Teaching the “acid–base” subject in biochemistry via virtual laboratory during the COVID-19 pandemic

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Abstract
Virtual laboratories have started to be the leading alternative teaching tools during the Covid-19 pandemic process. The “Acid–Base” subject is among those that form the foundations of biochemistry. Students can learn the “Acid–Base” subject in a secure environment, with remote access through the use of virtual laboratory simulations. Simulation was applied to fourth-year undergraduate students in Turkey who want to obtain a bachelor’s degree in science teaching during the present study. During the application process, the students conducted different experiments on the concepts of strong acid, strong base and pH, which are the basic concepts of biochemistry. In addition, student opinions regarding the application were also obtained. It was thus determined that the majority of the students were able to write hypotheses, test their accuracy and report the test findings correctly; a small number of students started to apply the simulations after examining them in accordance with scientific terminology. At the end of the application, the students also stated that they had fun during the application which also provided effective learning. It is recommended that classroom activity which is integrated with simulation be used in Chemistry, Biochemistry and Science Laboratory Applications courses.

KEYWORDS
Acid–Base, biochemistry, COVID-19, virtual laboratory

1 | INTRODUCTION

The Covid 19 pandemic started in 2020 and as is the case in many areas, has made it necessary to make changes in education and training activities. In this process, most of the countries reported that schools were temporarily closed and that more than 91% of the students were affected worldwide.1 For this reason, there is a need to use different tools while teaching. Virtual laboratories are among alternative teaching tools; they are learning environments where a real laboratory is simulated, and theoretical knowledge is transformed into practice while providing the opportunity for practitioners to experiment.2 The learning process with simulations in virtual laboratories takes place with the interaction of the user with the simulation.3 Various programs utilized in virtual laboratories enable the visualization of concepts that cannot be seen with the naked to thereby facilitating learning among the students.4

The “Acid–Base” subjects are among those that form the basis of biochemistry. It is reported in the literature that students at all levels have difficulties in this subject and have a lot of misconceptions since the subject of “Acid–Base” contains abstract concepts.5–8 The subject of “Acid–Base” was chosen because it was stated as a difficult subject by the students, the students had a lot of misconceptions on this subject, and it was also one of the basic subjects of chemistry. The “Acid–Base” subject;
Chemistry, Biochemistry and Science Laboratory Applications are included in the content of the courses. Chemistry I-II-III and Science Laboratory course is a compulsory course for Istanbul University-Cerrahpaşa students in Turkey who want to obtain a bachelor’s degree in science teaching. The fact that pre-service teachers learn basic science subjects correctly plays a key role in educating generations with solid scientific foundations in the future. The applications to be used in the teaching of these concepts should also have features that enable students to learn effectively, establish connections between concepts, and see abstract concepts concretely. For this reason, the aim of the present study was to share classroom activity which is integrated with simulation on the subject of “Acid–Base” conducted using a virtual laboratory and obtain the views of students on the application.

2 | APPLICATION PROCESS

Synchronous and asynchronous platforms were used together in the application process. Firstly, students were asked to read the article on “Acid–Base” and to discuss with the group members in synchronization over the Zoom video conference platform. It has been reported that simulation will be used in teaching the subject. Links to acid–base solutions (Figure 1) and pH scale (Figure 2) simulations were added to the Google Classroom platform by the instructor. Afterward, students were asked to examine the simulations, write hypotheses according to the content, test the accuracy of the hypotheses with a simulation application, and present the test results in a report. Also, students were asked for their opinions about the application process of simulations. The application process took place in 2 weeks. The lecturer provided guidance when the students needed it through the Google Classroom platform.

3 | EVALUATION OF THE SIMULATION APPLICATION PROCESS

“Simulation application process evaluation rubric” was used in the present study to evaluate the application process of simulations. The rubric consists of five dimensions: “Examination of simulations,” “Writing hypotheses,” “Testing the accuracy of the hypotheses,” “Reporting of test results,” “Opinion on the application process.” Each dimension was evaluated with three levels. The scores of the students were calculated to get 1 point from the 1st level, 2 points from the 2nd level and 3 points from the 3rd level. The rubric used in the study is shown in Table 1.

4 | STATISTICAL ANALYSIS

Descriptive analysis was used for analyzing the data obtained during the study and to calculate the frequency and percentage values. Analyses were conducted SPSS 16 package program.

**FIGURE 1** Acid–Base solutions simulation
RESULTS

The study was carried out with 36 fourth-year undergraduate students. Students’ proficiency was measured using the “Simulation application process evaluation rubric.” Results are presented in Table 2.

When the findings obtained from the rubric are examined, it is seen that students have strong gains with the practical application of simulation. However, it was determined that the students had difficulties in examining scientific terminology in simulation (Table 2).

Some of the student opinions are presented below:

- **Simulation teaching increases the interest of us as students in the lesson while making the lesson more fun.**
- **During the distance education process, simulations helped us to visualize in our minds the acid–base subject, which includes abstract concepts. That’s why I think it’s very useful.**

LEARNING OUTCOMES

The students presented their final reports at the end of the application. An example of the final report is presented in Appendix. During the application process, the students conducted different experiments on the concepts of strong acid, strong base and pH, which are the basic concepts of biochemistry. In this process, it was determined that the majority of the students were able to write hypotheses, test
their accuracy and report the test findings correctly, a small number of students started to apply the simulations after examining them in accordance with scientific terminology. It can be thought that the reason students go directly to the application without examining the simulation is because they are not very accustomed to virtual laboratory simulations. With the study carried out, information on how to teach the subject of “Acid–Base” has been provided to the fourth-year undergraduate students who will become science teachers when they graduate. Moreover, the students stated at the end of the application that they found it to be fun and that it provided effective learning.

As a result, students were able to implement their designs without losing their interest in the lesson by using the virtual laboratory application despite all the difficulties of the pandemic process. The study is limited to the subject of “Acid–Base.” The “Acid–Base” simulation applied in the study and the entire application process, represents a new classroom activity that will be used to deal with abstract concepts. In this context, it can be said that it is an original classroom activity. The idea that classroom activities created with virtual laboratories with similar studies on different subjects can be an alternative method can be expanded.

Class activity, which includes the inquiry processes created by integrating the “Acid–Base” simulation applied in the study, provides ease of implementation. In addition, it is thought that it will contribute to all educators, primarily Chemistry, Biochemistry and Science educators as a method to be used in eliminating misconceptions by allowing students to make inquiries. It is recommended to develop curriculum and course content similar to the simulation integrated classroom activity proposed in the study in all educational environments, primarily in distance education environments used during the Covid-19 epidemic.

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APPENDIX: EXPERIMENT REPORT
EXAMPLE X

You can access two simulations of Acid–Base with links: “https://phet.colorado.edu/en/simulation/acid-base-solutions” and https://phet.colorado.edu/en/simulation/ph-scale. Perform the following steps in the implementation process.

Acid–base solution simulation

a. Examine the simulations
   In the simulation called Acid–Base solution, it was aimed through the utilization of the electrical circuit tool provided in the simulation to observe whether the solutions provided conduct electricity or not and accordingly, we made our hypotheses and observed whether they were correct or not.
   Simulation link: https://phet.colorado.edu/tr/simulation/acid-base-solutions

b. Write at least two hypotheses suitable for the content of the simulation
   Hypotheses:
   1. Pure water does not conduct electricity very well.
   2. As hydrogen ion concentration increases in Strong Acid solutions, the brightness of the bulb increases in the electric circuit immersed in the solution.
   3. As the hydroxide ion concentration increases in strong base solutions, the brightness of the bulb increases in the electric circuit immersed in the solution.

c. Testing the accuracy of the hypotheses

1. Testing the hypothesis with practice:
   - When the electric circuit is immersed in the container containing 1 L of water, it was observed that the bulb was slightly lit. However, we observed that our hypothesis is correct.

2. Testing the hypothesis with practice:
   - When the electric circuit is immersed in the container containing 1 L of the strong acid solution, it was observed that the brightness of the bulb increases when the hydrogen ion concentration in the acid solution is increased. However, we observed that our hypothesis is correct.

3. Testing the hypothesis with practice:
   - It was observed that the brightness of the bulb increased when the hydroxide ion concentration in the base solution was increased when the electric circuit was immersed in the container with a 1 L strong base solution. However, it was observed that our hypothesis is correct.

d. Reporting of test results
   1. Hypothesis result
      - The hypothesis established as a result of the applications we have done is correct.
2. Hypothesis result:
- The hypothesis established as a result of the applications we have done is correct.

3. Hypothesis result:
- The hypothesis established as a result of the applications we have done is correct.

**pH scale simulation**

a. Examine the simulations
The aim of the pH Scale simulation, one of the simulations examined in the study, was to measure the pH values of the substances provided and to observe their acidity. Our first four hypotheses were presented after which it was observed whether these hypotheses were correct or not.

Simulation link: https://phet.colorado.edu/tr/simulation/ph-scale

b. Write at least two hypotheses suitable for the content of the simulation
Hypotheses:
1. The pH value decreases when water is added to the base solution
2. The pH value increases when water is added to the acid solution.
3. The pH value does not change as the volume increases in the acid solution.
4. The pH value does not change in the base solution with increasing volume.

c. Test the accuracy of the hypotheses
1. Testing the hypothesis with practice:
   - It was observed that the pH value was 13.00 when a 0.50 L sink opener was added to the container. We observed that the pH value was 12.70 when water was added to make up to 1 L on the sink opener, so our first hypothesis was correct.

2. Testing the hypothesis with practice:
   - When 0.50 L of orange juice was added to the container, it was observed that the pH value was 3.50. We observed that when water is added to make up to 1 L of orange juice, the pH value increased up to 3.80, so our second hypothesis is correct.

3. Testing the hypothesis with practice:
   - Firstly, 0.50 L of the soda was selected as the acid was poured into the container and the pH was measured as 2.50. Afterward, it was observed when 0.50 L of soda was added that the pH value did not change, and the result was again 2.50. Thus, we observed that our hypothesis is correct.

4. Testing the hypothesis with practice:
   - The hand soap selected as the base was first placed into the container with 0.50 L with the pH measured as 10.00. The pH value did not change after adding 0.50 L of hand soap and thus it was observed that the pH was again 10.00. Out hypothesis was observed to be correct.

d. Report test results

e. What are your opinions on the application process?
Especially in the distance education process, simulations helped us to visualize the acid–base issue, which includes abstract concepts, in our minds more easily. That is why I think it is very useful.

Simulations can be used in the classroom environment or through the use of the interactive board.

### 1. Hypothesis: When water is added to the base solution, the pH value decreases

| Volume combinations       | pH 0.50 L (0.50 L drain opener) | pH 1 L (0.50 L drain opener and 0.50 L water) | pH 1.20 L (0.50 L drain opener and 0.70 L water) |
|---------------------------|---------------------------------|-----------------------------------------------|-----------------------------------------------|
| pH                        | 13.00                           | 12.70                                         | 12.62                                         |

The accuracy of the hypothesis.

The established hypothesis is correct.

### 2. Hypothesis: The pH value increases when water is added to the acid solution

| Volume combinations       | pH 0.50 L (0.50 L Orange juice) | pH 1 L (0.50 L Orange juice and 0.50 L water) | pH 1.20 L (0.50 L Orange juice and 0.70 L water) |
|---------------------------|---------------------------------|-----------------------------------------------|-----------------------------------------------|
| pH                        | 3.50                            | 3.80                                          | 3.88                                          |

The accuracy of the hypothesis.

The established hypothesis is correct.

### 3. Hypothesis: The pH value does not change as the volume increases in the acid solution

| Volume combinations       | pH 0.50 L (0.50 L soda) | pH 1 L (1 L soda) | pH 1.20 L (1.2 L soda) |
|---------------------------|------------------------|------------------|------------------------|
| pH                        | 2.50                   | 2.50             | 2.50                   |

The accuracy of the hypothesis.

The established hypothesis is correct.

### 4. Hypothesis: The pH value does not change as the volume increases in the base solution

| Volume combinations       | pH 0.50 L (0.50 L hand soap) | pH 1 L (1 L hand soap) | pH 1.20 L (1.2 L hand soap) |
|---------------------------|-------------------------------|------------------------|----------------------------|
| pH                        | 10.00                         | 10.00                  | 10.00                      |

The accuracy of the hypothesis.

The established hypothesis is correct.