IMPROVEMENT OF PEDAGOGY AS APPLIED TO THE BIOCHEMICAL CONCEPT OF TRANSAMINATION AND THE UREA CYCLE

By

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APPROVED

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Abstract

The advancement of technology introduces an opportunity for educational institutions to integrate technology into traditional forms of teaching. In addition to modified forms of pedagogy, the integration of technology could promote the interest and success of students taking rigorous courses in college. Amino acid catabolism is a topic taught in the Biochemistry 100 (BCH 100) course at the University of California, Riverside. It is a part of the larger category of nitrogen metabolism and follows the two components of amino acids (the nitrogen group and the carbon skeleton) through metabolic processes in the body. Due to its diversion from the carbon-based metabolism of carbohydrates and lipids, it is one of the most difficult parts of the introductory biochemistry course. The purpose of this project is to improve the way that amino acid catabolism is taught to BCH 100 students through the incorporation of technology to supplement the traditional lecture-styled course. By employing animations, the Fall 2018 BCH 100 class is expected to have a higher retention rate than the control group made up of the Spring 2018 cohort. The success rate will be measured through knowledge retention tests.

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Introduction

Purpose

Dr. Stephanie Dingwall's group explores methods that could improve the traditional lecture style of courses such as Introduction to Biochemistry (BCH 100) at the University of California, Riverside. Given the influx of technological advancements made in the past decade, the incorporation of technology into higher education is not surprising. Critical decisions regarding the use of technology in the classroom have been presented (such as the incorporation of clickers and online office hours) and its use is typically determined by its ability to make a substantial difference to both the teaching and learning process[1]. With this baseline, the use of animations in BCH 100 could arguably contribute to a difference in students' retention and learning of historically difficult material in the course. Animations could provide a visual aid and cater to a different learning style that some students may be more inclined to learn from in comparison to only having standard lecture slides. If so, removing ourselves from a linear teaching method such as the traditional classroom setting and catering to the needs of a variety of learners (audial, visual, kinesthetic, etc.) could provide greater success to students taking rigorous college courses.

Why BCH 100?

Introduction to Biochemistry is a historically rigorous course at the University of California, Riverside. As an introductory class, it provides condensed lessons on topics that will be expanded on in upper-division biochemistry-major courses such as the BCH 110ABC series. The nature of BCH 100 provides insight to the structure of other biochemistry-related courses.

This insight can help determine a student's attitude towards the subject and whether it is appealing to pursue a major in biochemistry. The decision to analyze the effect of technology and pedagogy on BCH 100 was due to impact that it can have on attitudes toward career aspirations and future interests relating to biochemistry[2]. Through this research experiment, I hope to contribute to further discussion of how to retain interest and knowledge of biochemistry.

Why Technology/Animation?

The curriculum at the University of California, Riverside has noticeably integrated more technology into its courses over the previous years. From the use of clickers and Poll Everywhere to the employment of the program Zoom to create online courses and accessible office hours, the use of technology in lecture-based classrooms becomes a possible opportunity for professors to extend their influence on student attitudes towards subjects. But to what extent should technology be incorporated into learning? The use of animations to supplement lectures in BCH 100 is so that we may begin to expand teaching methods towards those who learn visually rather than verbally (via note-taking, etc.). The goal of utilizing animations is not to replace lecture slides completely, but to see if the use of additional technological features to supplement the standard biochemistry slides will help students increase their retention of the material. Animations is one possible pedagogical method in which technology is being used. Its effect will help determine whether other ways of integrating technology into pedagogy should be researched in the future and if pedagogical animations should be tested further. This experiment is not to prove that all technology should be used in the classroom. It is meant to strategically select one aspect of technology to implement in BCH[3] 100. Every subject differs in study approaches, so

finding a specific supplemental method for biochemistry does not mean that it will be effective across every subject, but it can suggest that students learn differently and we should be considerate of that fact.

Why Amino Acid Catabolism?

As previously mentioned, BCH 100 condenses material taught in the first two quarters of the major's series. The speed at which the material is covered requires critical decisions to be made about what main ideas should be emphasized in such a limited amount of time[4]. As a result, the course is structured with the four biomolecules as the foundation: carbohydrates, lipids, proteins, and DNA. The extensive detail that is involved in learning and teaching the metabolism of each biomolecule creates pressure for students who are not only rushed to learn the material, but also prioritize memorization, believing it to be the best way to receive a good grade in the course[5]. By the time students finish memorizing and applying concepts from glycolysis, gluconeogenesis, and the TCA cycle, they can stray from the main idea of biochemistry. Transitioning into lipid metabolism, students can make memorization their primary goal, forgetting the connections that should be established between each metabolic process learned. After the second midterm, when protein and DNA metabolism are introduced, the overwhelming need to simply pass finals arrives. It is at this point that the purpose of learning protein metabolism can disappear.

Amino acid catabolism, specifically transamination and the urea cycle, was very difficult for my peers and myself in the Spring 2017 cohort. We struggled with the volume of material, and thus lost sight of the main message. This struggle is the reason I chose to test retention on

transamination and the urea cycle. Other cohorts expressed similar concerns, which led to the development of the capstone project.

What is the Main Point of Amino Acid Catabolism?

Transamination is one way to transport toxic, free ammonia safely through the body to be excreted via the urea cycle. This metabolic process specifically explores the effects of breaking down amino acids into its amine group and carbon skeleton. By doing so, the amine group can then be transferred onto an α-ketoglutarate molecule, transforming it into glutamate. As students of BCH 100, we have seen α-ketoglutarate before in the TCA cycle and we were asked to memorize amino acids since the first week of class. The familiar components of amino acid catabolism demonstrates the need for students to be able to recall and utilize information learned in the past. Instead of concerning themselves with simple memorization, students should be able to use amino acid catabolism to link past information to current information. Additionally, transamination is the third biomolecule discussed in BCH 100. It demonstrates another biomolecule metabolic process; a continuation from carbohydrate and lipid metabolism. By recognizing that amino acid catabolism is the next topic of metabolism, the big picture becomes clearer. Students begin to understand that the molecules learned in the past connect to processes learned later in the quarter. Most importantly, by simplifying how protein catabolism fits into biochemistry, I hope to reduce anxiety for students who are overwhelmed by the information. This change in perspective could then positively affect the attitude towards biochemistry as a course and potentially as a major.

Why Spring 2018 and Fall 2018 as Samples?

When this project began in Winter 2018, I spent time with research group members who were focused on pedagogy for fatty acid metabolism. After observation of this group, I realized that I needed a two samples — a class that did not watch the animation and a class that did. With the given timeframe of my research, the most convenient samples would be those who took the course during Spring 2018 and Fall 2018. But more than that, I wanted to do my best to have similar samples. The students who take BCH 100 in the spring tend to be at the end of their second years and those who take BCH 100 in the fall tend to be at the beginning of their third years. The likelihood of my sample being from the Class of 2020 was higher than other quarters. This similarity allowed for students who have taken similar classes and have studied for similar material (general chemistry, biology, physics, and organic chemistry) to be less influenced by outside knowledge of biochemistry.

Materials and Methods

Materials Used

I used a 2017 Apple iPad Pro (11 inches) and a generation one Apple Pencil as materials to animate. On the iPad, I used the application Animation Desk to create the animation itself. I also used iMovie on my 2015 Apple MacBook Pro to edit the speed and voiceover the animation. I used the application Pages on my MacBook Pro to type out the comprehensive test questions. A 2016 model of the Epson Work-Force 2760 printer was used to print the comprehensive test. The test was printed on Staples brand multipurpose printer paper. In order to make appointments for

the comprehensive test with students and to make it anonymous, I used the online form builder Wufoo. Lastly, to perform my statistical analyses, I used Microsoft Excel.

Animation

On my Apple iPad Pro, I used the application Animation Desk. I used the Apple Pencil to draw various figures such as proteins, carbohydrates, and other figures I deemed necessary to make the animation interesting and helpful. My animation consisted of a quick summary of things the class had already learned up to that point. This includes knowledge of carbohydrates, the amino acid structure, and lipids. The animation then goes in depth on the specific topic: transamination. I begin by talking about pertinent material that they have learned before which were carbohydrates and lipids. I give background information about amino acids that the class should already know to make sure that they have a solid base for the topic. The animation was most useful in showing how the transfer of molecules worked in transamination. Dr. Dingwall emphasized the need to recognize familiar molecules that were present in previous lessons, and how the transfer of NH_3 from one molecule to another will introduce new molecules.
The animation then went into detail on the urea cycle including the steps and intermediates of the cycle. I made sure to only give information pertinent to the class and did not add extra information such as the enzymes.

iMovie Editing

After finishing the animation writing portion, I used iMovie to add a voiceover recording of my own voice that detailed what the animation was covering. I also used it to adjust the speed

of the video to make it a little bit slower so it was easier to follow. Subtitles were added through this program as well. After syncing up the timing of the video, my voice, and the subtitles, the animation was completed.

Comprehensive Test Writing and Distribution

I wrote the comprehensive test after looking at Dr. Dingwall's slides for her class, Biochemistry 100. I chose concepts that emphasized the main ideas of amino acid catabolism to her class and received her approval on these questions. To write these questions, I used the application Pages on my Apple MacBook Pro, creating a 9-question comprehensive test. The test consisted of I mainly used the Epson Work-Force 2760 printer to print out the tests and then used the same type of Staples brand multipurpose printer paper.

To recruit participants to the study, Dr. Dingwall emailed students from her previous courses with the Wufoo link to sign up to take my comprehensive test. I made sure to have a group of students who took the class and did not watch the animation as well as a group that took the class and watched the animation.

Comprehensive Test

I had rooms reserved in Orbach Library for most of my experimentation days. Students would show up to the room and I would hand them the test. I gave them no time limit and asked them to do the best that they could. I did not ask any questions about their grade in the course nor did I ask for their names. All that I did was make sure they took the test to its completion and gave it their best effort. I also made sure that they knew Dr. Dingwall would not be seeing their

scores and it would not affect them in her eyes in any way. After the students finished their test, I asked them if they wanted their score. If they said yes, I would tell them; and if not, I would let them leave.

Data Analysis

I used Microsoft Excel to perform data tests. My analyses included finding the average, standard deviation, and chi-square test.

Data

Null Hypothesis

The null hypothesis assigned to this experiment is that there is no correlation between having watched the animation and retention score.

S18 Cohort

Figure 1a

Participant	Observed
1	11.1%
2	33.3%
3	22.2%
4	44.4%
5	100%
6	22.2%
7	44.4%
8	33.3%

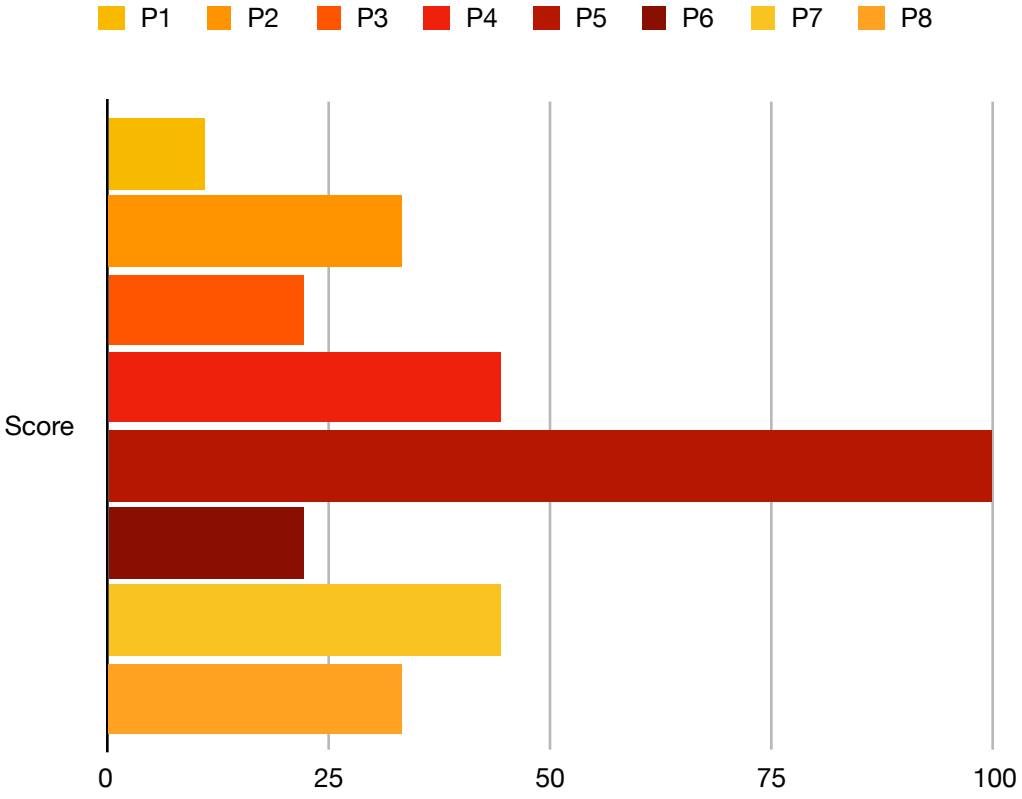


Figure 1b

Average and Standard Deviation

The average value was determined to be 38.9% with a standard deviation of 0.272.

F18 Cohort

Figure 2a

Participant	Observed
1	33.3%
2	33.3%
3	44.4%
4	44.4%
5	11.1%
6	77.7%
7	44.4%
8	55.5%
10	33.3%
11	33.3%
12	44.4%
13	33.3%

*Participant 9 did not watch the animation and scored 44.4%.

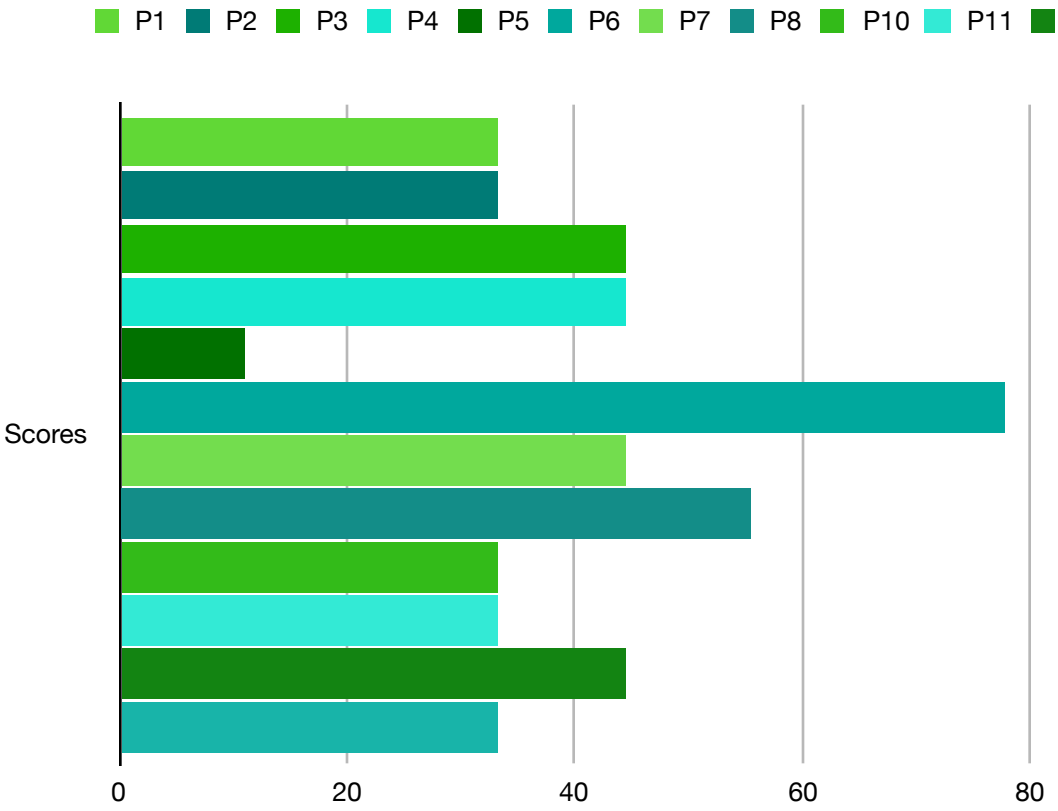


Figure 2b

Average and Standard Deviation

The average value was determined to be 40.7 % with a standard deviation of 0.159.

Figure 3

Spring 2018 Treatment

N_2: 8

df_2: (N-1) = 7

SS_2: 5187.04

S^2_2: $SS_1/(N-1) = (5187.04)/(7) = 741.01$

Fall 2018 Treatment

N_1: 12

df_1: (N-1) = 11

SS_1: 2792.76

S^2_1: $SS_1/(N-1) = (2792.76)/(11) = 253.89$

$$t = \frac{\bar{x}_1 - \bar{x}_2}{\sqrt{s^2 ([1/n_1] + [1/n_2])}}$$

T-Value Calculation

$S^2p = ((7/18)(741.01)) + ((11/18)(253.89))$

$= 443.32$

$S^2_{M1} = S^2p/N_1 = 443.32/12 = 36.94$

$S^2_{M2} = S^2p/N_2 = 443.32/8 = 55.42$

$t = (M_1 - M_2)/\sqrt{(S^2_{M1}-S^2_{M2})} = 0.19$

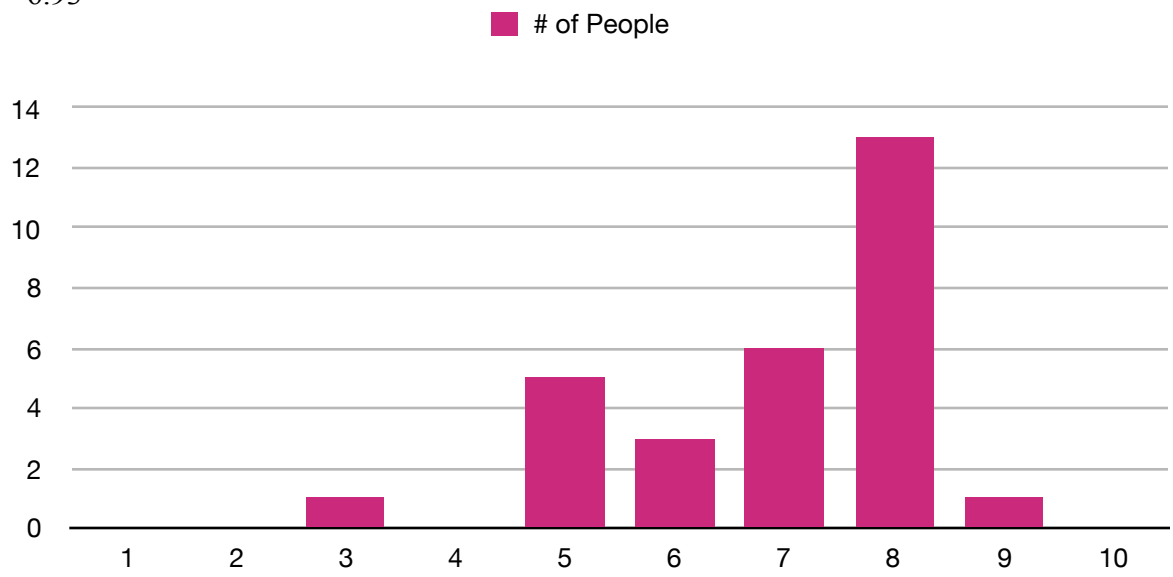
T-Value

The calculated t-value is 0.19 with a p-value of 0.4252.

Survey

Difficulty of Transamination

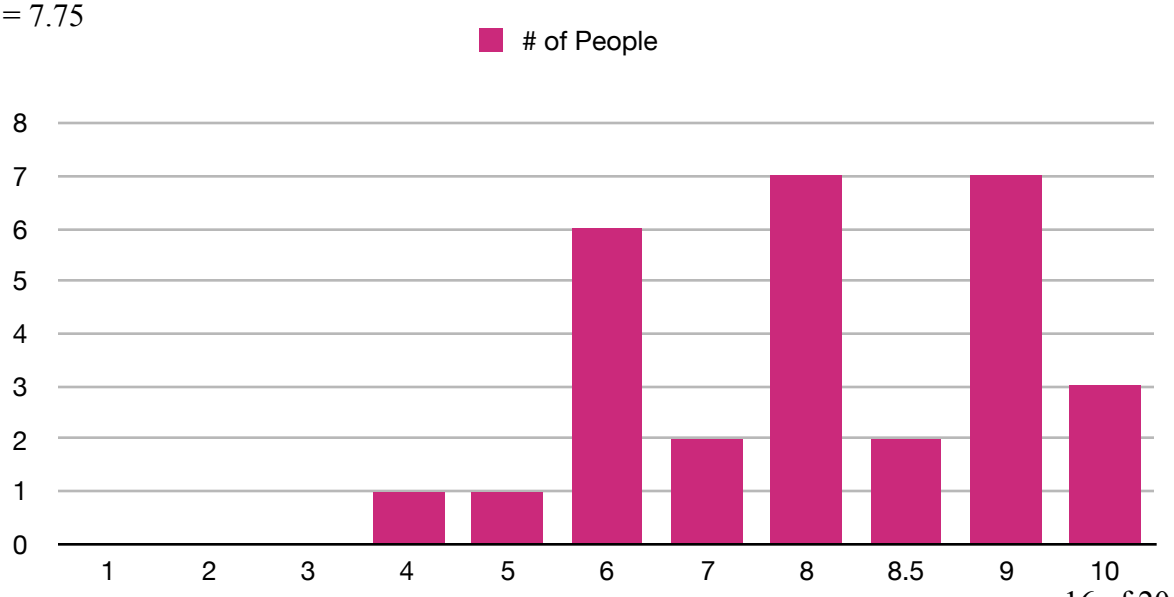
Mean = 6.93



Rating (10 being the most difficult)

Relative Success of Course

Mean = 7.75



Rating (10 being the most success)

Data Analysis

Average Performance of Samples

With the resulting means from each sample differing by only ~1.8%, it is necessary to determine the statistical significance between the two means. In order to find the statistical significance, the independent two-sample t-test was used to compare the means of the two unrelated groups. This unpaired t-test provided a score of 0.19 and according to the p-value table, results in a p-value of 0.4252. The p-value is greater than the significance level of 0.05 and therefore, the result is not significant.

The insignificant difference ultimately determines that I fail to reject the null hypothesis. Thus, according to the data, there is no correlation between the animation and the performance scores of the participants. By extension, this form of technology does not provide a significant change in student scores that could help benefit their performance in BCH 100.

There were noticeable outliers in both samples that skewed the mean calculations and consequently the t-test. Mean calculations are not resistant to outliers and will tend to move towards more extreme numbers. One student scored 100% in the Spring 2018 sample, increasing the average. Another student was an outlier in Fall 2018 with an 77.7% score on the comprehensive test — again, increasing the average. Additionally, the standard deviation is affected by the outliers. However, if we were to calculate the median, the results for Spring 2018 would be 33.3% and 38.85% for Fall 2018. The median is then, within reason in comparing both data sets.

Difficulty of Transamination

Students were asked to rate the difficulty of transamination on a scale from 1 to 10 with the score of 10 being the most difficult. The resulting average rate was a difficulty rating of 6.93, pointing towards the possibility that more students had trouble with transamination than not.

Relative Success

Students were asked to rate how successful they felt in taking BCH 100. This scale can be interpreted in several ways for students — success in understanding material, the letter grade received at the end of the quarter, stress level of the course — and it can be an accumulation of every factor. The resulting average was a success rating of 7.75, suggesting that students felt more successful in the course than not.

Conclusion

Limits

Although the focus of the project was to find a possible benefit from an updated pedagogical method for a large class, many limitations occurred that could have prevented an accurate representation of those who take the course.

Sample Size and Qualities

The sample size for both Spring 2018 and Fall 2018 were smaller than expected, totaling to 21 participants total in the overall project. These sample sizes were not enough to be representative of both cohorts that took the course during spring and fall quarter — the fall class alone had ~500 students. With that being said, the performance of the samples may not

accurately reflect the overall performance and retention of those who took BCH 100 during the time that the project was active.

Those who chose to participate in the research project may have also affected the data. The experiment was announced as a project under Dr. Dingwall's pedagogy lab. Mentioning Dr. Dingwall may have deterred certain students from participating in fear of scoring poorly in front of a professor or may have encouraged certain students to participate in hopes of meeting with a professor. I speculate that the students who participated in my research project may have done better in BCH 100 than others in their cohort which is why they were willing to attend an experiment procedure. This could have moved the average up for retention rate scores and the transamination difficulty and course success ratings.

Finally, the comprehensive test contained two forms of questions: multiple-choice and short answer. Since students vary in their test preferences, it is possible that their scores were affected by their ability to answer certain question types.

Future Directions

The results of this experiment suggests no significant difference between those who watched the animation and those who did not. Since many factors could have confounded these results, I would like to encourage further research on specific conditions that could lead to higher success for students in biochemistry. Animation is one form of technological pedagogy, but the possibility of the integration of technology in the classroom is limitless and should be pursued to enhance the learning environment that the traditional lecture style sets for its students.

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