Project Deliverable D:
Conceptual Design

GNG 1103 F
Group 11

February 9, 2020

The focus of this deliverable is to accumulate conceptual designs for the various subsystems of the VR system. By creating these designs, it is much easier for the design team to effectively choose which concept is best. Through analysis and careful considerations to the design criteria (from Deliverable C), the design team will decide on the best subsystem concept. Based on the problem statement (from Deliverable A) and benchmarking criteria (from Deliverable C), the design team will organize and refine these subsystems.

Once the team has reconvened and modified the subsystem concepts, global designs will be created. These global concepts will include each of the subsystem designs, and they will be further analysed using the benchmarking and design criteria. Once various global concepts have been created, they will be compared using the benchmarking process; this will allow the team to decide which is the best option.

One of the goals of this deliverable is to fully document the process. By thoroughly describing the global concepts, it is much easier to revisit older designs. For example, if the primary global design is not ideal or does not satisfy the customer, rather than restarting the project, it is easier to reconsider older concepts.

Once a global design is created, it will then be shown to the customer at a later date. At this point, the customer's comments and concerns will be considered, and the design will be adjusted accordingly.

Throughout this design process, the goal has been to create a virtual reality software that will allow students to effectively learn organic chemistry. As stated in previous deliverables, the design team will focus on the students' ability to interact with the system, and how easy the software is to use. To achieve these goals, a virtual reality system will be made, with the following subsystems:

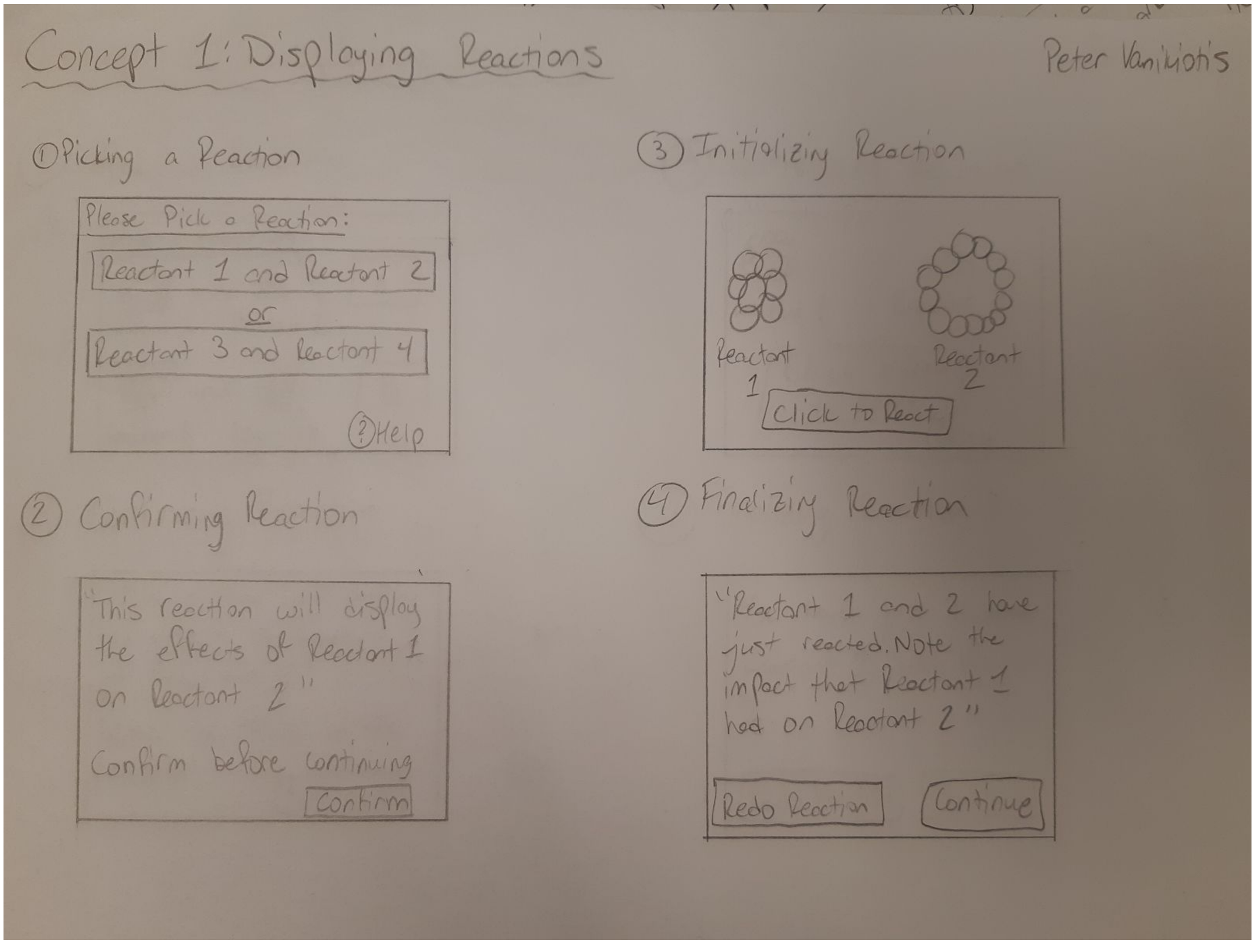
- Reaction Display
- User Assistance
- Student Progress
- Chemical Molecular Models

Below are all the subsystems that were created by individual members of the design team. These rough sketches provide a vague idea on how the subsystem will be created.

Subsystem 1: Displaying Reactions (Peter)

Note that all boxes in this subsystem represent different screens that the user will be presented. This subsystem encompasses the process in which the user will interact with the system.

Concept #1



"This reaction will display the effects of Reactant 1 on Reactant 2"

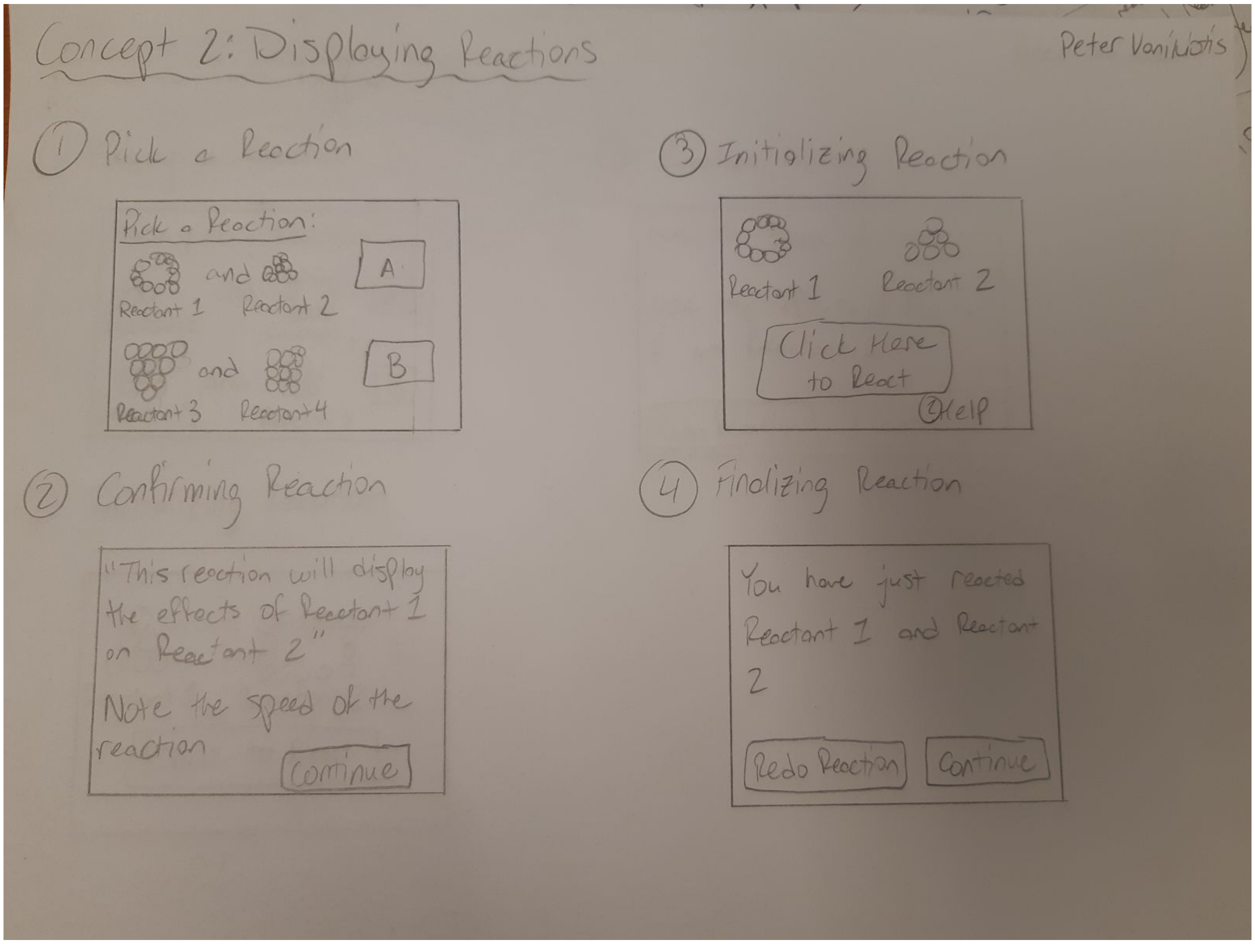
Confirm before continuing

"Reactant 1 and 2 have just reacted. Note the impact that Reactant 1 had on Reactant 2"

Key features of this concept:

- Reactants are displayed using chemical names, not structures
- Provides key reaction notes at the end of the reaction process

Concept #2



"This reaction will display the effects of Reactant 1 on Reactant 2"

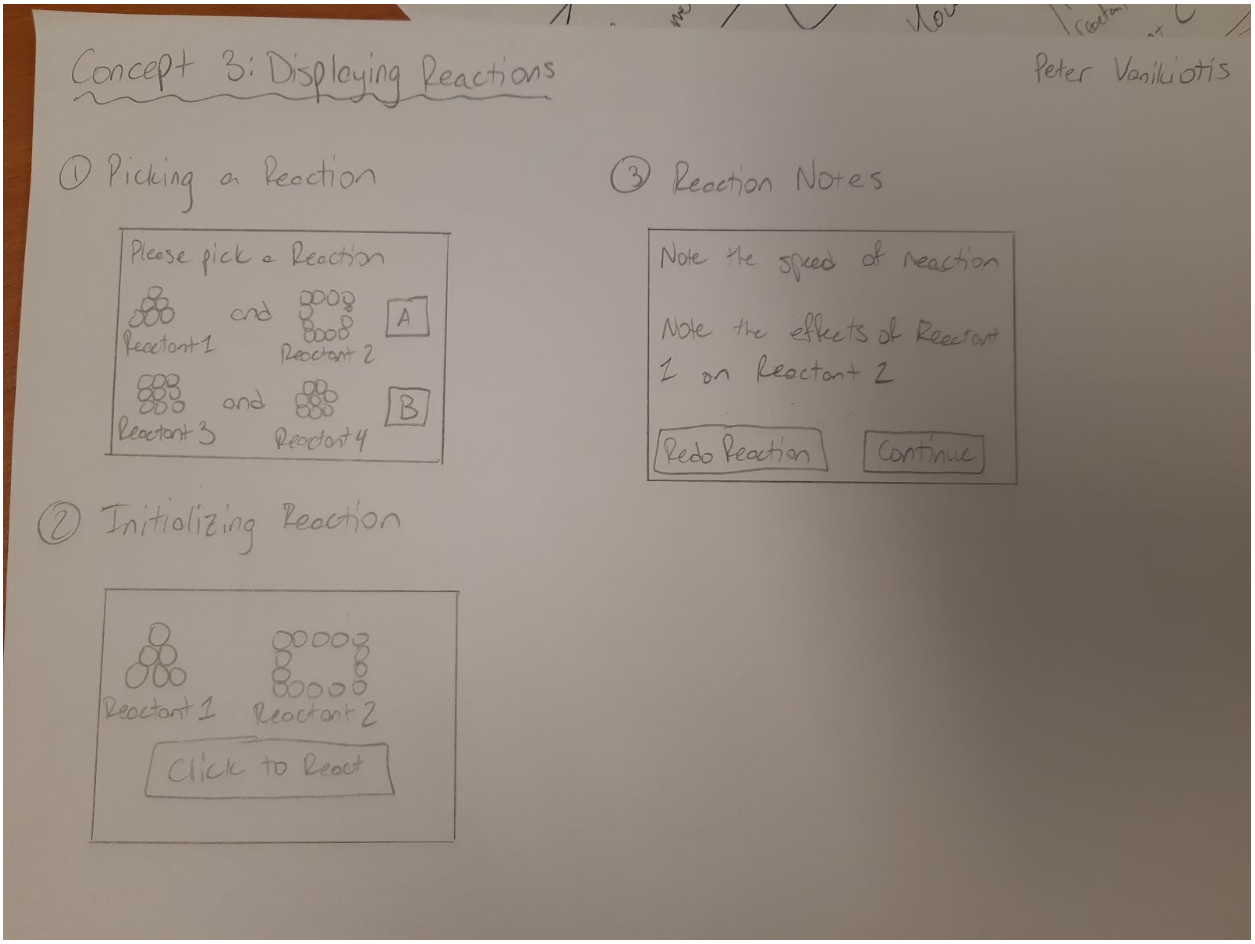
Note the speed of the reaction

You have just reacted Reactant 1 and Reactant 2

Key features of this concept:

- Reactants are displayed using chemical structures and names
- Provides key reaction notes before commencing the reaction

Concept #3



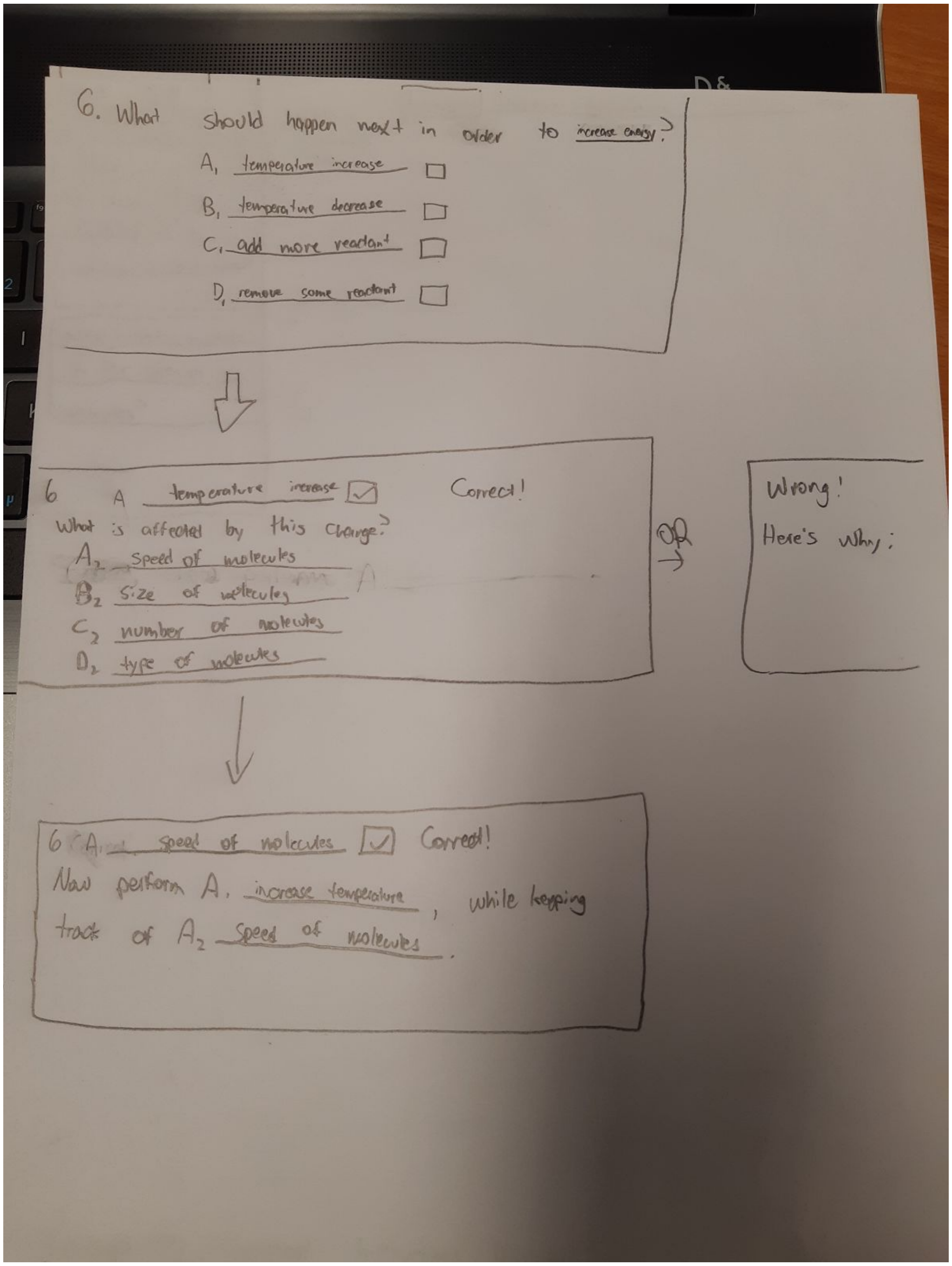
Key features of this concept:

- Reactants are displayed using chemical structures and names
- No information about the reaction is given before it takes place
- Summary of the reaction after it takes place

Overall, the goal of Subsection 1 was to create a means to display reactions that are easiest for the viewer to interpret. This was important, as a clear user understanding is an important design criterion. Through modelling using chemical structural models and reaction descriptions, the subsection can be optimized to provide a clear idea for viewers regarding project modelling.

Subsystem 2: User Assistance (Spencer)

Concept 1:



6. What should happen next in order to increase energy?

A_1 temperature increase ☐

B_1 temperature decrease ☐

C_1 add more reactant ☐

D_1 remove some reactant ☐

6 A temperature increase ☑ Correct!

What is affected by this change?

A_2 speed of molecules

B_2 size of molecules

C_2 number of molecules

D_2 type of molecules

OR

Wrong!

Here's why:

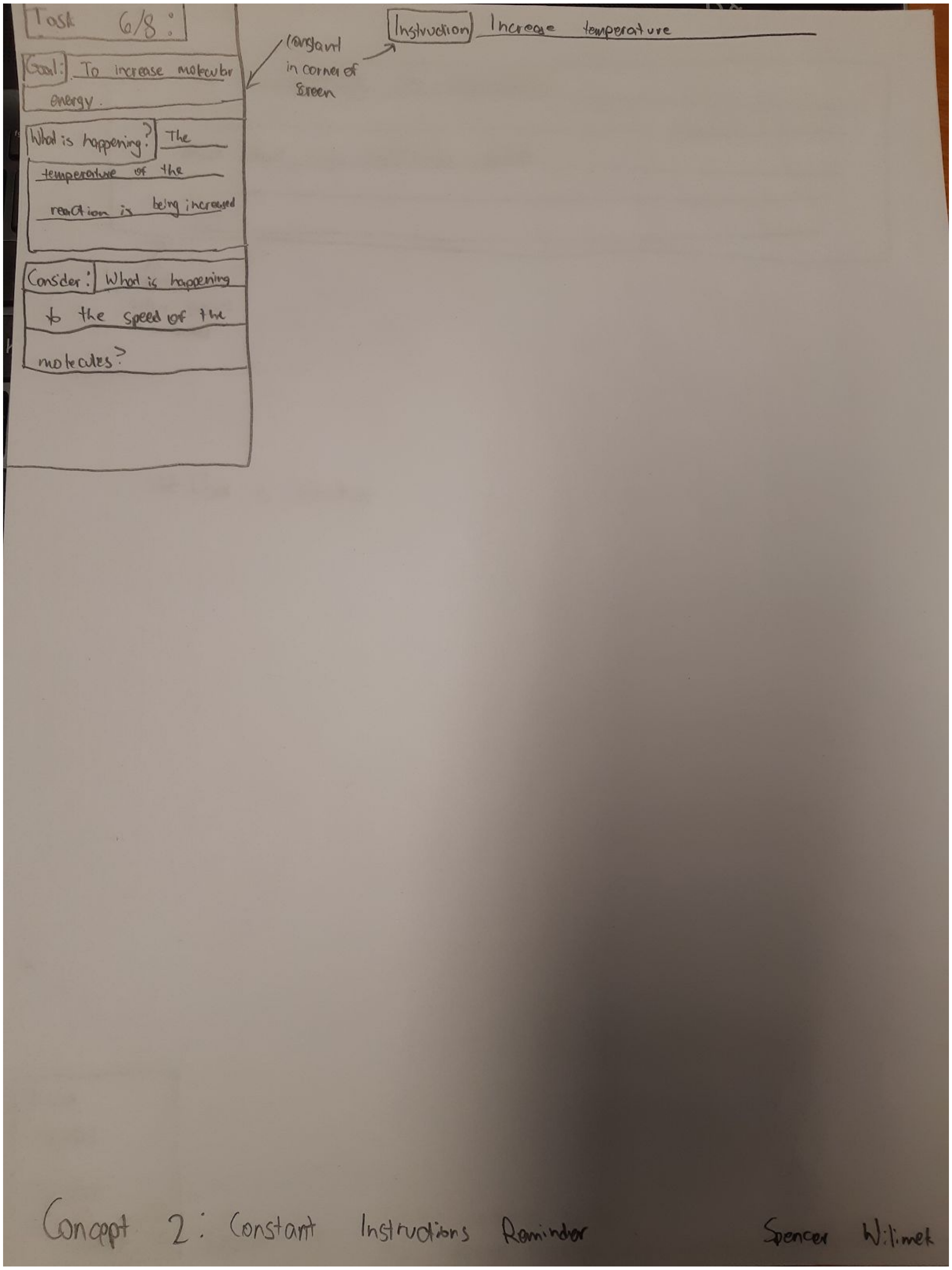
6 A_1 speed of molecules ☑ Correct!

Now perform A_1 increase temperature, while keeping track of A_2 speed of molecules.

Key features of this concept:

- Asks users to choose correct processes
- Requires user to choose correct processes before performing tasks
- Explains mistake if wrong answer is input

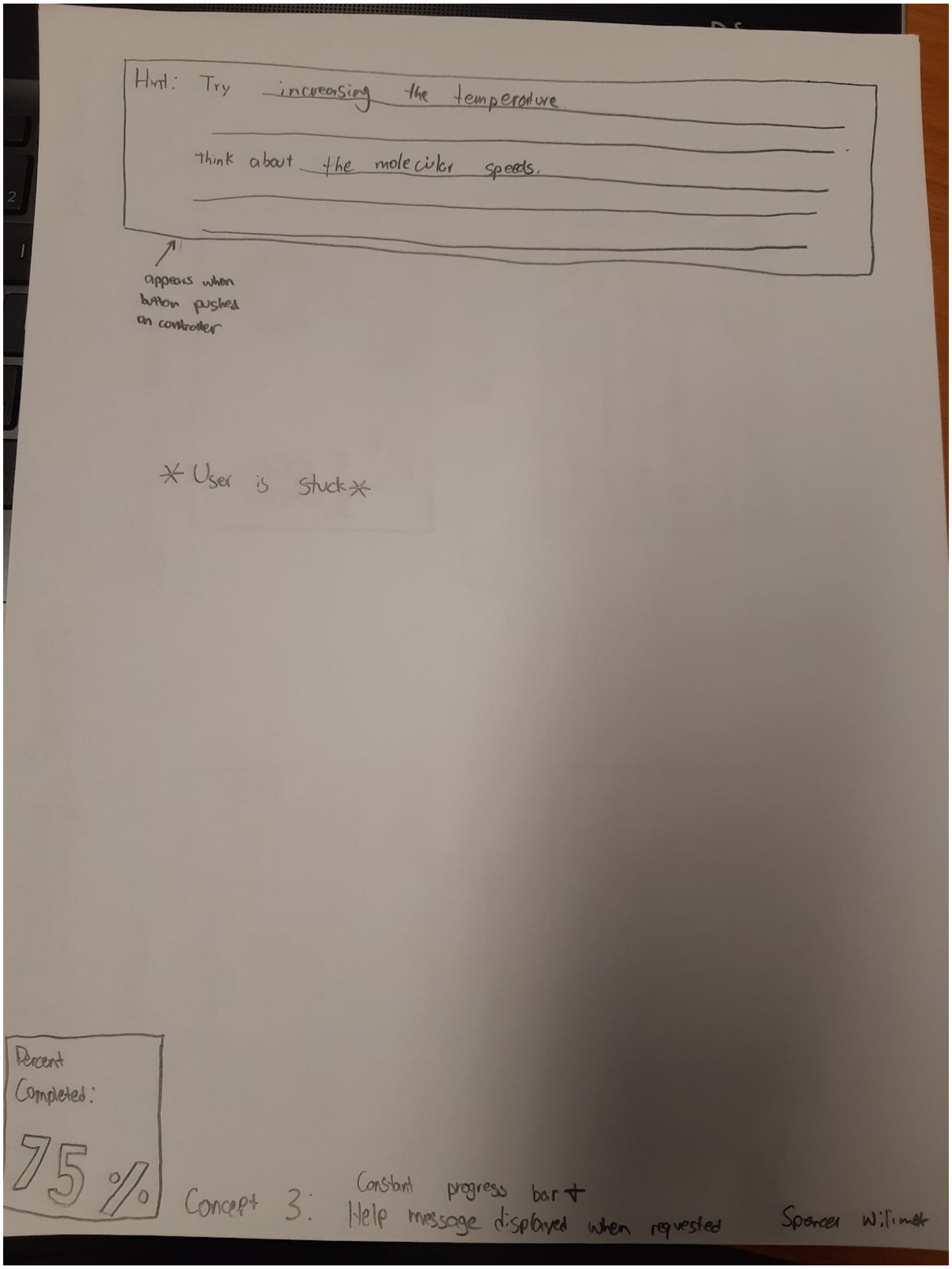
Concept #2


Task 6/8:
Goal: To increase molecular energy.
What is happening? The temperature of the reaction is being increased
Consider: What is happening to the speed of the molecules?
Constant in corner of screen
Instruction Increase temperature
Concept 2: Constant Instructions Reminder
Spencer Wilimek

Key features:

- Constant task reminder
- Shows next instruction at top of screen

Concept #3

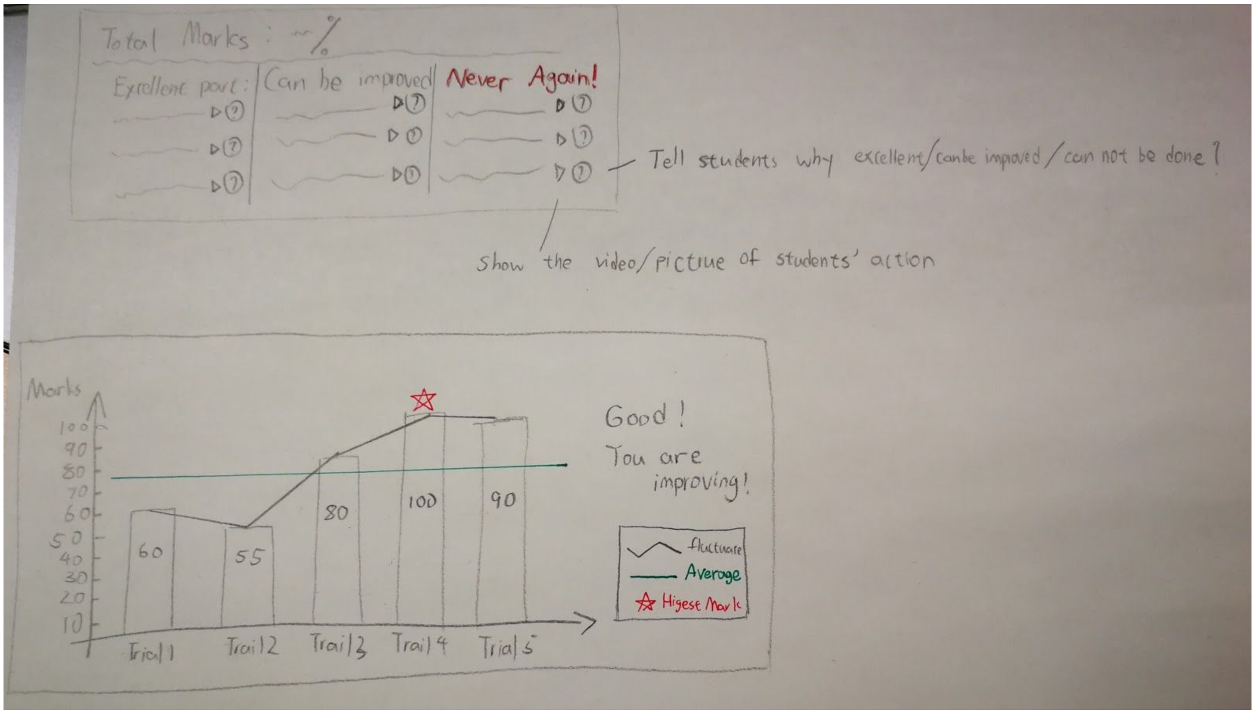

Hint: Try increasing the temperature.
Think about the molecular speeds.
appears when button pushed on controller
* User is stuck *
Percent Completed:
75%
Concept 3: Constant progress bar + Help message displayed when requested
Spencer Willmek

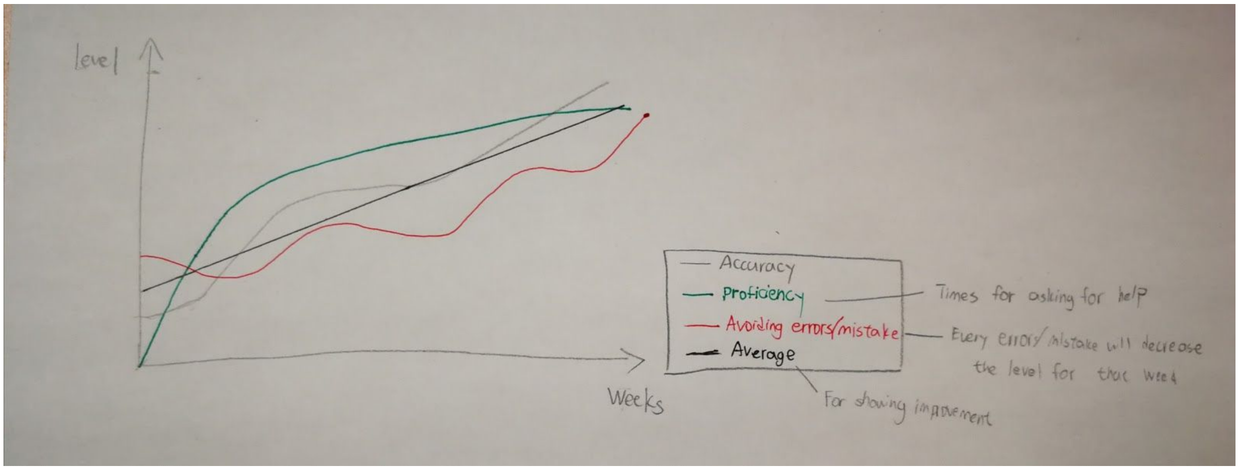
Key features:

- Displays help message when user presses button
- Constant completion reminder
- Unobtrusive when help is not required

The goal of Subsystem 2 is to formulate a system that provides user assistance when needed and ensures the user can perform tasks with ease. This is conveyed through several different concepts, such as a pop-up help window or a pre-experiment quiz. Subsystem 2 effectively provides instructions to the user to perform successful reactions.

Subsystem 3: Students progress (Hairuo)



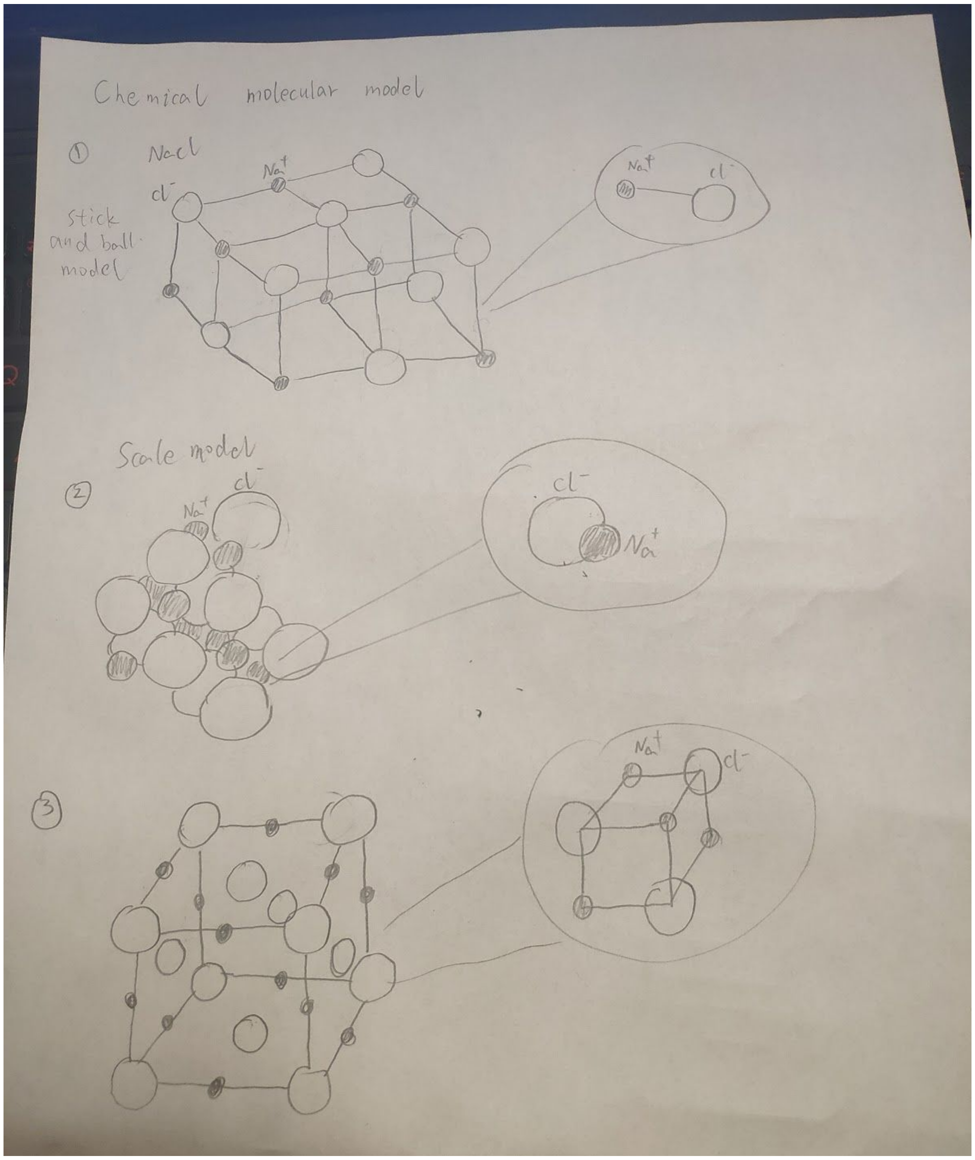


1) Show students' progress for one trial/lab, and making the lists of excellent/ok/bad parts (also at the end of each point, there will be two buttons to show the video or picture of students' action and why it is good or not)
2) Show the marks of each time and final mark of the student and tell the student whether he/she is improving or not.
3) Evaluate the student from various parts and show the tendencies of the student over time.

Another important design criterion was the user feedback. By providing feedback to the user, the system ensures that the user understands all concepts, as well as potential shortcomings in their knowledge. By showing different metrics on-screen, Subsystem 3 accomplishes the feature of informing users. Thus, by utilising graphs and charts, Subsystem 3 shows the reader a summary of their progress.

Subsystem 4: Chemical Molecular Models (Shawn)

1) The stick-ball model reflects the spatial structure of molecules and the type of bonding. Students can clearly see the type and number of chemical bonds between atoms. But the model will be more complicated.
2) The scale model reflects the size relationship between the atoms that make up the molecule. More intuitively reflects the size of the atom when there are many kinds of atoms
3) The third model is like the first model, but it reduces some internal chemical bonds, making the model look clearer and more concise. It also reflects the size of the atoms and the chemical bonds between atoms, and it also reflects the volume of space more intuitively

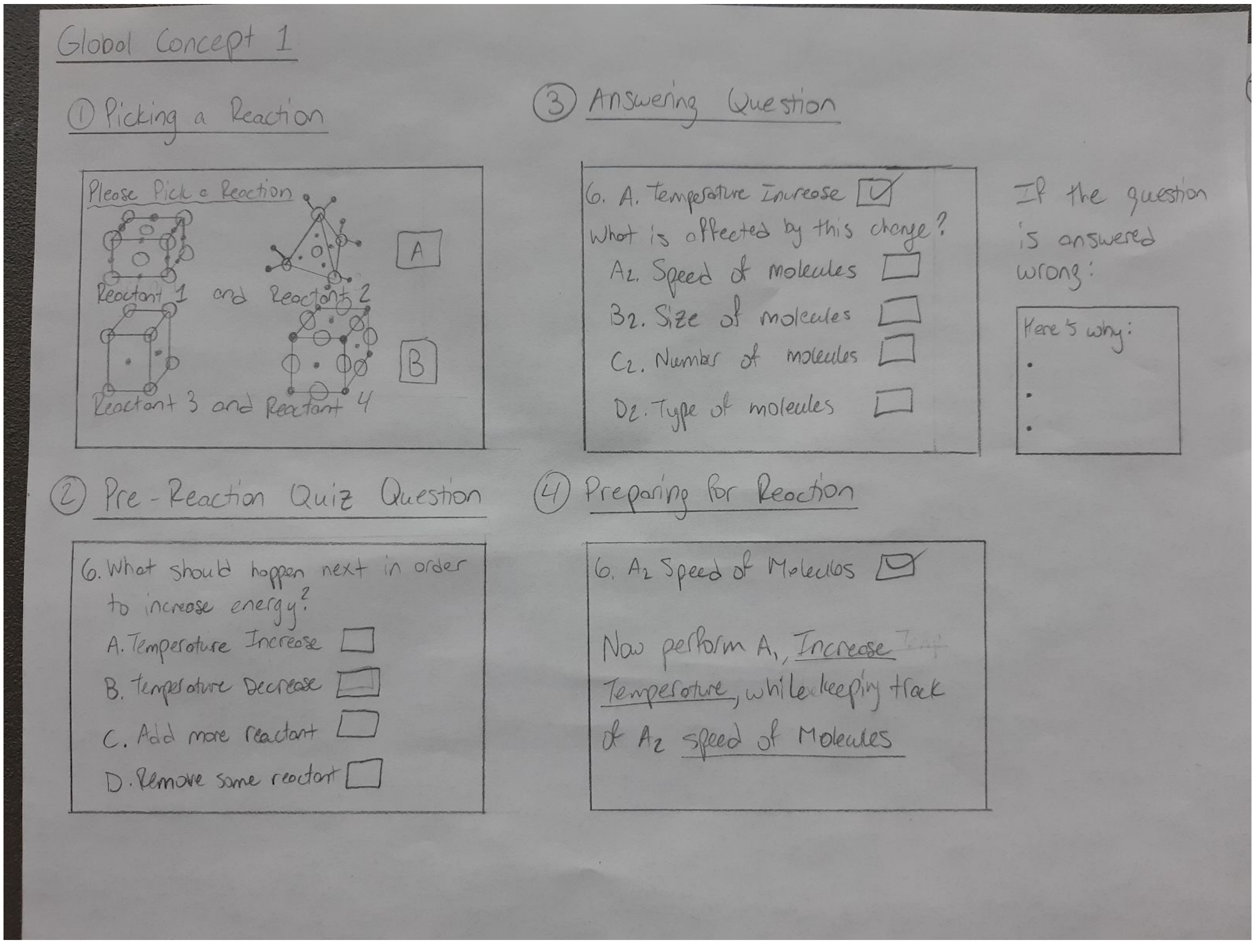


The final subsystem describes the physical modelling process of the software. A criterion requires that the modelling provides a clear and physically accurate image of which to view molecules. Although the most common means of modelling software is using the ball-and-stick method, it was determined that a mere outline plus the interior molecules was also a viable modelling solution.

Global Concepts

For every global concept, the design team ‘mixed-and-matched’ the subsystem designs, to visualize the many different possibilities. After lengthy discussions, and careful considerations concerning the design criteria and problem statement, the global designs below were created. Supplemental attention was given to certain design features over others, in accordance with the feature’s relative importance. Below each concept will be a summary that highlights the crucial features and what separates it from the other designs. Once all the global concepts were made, the design team then selected the best global design, which will be used for the remainder of this project. In relation to other benchmarked products, Concept 1 provides more ease of use and more comprehensive and physically accurate models, therefore making it viable as a final concept.

Concept #1



Global Concept 1

① Picking a Reaction

Please Pick a Reaction

Reactant 1 and Reactant 2 A

Reactant 3 and Reactant 4 B

② Pre-Reaction Quiz Question

6. What should happen next in order to increase energy?
A. Temperature Increase ☐
B. Temperature Decrease ☐
C. Add more reactant ☐
D. Remove some reactant ☐

③ Answering Question

6. A. Temperature Increase ☑
What is affected by this change?
A2. Speed of molecules ☐
B2. Size of molecules ☐
C2. Number of molecules ☐
D2. Type of molecules ☐

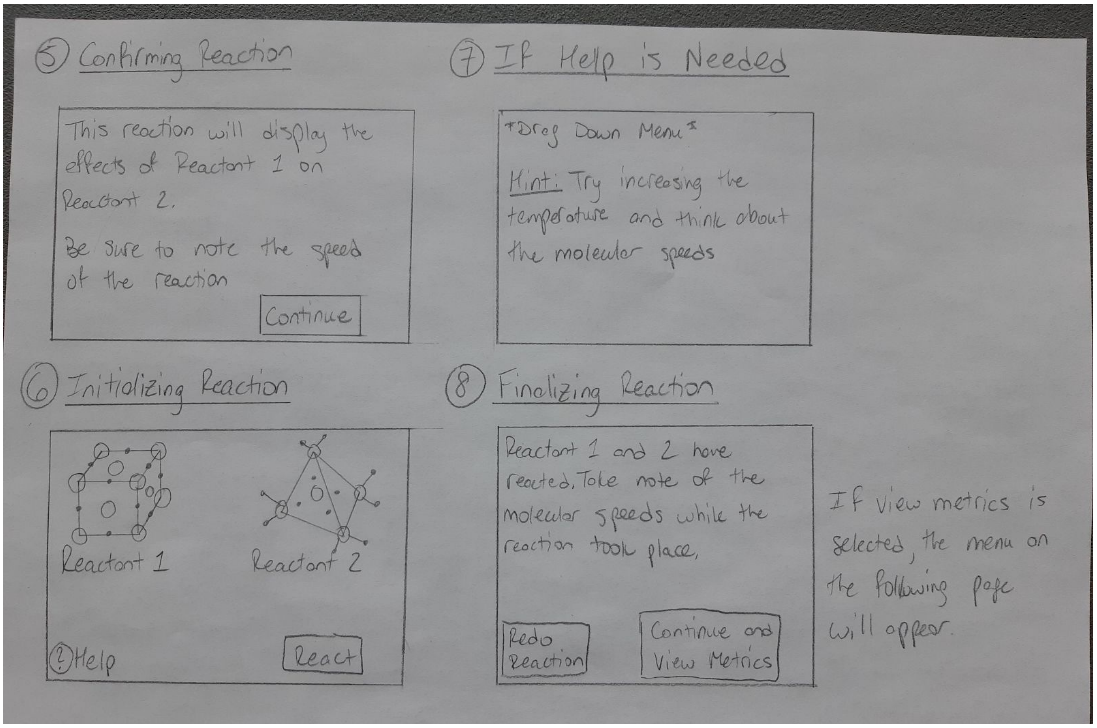
If the question is answered wrong:

Here's why:
-
-
-

④ Preparing for Reaction

6. A2 Speed of Molecules ☑

Now perform A1, Increase Temperature, while keeping track of A2 speed of Molecules



⑤ Confirming Reaction

This reaction will display the effects of Reactant 1 on Reactant 2.

Be sure to note the speed of the reaction

⑥ Initializing Reaction

⑦ If Help is Needed

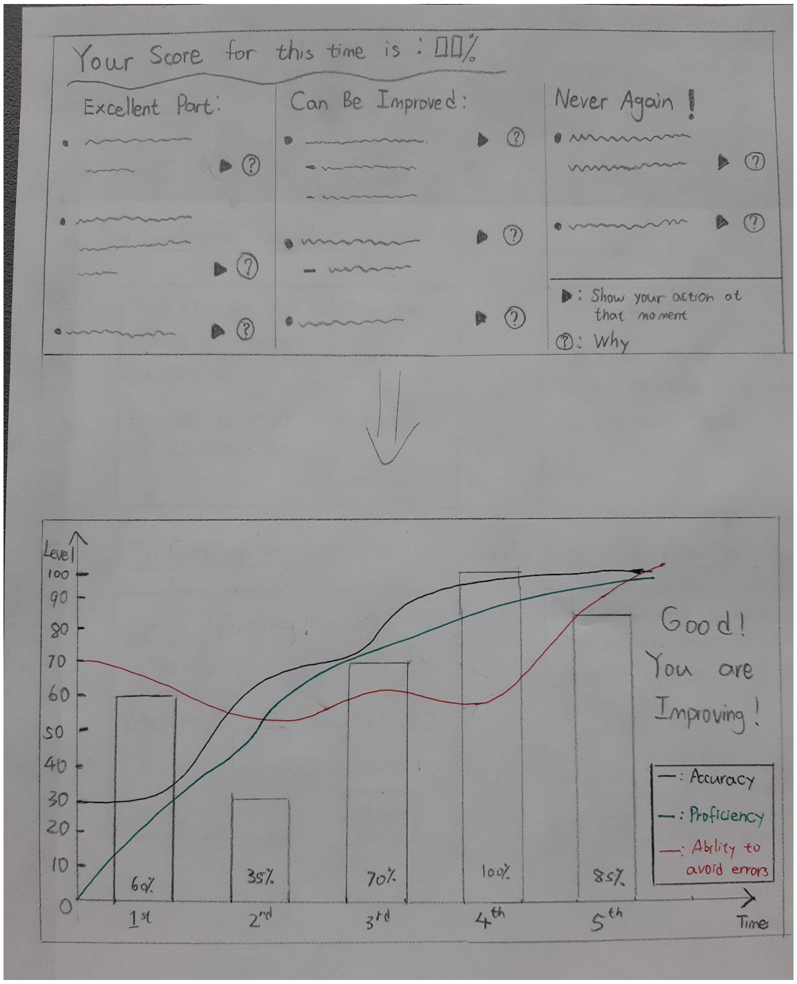
Drag Down Menu

Hint: Try increasing the temperature and think about the molecular speeds

⑧ Finalizing Reaction

Reactant 1 and 2 have reacted. Take note of the molecular speeds while the reaction took place.

If view metrics is selected, the menu on the following page will appear.



Global concept #1 begins with the user picking their reaction. The design team decided that it would be more effective to include the molecular structures, along with the names, before the reaction commences. There were several different options concerning the design of the molecular structures. In accordance with the design criteria that emphasized chemical accuracy, concept #3 for chemical structures was used. This was done because this design best displays the relative size and spaces of molecules.

The design team also decided that it would be best to do a mini-quiz before the reaction begins, to engage the user more efficiently. Another option was to put the quiz after the reaction, to affirm the user’s learning; doing the quiz beforehand provides the user with the opportunity to focus more heavily on certain parts of the reaction. Once the quiz is complete, the user is prompted with a message containing their instructions. Rather than placing the instructions at the very beginning, as seen in other concepts, the design team decided it was best to place them right before the reaction takes place.

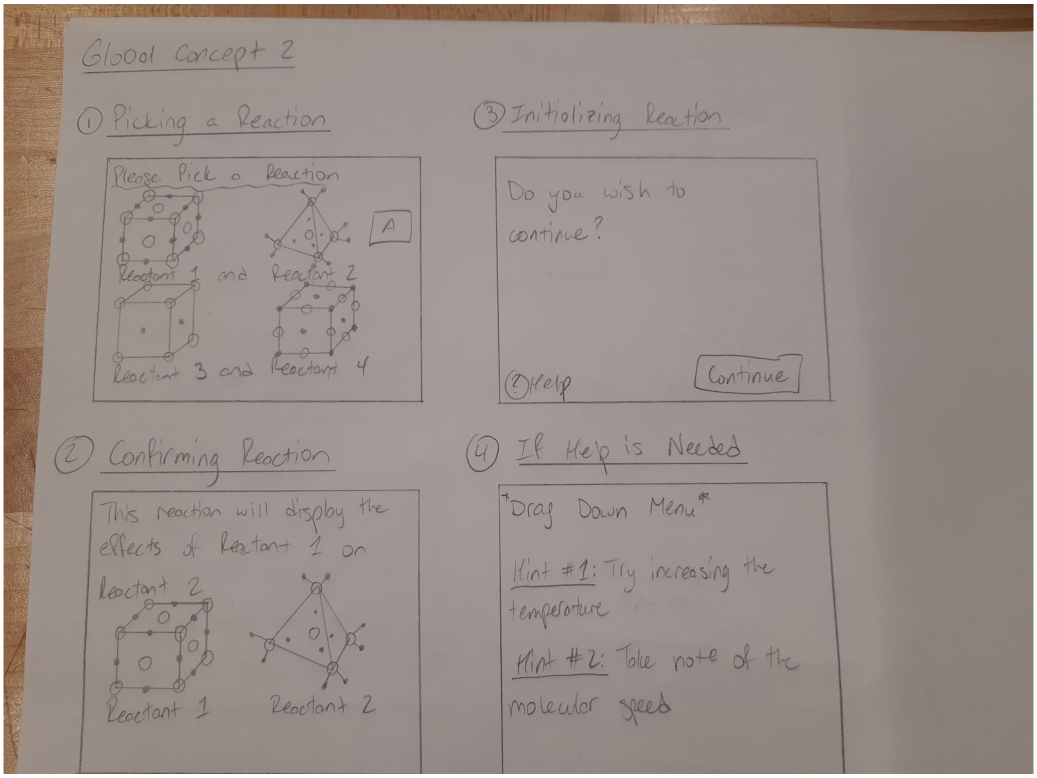
A confirmation screen is then presented to the user, which contains some key notes. There were concepts that were created where no confirmation was included. In accordance with the problem statement that said the system must be easy to use, it was best to present the user with some extra information.

Once again, another screen is presented to the user, which initializes the reaction, and includes a help button. In other subsystem concepts, the help button was not placed in this window. The design team decided that it would be best to give the user the chance to seek help before the reaction begins. Next, if the help button is pressed, a drag down screen containing hints and other useful information is presented to the user.

Finally, once the reaction is completed, a final message is given to the user, summarizing the results of the reaction. At this stage, the user is given the option to redo the reaction or view their metrics. If they choose to view their metrics, the user can view their metrics across multiple reactions.

For the metric page, a chart containing areas to improve are presented to the user. In initial designs, only once metric was shown to the user, but the design team decided to present multiple tables and graphs at once. This is an emphasis on the design criteria which stated that the user should see their results in several different ways.

Concept #2



Global Concept 2

① Picking a Reaction

Please Pick a Reaction

Reactant 1 and Reactant 2

A

Reactant 3 and Reactant 4

② Confirming Reaction

This reaction will display the effects of Reactant 1 on Reactant 2

Reactant 1

Reactant 2

③ Initializing Reaction

Do you wish to continue?

?Help

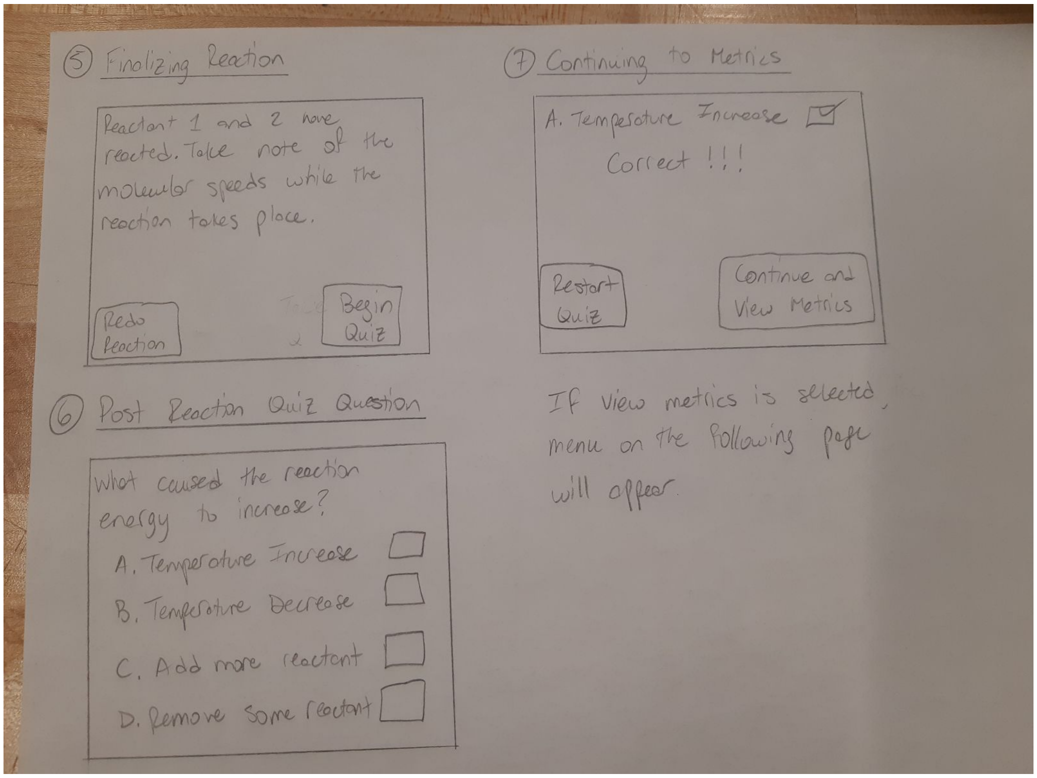
Continue

④ If Help is Needed

Drag Down Menu

Hint #1: Try increasing the temperature

Hint #2: Take note of the molecular speed



⑤ Finalizing Reaction

Reactant 1 and 2 have reacted. Take note of the molecular speeds while the reaction takes place.

Redo Reaction

Begin Quiz

⑥ Post Reaction Quiz Question

What caused the reaction energy to increase?

A. Temperature Increase ☐

B. Temperature Decrease ☐

C. Add more reactant ☐

D. Remove some reactant ☐

⑦ Continuing to Metrics

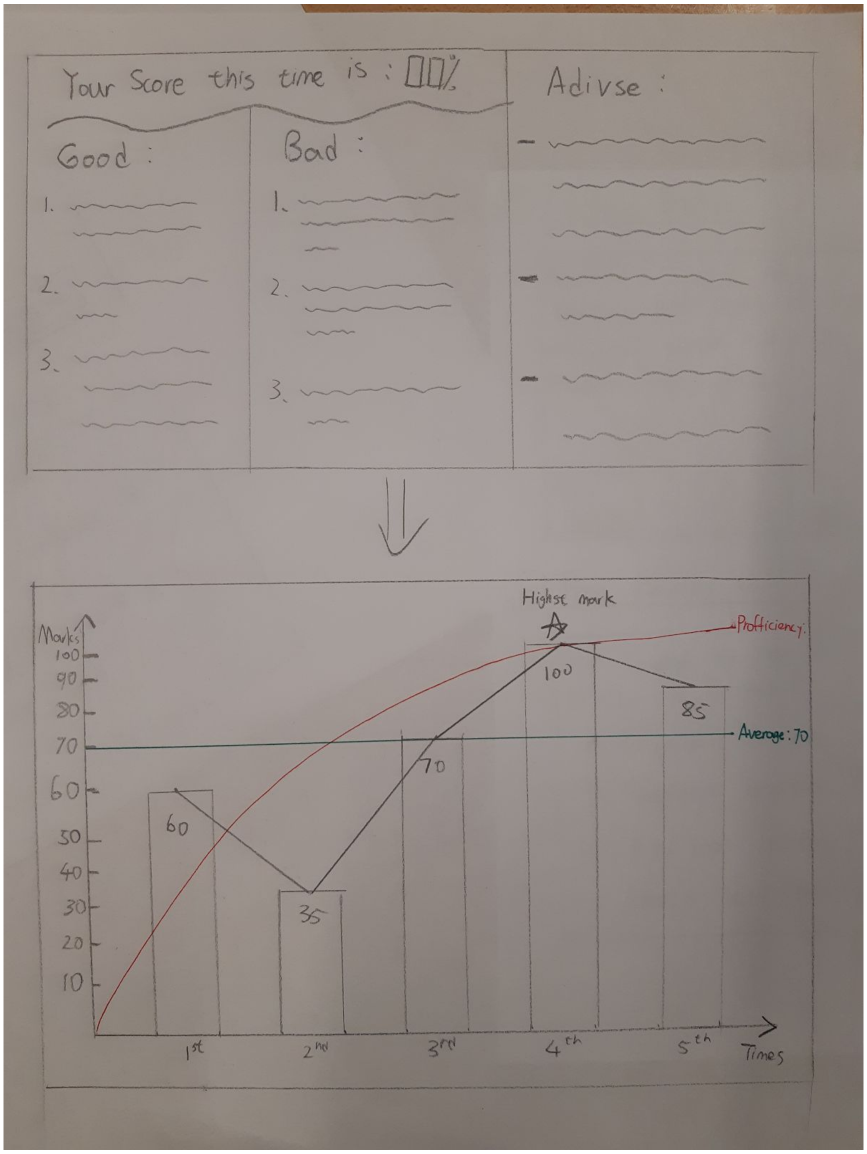
A. Temperature Increase ☑

Correct !!!

Restart Quiz

Continue and View Metrics

If view metrics is selected, menu on the following page will appear.



Global concept #2 begins with the user picking their reaction. The design team decided that it would be more effective to include the molecular structures, along with the names, before the reaction commences. There were several different options concerning the design of the molecular structures. In accordance with the design criteria that emphasized chemical accuracy, concept #3 for chemical structures was used. This was done because this design best displays the relative size and spaces of molecules.

Unlike global design concept #1, the design team decided not to include a mini-quiz before the reaction begins. The goal of this decision was to reaffirm the user's knowledge after performing the reactions, rather than doing the quizzes beforehand.

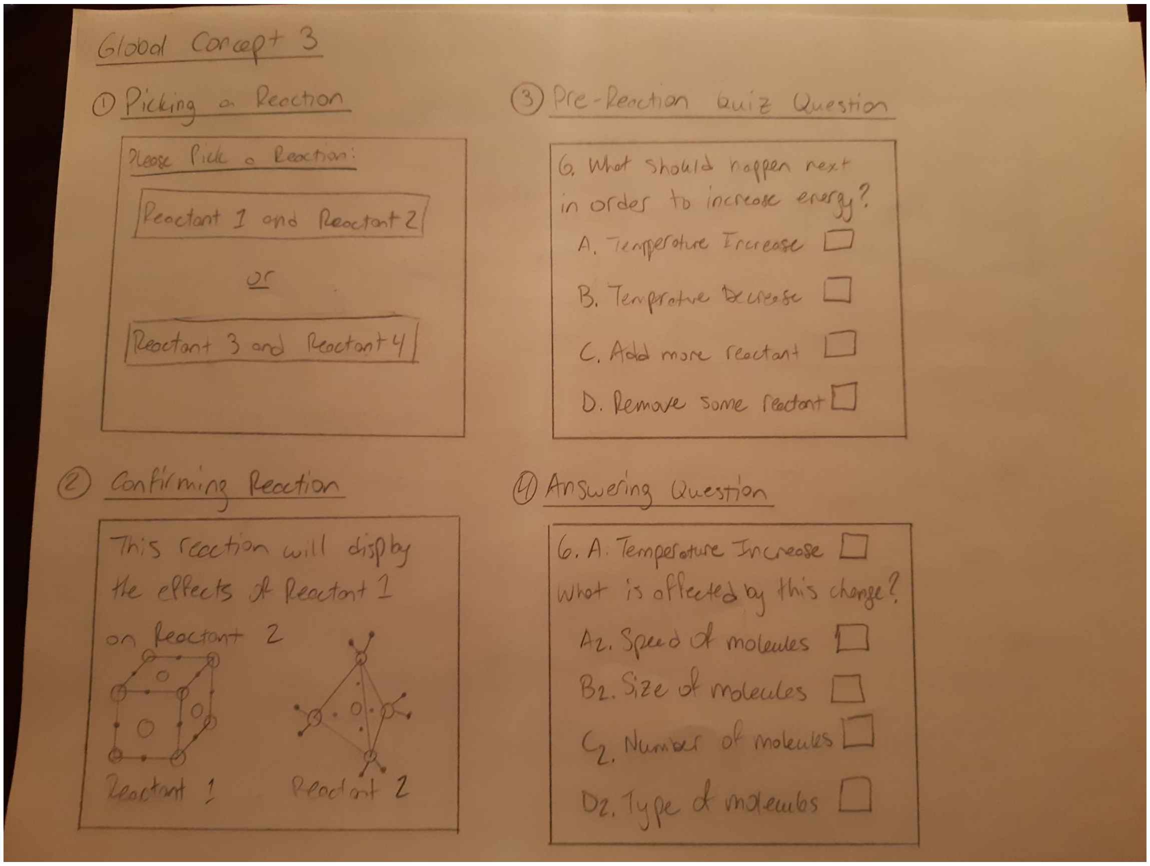
A confirmation screen is then presented to the user, which contains some key notes. In accordance with the problem statement that said the system must be easy to use, it was best to present the user with some extra information.

Once again, another screen is presented to the user, which initializes the reaction, and includes a help button. In other subsystem concepts, the help button was not placed in this window. The design team decided that it would be best to give the user the chance to seek help before the reaction begins. Next, if the help button is pressed, a drag down screen containing hints and other useful information is presented to the user.

Finally, once the reaction is completed, the user is given the option to redo the reaction or begin their quiz. At this point as well, some key notes are provided to the user, emphasizing the importance of key information. Once the user finishes the quiz, they are given the option to redo the quiz, or to view their metrics. If they choose to view their metrics, the user can view their metrics across multiple reactions.

For the metric page, a chart containing areas to improve are presented to the user. In initial designs, only once metric was shown to the user, but the design team decided to present multiple tables and graphs at once. This is an emphasis on the design criteria which stated that the user should see their results in several different ways.

Concept #3



Global Concept 3

① Picking a Reaction

Please Pick a Reaction:

Reactant 1 and Reactant 2

or

Reactant 3 and Reactant 4

② Confirming Reaction

This reaction will display the effects of Reactant 1 on Reactant 2

③ Pre-Reaction Quiz Question

6. What should happen next in order to increase energy?

A. Temperature Increase ☐

B. Temprature Decrease ☐

C. Add more reactant ☐

D. Remove some reactant ☐

④ Answering Question

6. A. Temperature Increase ☐

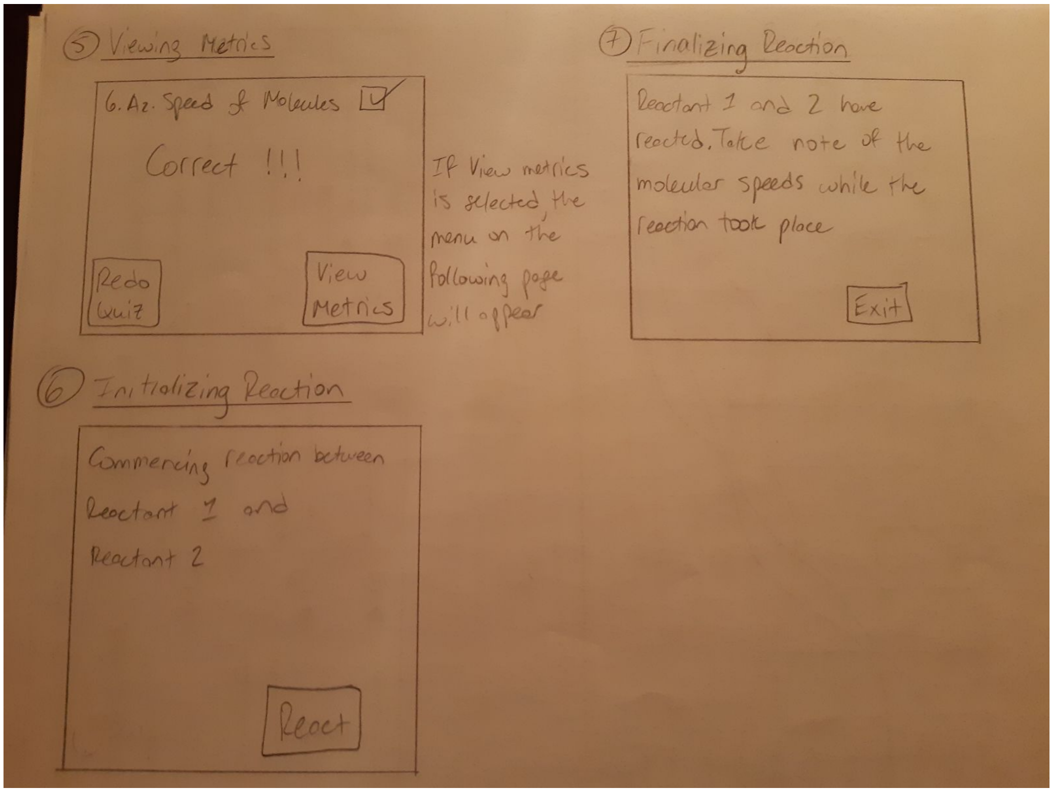
What is affected by this change?

A_2. Speed of molecules ☐

B_2. Size of molecules ☐

C_2. Number of molecules ☐

D_2. Type of molecules ☐



⑤ Viewing Metrics

6. Av. Speed of Molecules ☑

Correct !!!

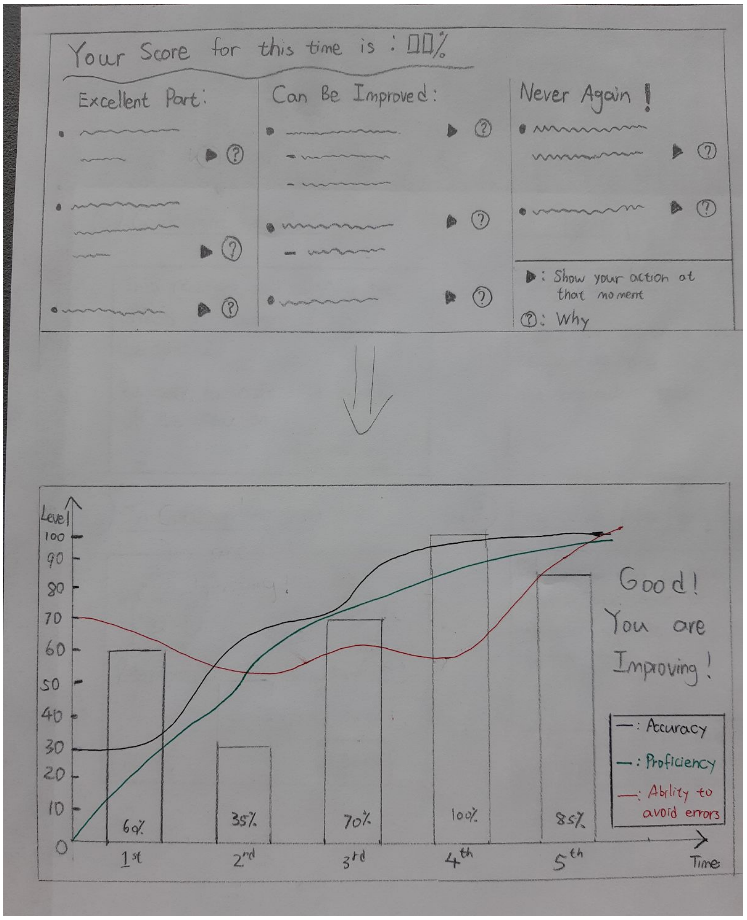
If View metrics is selected the menu on the following page will appear

⑥ Initializing Reaction

Commencing reaction between Reactant 1 and Reactant 2

⑦ Finalizing Reaction

Reactant 1 and 2 have reacted. Take note of the molecular speeds while the reaction took place



Your Score for this time is : □□%

Excellent Part:

Can Be Improved:

Never Again !

▶ : Show your action at that moment

ⓘ : Why

Good! You are Improving!

Global concept #3 begins with the user picking their reaction. Contrary to the other global designs, only the chemical names were included at this stage. Instead of including the molecular structures at this stage the user can see them before the reaction begins.

Next the user can see the molecular structures of the reactants, and brief notes about the reaction are also displayed. This coincides with the design criteria presented in earlier deliverables. There were several different options concerning the design of the molecular structures. In accordance with the design criteria that emphasized chemical accuracy, concept #3 for chemical structures was used. This was done because this design best displays the relative size and spaces of molecules.

The design team also decided that it would be best to do a mini-quiz before the reaction begins, to engage the user more efficiently. Another option was to put the quiz after the reaction, to affirm the user’s learning; doing the quiz beforehand provides the user with the opportunity to focus more heavily on certain parts of the reaction. Once the quiz is complete, the user is prompted with the option to redo the quiz or to view their metrics. If they choose to view their metrics, the user can view their metrics across multiple reactions.

For the metric page, a chart containing areas to improve are presented to the user. In initial designs, only once metric was shown to the user, but the design team decided to present multiple tables and graphs at once. This is an emphasis on the design criteria which stated that the user should see their results in several different ways.

A screen is presented to the user, once they have viewed their metrics, which initializes the reaction. Note for this global design concept, there is no ‘in-game’ help. The user only uses the information provided in previous steps for assistance. Critical notes are also provided to the user at the end, and they are given the option to exit the system.

Benchmarking Process

By completing the benchmarking process below, it will be much easier for the design team to compare the various global designs. The criteria that will be evaluated are found in past deliverables, including the design criteria and the problem statement.

Product specification	**Importance**	**Global Concept 1**	**Global Concept 2**	**Global Concept 3**
Physically interactive	3	Click and drag	Click and drag	Click and drag
In-software help	4	Pre-reaction quiz to make sure the student is ready and give hint if help is needed during reactions	Give hints if help is needed and quiz after reactions	None
Immersive in reactions	5	Freely switch perspectives	Freely switch perspectives	Freely switch perspectives
Displays accurate dynamics	4	Yes	Yes	Yes
Easy to use	3	Yes	Yes	Yes
Clearly feedback	2	Provide feedback for students' actions during reactions and why it is good or not; and chart of lines and bars to show students' improvements in different metrics	Provide feedback for students' actions during reactions; and bar chart and feel lines to show the fluctuation and proficiency	Provide feedback for students' actions during reactions and why it is good or not; and chart of lines and bars to show students' improvements in different metrics
Knowledge retention	4	Give questions and explanations before giving actual model demonstrations	Give a model demonstration before answering questions	Does not provide a model demonstration before answering questions
TOTAL		75	65	59

After the benchmarking process, Global Concept 1 does the best in all different metrics. It is easiest for students to use; it has in-software help and is physically interactive. This concept also teaches students effectively since it immerses students in the reactions; the system helps students remember the information.

Overall our solution provides the user with an easy-to-use, physically interactive, and chemically accurate virtual reality system.