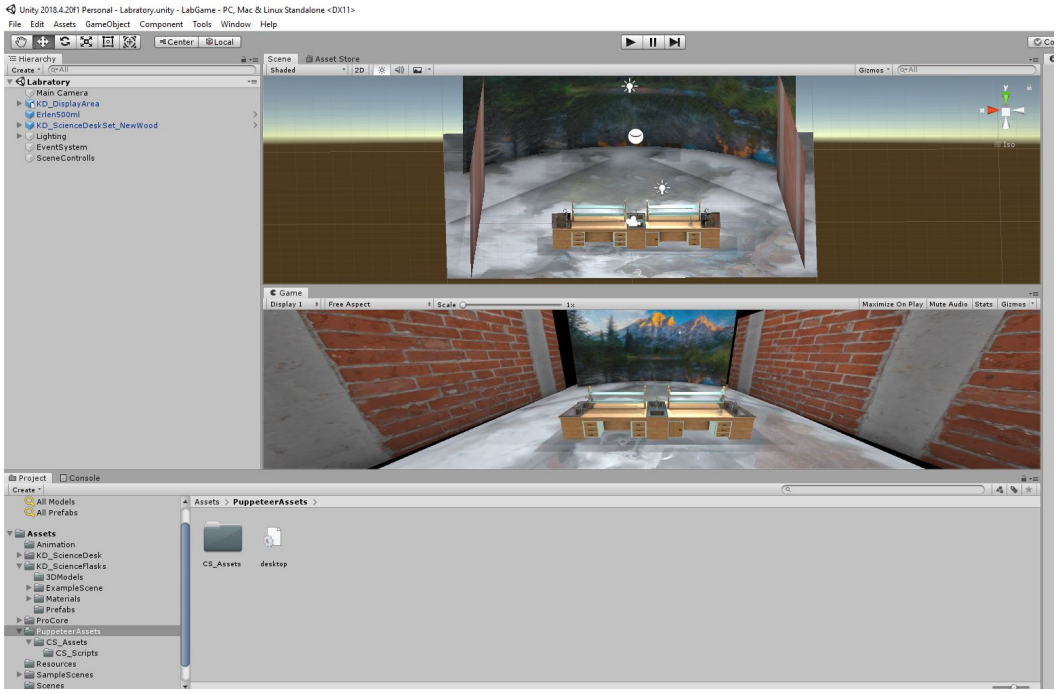
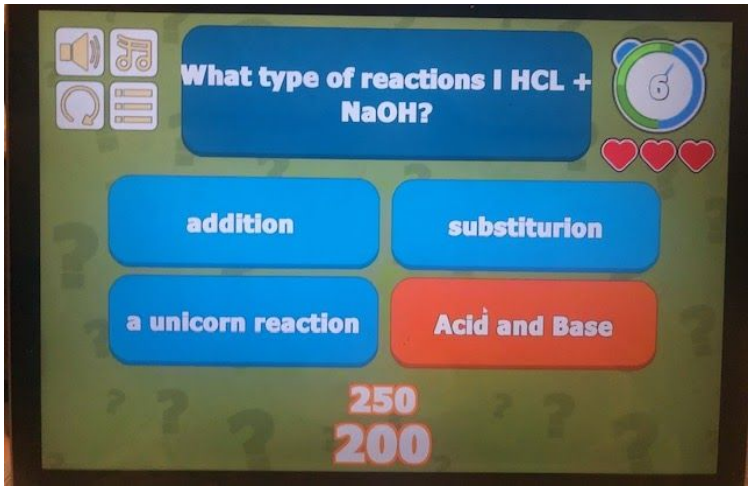
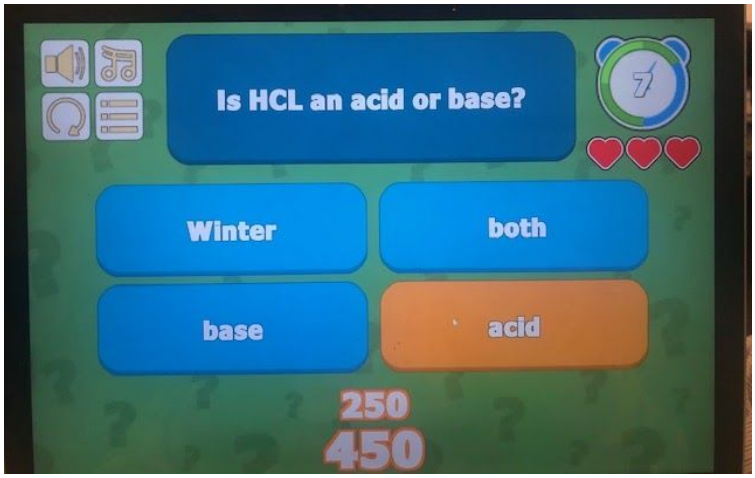


Figure 15 and 16. Lab scene where the Trivia Game takes place

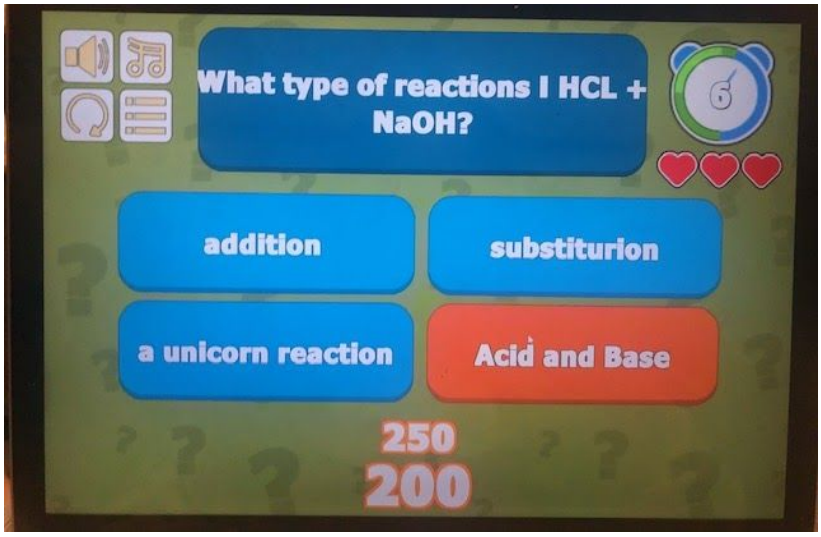
Trivia Game

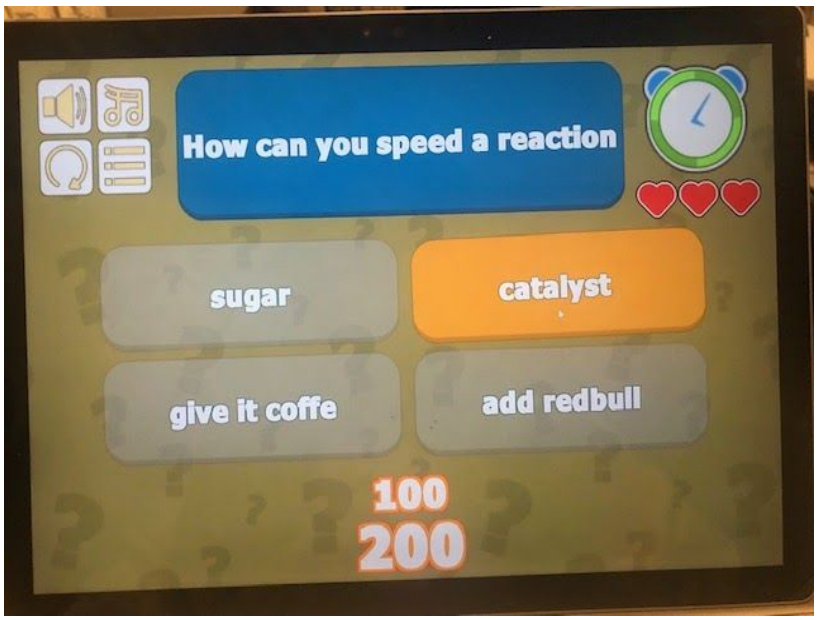
The trivia game was developed by modifying the code of a trivia game that was in the unity asset store. After extensive research on how the C# language works we were able to code it. We had to change the questions and figure out how to code so that it would give feedback. Finally music was added and all the final details. In the trivia game the player has three lives. He must answer the questions correctly to win the game. If the player misses more than twice the player automatically loses the game. Also, if the player chooses the wrong answer the right answer will be shown after the player makes the mistake.In order to win the player must answer as many questions correctly as possible in the lowest amount of time. You can choose to either have the background music playing or have it muted.

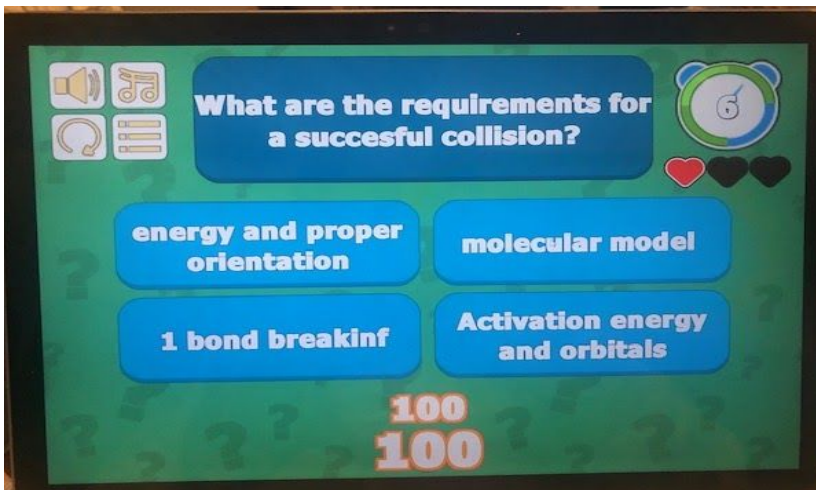

What type of reactions I HCL + NaOH?
6
addition
substiturion
a unicorn reaction
Acid and Base
250
200


Is HCL an acid or base?
7
Winter
both
base
acid
250
450

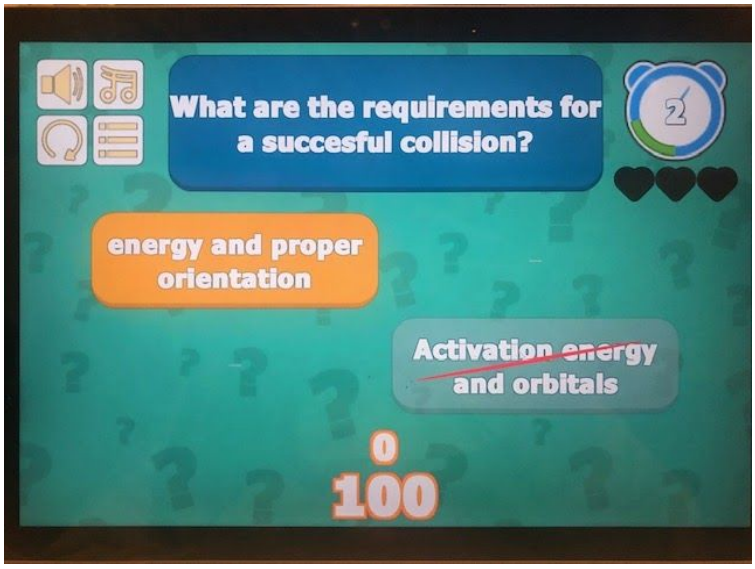

VICTORY!
SCORE 700
HIGH SCORE 700

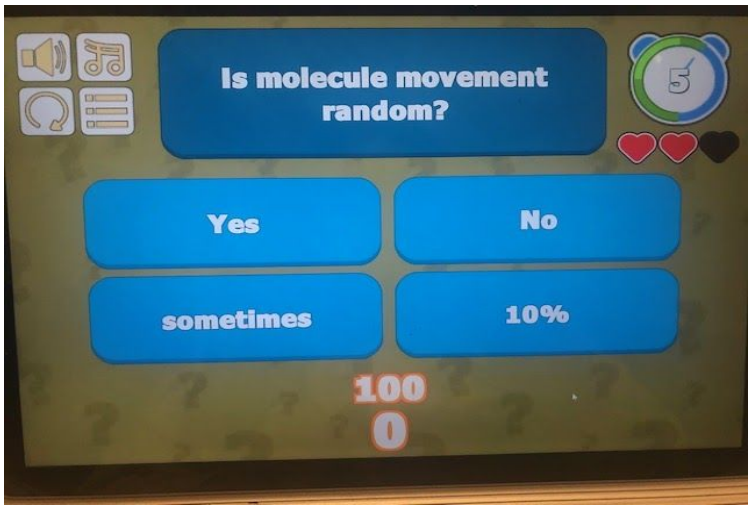

What type of reactions I HCL + NaOH?
addition
substiturion
a unicorn reaction
Acid and Base
250
200


How can you speed a reaction
sugar
catalyst
give it coffe
add redbull
100
200


What are the requirements for a succesful collision?
energy and proper orientation
molecular model
1 bond breakinf
Activation energy and orbitals
100
100


GAME OVER
SCORE 100
HIGH SCORE 100


What are the requirements for a succesful collision?
2
energy and proper orientation
Activation energy and orbitals
0
100

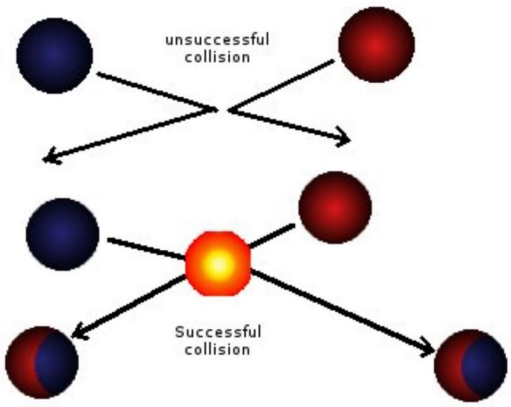

Is molecule movement random?
5
Yes
No
sometimes
10%
100
0

Link to trivia game youtube:
https://www.youtube.com/watch?v=KLnPLTwNHSI&feature=youtu.be

Collisions

An animation appears in a 2D pop screen demonstrating the collision between Acetone molecule and HCL molecule. Then after the collision is shown a bang pop up will show an explanation that will explain what is necessary for a successful collision. After that happens what will happen is that the protonated Acetone will show up and the acid base reaction will be completed.

The first figure to Pop up when entering the collision theory scene.



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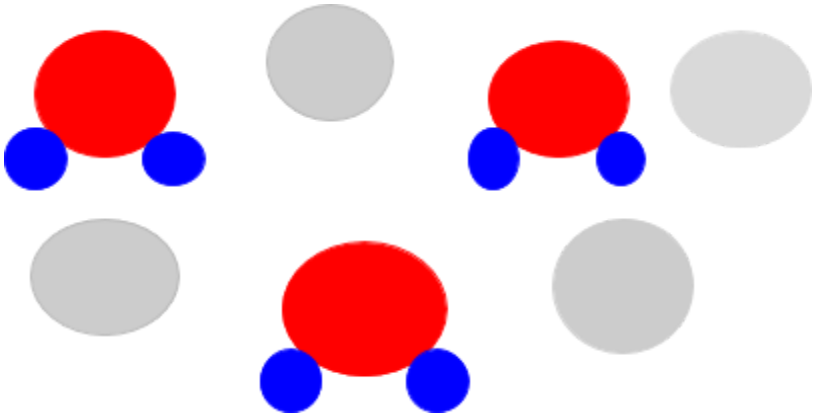
Second figure will be a 2D image of what is needed for a successful collision.

Successful Collision

1) Molecules must collide with proper orientation

2) Molecules must collide with sufficient energy

Activation energy

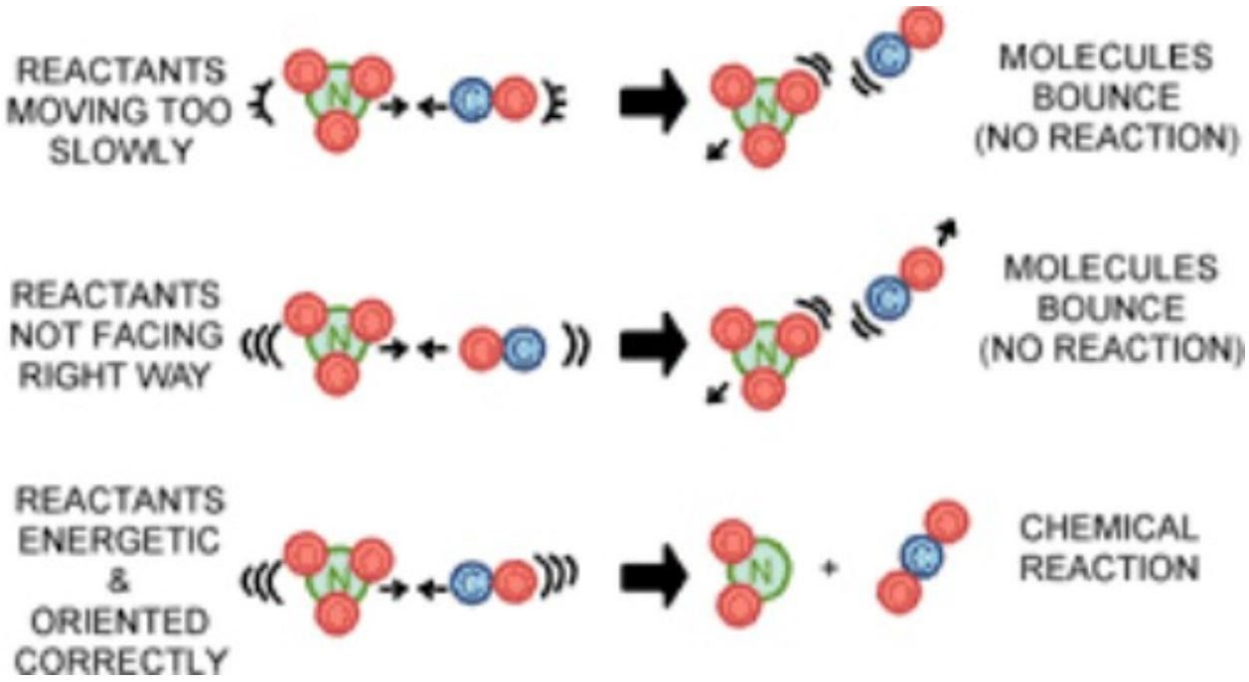


The third figure to pop-up will be the solid work molecules that you can choose from grabbing a base or an acid . The player will be able to move around the environment and grab the acid and a base to create a reaction and make the molecules collide.

Then a Bang will show up:

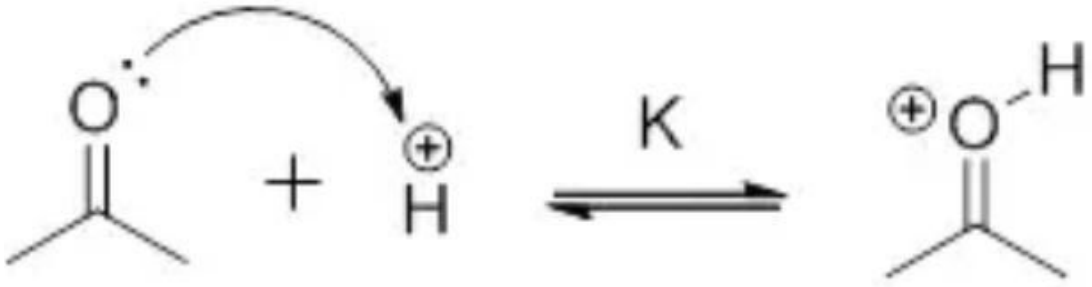
Finally the product corresponding to the correct reaction will appear.

Lastly a pop up explaining why you collision would work will appear,



Reactions

Acid Base-it was impossible to show this in 3D specially since we couldn't test it. As a group we decided to show the reactions in pop-up 2D to explain how you go from an acetone to a protonated acetone.



Difference between pi and sigma Bonds

In the last client meeting the client asked us to differentiate between sigma and pi bonds. We decide to show 2D pop up to explain the difference between the pi and sigma bond in the orbital representations. The reason we choose acetone is because acetone is a molecule that has both pi and sigma bonds. In the figure below you can observe the difference between sigma and pi bonds.

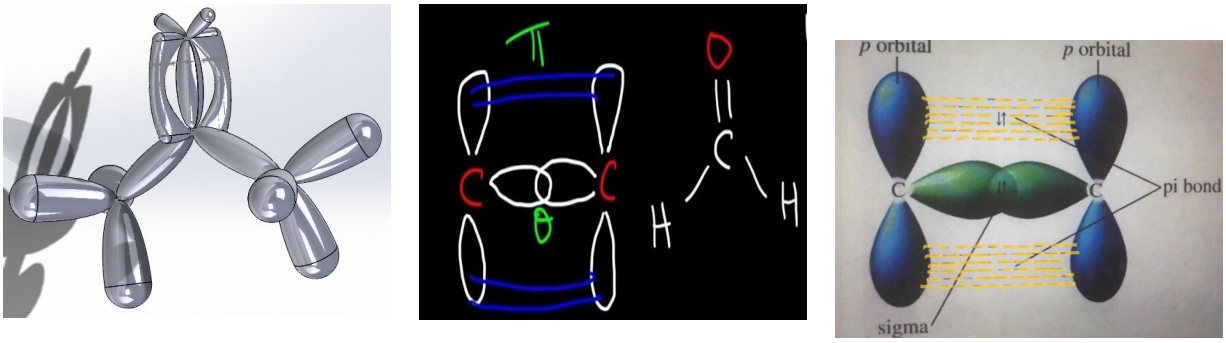


Figure 17. Explanation of Pi and Sigma Bond

Cost of Prototype

We are allowed to spend 100 CAD in the unity store. We bought a trivia game for $29 USD. We are currently trying to find a way to create the pop up quiz without spending the money. In total till now we have spent around $42.97 USD.

Bill Of Materials

Unity Asset	Cost in USD
Lab Bench	$8.99
Flask	$3.99
Trivia Game	$29.99
Total	$42.97

Testing Plan

The first prototype did not resemble our last prototype, yet the second prototype was closer to our final prototype. The final prototype is as close to what we wanted it to be as possible because of the situation as we never got to test with the VR headset. We were never able to test but if we had been able we would have tested it at least three times before design day.

In Deliverable B we wanted our final prototype to have gaming options in a way that allow for an experience in which the user can be immersed in the material in a fun and productive way using 3D models instead of the conventional 2D. We were able to accomplish this by creating 3D molecules in solid works and unity. We also wanted our final prototype to be easy to comprehend with clear learning outcomes . We wanted the players to be able to learn and easily visualize the material. The game had to also be interactive and cost effective. We implemented the trivia quiz game to be able to assess the learning of the user.

Previous Target Specifications	Final Performance after testing final Prototype
Immersion and interactivity	The game is interactive and immersive
Easily being able to comprehend and Understand the learning outcomes	The prototype addresses the Learning outcomes and common misconceptions.
Measurement criteria to evaluate user	The single player trivia game

Since normal prototype testing was not possible the systematic testing we would have followed would have been that we would have followed three testing dates. This testing dates would have take place on one on March 12 and the final testing on March 18 this testing would have happened with the Vr set.In each test we would have tried the components in isolation, then each team member would have tried, and then a group of recruited people would have tried it.Stopping criteria was simple; once we create a good prototype and have both positive and negative feedback we would have stop testing the prototype.

Order Of Most Important Specifications:

1. Model style
2. Cost
3. Assessments
4. Operating System

The purpose of the software is to aid in the visualization of molecules and thus the molecules need to be represented in a clear, unambiguous way that is realistic and avoids confusion. We were able to accomplish this in our final prototype. The molecules are really well

designed and modeled. Presenting the molecules in different ways is an important way to realize this goal which we were able to do with three different representations: orbitals, Ball and stick and space filling. The finished product is intended to be licensed under Creative Commons licensing and as a result it has to be free. The role of the product also presents an interesting criterion: because the software is to fill an educational role it is important that it includes well-defined and clearly conveyed goals to assess learning. This we were able to do by concisely focusing on the learning objectives given by the client. The trivia game will assess the learning objective. It is also important the software can run on different operating systems and machines because accessibility is a major goal of the client. Additionally it is extremely important that the content and representations are scientifically accurate which we were able to do thanks to our team members who have taken several chemistry courses and intensive research.

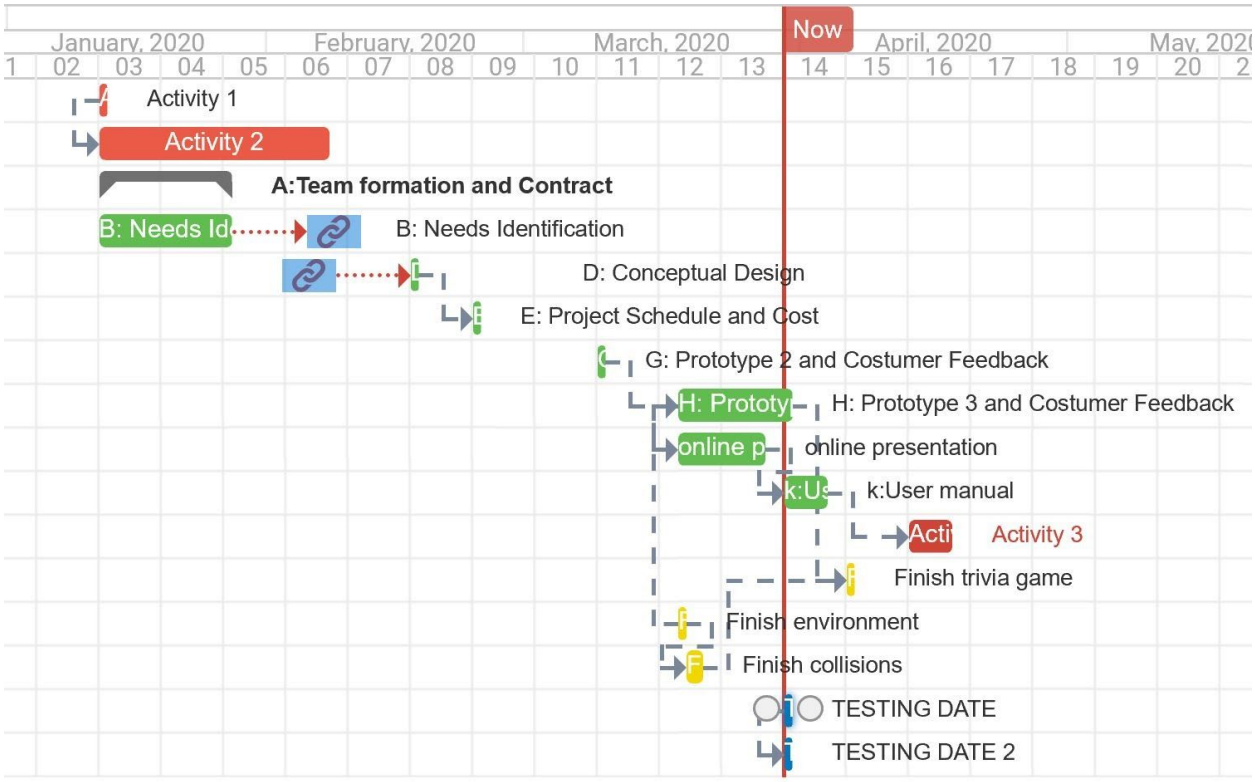
Feedback

During the first client meeting the client stated how it was important to address the common errors the users tend to make and explain to them why these misconceptions are untrue. The client mentioned two common errors that need to be addressed. First we need to show that collisions are a probability and that molecule movement is not random.This was shown in a 2D pop up and the trivia game.The second common error is that molecules do not move internally. In our last client meeting we got some positive feedback but the client also asked us to address the misconception that there is only one molecule in a solution so we decided to make this more clear by creating a beaker full of water and showing that there are several molecules. The client also specified that it would be good to show the differences between the pi bond and the sigma bonds which we were also able to accomplish by teaching this in a 2D popup window and through testing it in the trivia game.

Planned Execution under Normal Conditions:

The prototype was not completed due to COVID-19 facility closures and social distancing. We were not able to finish the code for the player moving around the environment nor the code for the change of scenes. We were not able to see how the game would have worked on the VR as we were not able to complete our testing so we were not able to test the codes. Our group was completely separated. We tried our best with the different time zones and communication difficulties.

Attached you will see the Gantt chart of what we had done if we had followed our schedule under normal conditions with the testing dates that we had set to finish the final prototype. Under normal conditions we might have had a chance to improve the codes as we could have detected the glitches when testing them.



Conclusion

The purpose of the final prototype is to be an interactive, innovative, user-friendly and cost effective VR learning environment to visually understand organic chemistry and how molecules collide. At the end of the game the prototype will assess the understanding and knowledge of the player. The final prototype also assesses common misconceptions. Functional requirements and the non-functional requirements were also met.

Overall even though we weren't able to test our project due to the circumstances we still believe that the final prototype met all the requirements. That being said, if we had the chance to test the project and get feedback from different people we're sure that our project would've been much better. In addition we would have been able to know if the codes for the players moving around the environment worked. We weren't able to program the different scenes changing. We did write the code but don't know if it works. However,the prototype looks like a successful prototype as it resembles our design concept and it is aesthetically pleasing.The fidelity of our prototype is high as it represents the molecules and environment nearly as they will be in the final in spite of the narrow focus.The final prototype is very comprehensive and it is as close to our design criteria as we could make it due to the circumstances.