The use of virtual laboratory in teaching respiration subject in the Covid-19 process

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Abstract
Along with the Covid-19 pandemic, universities in Turkey as well as all over the world have started to carry out their education activities with the distance education method. In this case, many difficulties were encountered in the application of the Biology course, which is one of the applied courses carried out in the laboratory. Virtual laboratory applications can be preferred especially in teaching abstract subjects that are difficult to understand such as respiration. The teacher can write the process steps and theory related to the experiment to be designed, and the students can follow these process steps and perform the experiment in an interactive way. In this way, students can have a real-like laboratory experience by following the experimental procedure with laboratory materials step by step.

KEYWORDS
Covid-19, pre-service science teachers, respiration, undergraduate students, virtual laboratory

1 INTRODUCTION

Due to the Covid-19 pandemic, educational institutions have been closed and quarantined at various levels almost all over the world in the spring semester of the 2019–2020 academic year.¹ The first recorded case of Covid-19 in Turkey was seen on March 10, 2020.² After the first case was seen in Turkey, all social events planned to be held with the participation of students, teachers and school administrators in public–private schools and institutions have been canceled in order to protect from the effects of the virüs.³

On this occasion, every educator and learner with or without distance education experience suddenly had to teach or learn classes with the distance education method. Educational institutions and educators have searched for how to conduct courses with distance education and how to use various online tools.⁴ Universities in Turkey are affiliated to the Council of Higher Education (HEC). HEC first announced that universities were on holiday for 3 weeks on March 16, 2020. Later, universities were instructed to give courses via distance education and it was stated that there would be no formal education in the spring term of the 2019–2020 academic year. According to the decisions taken by HEC, it has been stated that universities should start distance education within their capacity as of 23 March 2020.⁵ As of March 23, 2020, many universities have conducted courses with distance education method during the 2019–2020 spring semester and the 2020–2021 academic year. Universities have used “synchronous,” “asynchronous,” or “both synchronous and asynchronous” distance education methods as far as their infrastructures allow. However, there were some problems in the implementation of the applied courses with the distance education model. It has been observed that students face difficulties especially in continuing the applied courses that require laboratory with the distance education model. Biology course, which is the subject of the research and is in the category of applied course, is a compulsory course in the curriculum
of the Faculty of Education, Department of Science Education.

There are many abstract concepts in biology. It is not possible for students to see and examine these concepts. One of these concepts is respiration. The importance of teaching the concept of respiration correctly was emphasized for the first time by Anderson et al.6 The subject of respiration has a close relationship with the subject of photosynthesis. Therefore, a student who has misconceptions about respiration is likely to make similar misconceptions about other subjects in biology. Therefore, during the pandemic period, it is important and necessary to use applications such as virtual laboratories so that students can learn respiration correctly and reflect the knowledge they have learned to other subjects of Biology.

In the virtual laboratory, students can perform their experiments as in a real laboratory by following the instructions given to them or the instructions in the experiment sheets. One of the important features that distinguish this type of virtual laboratories from computer-aided applications is the ability to design experiments suitable for many achievements in the field of science and technology. According to the findings obtained from the researches, it has been seen that virtual laboratory applications are effective in increasing academic success and ensuring the permanence of the learned information compared to teacher-centered teaching.7–9

“Gizmos” program, one of the virtual laboratories, is an interactive laboratory program developed by Explore Learning.10 This program includes experiment simulation, theories, worksheet, and procedures. The teacher can write the process steps and theory about the experiment to be designed, and the students can follow these process steps, perform the experiment in an interactive way, and note their observations. In this way, students can have a real-like laboratory experience by following the experimental procedure with laboratory materials step by step (Figure 1).

2 | LEARNING OBJECTIVES

Pre-service science teachers will;

Determine how oxygen and carbon dioxide cycles through a biological system by performing the activity.

Discover what gasses are used and produced by animals.

Discover what gasses are used and produced by plants (in light and dark).

Explain how animals and plants help each other survive.
Use an indicator to measure concentrations of oxygen and carbon dioxide.

Design controlled experiments using the scientific method.

3 | PROCEDURE

In practice, pre-service science teachers were first given an assignment to read a research article on the subject of respiration. Afterwards, the pre-service teachers defined the reaction of respiration and understood its relationship with photosynthesis and determined what could be measured with the available tools. Afterwards, pre-service teachers carried out the activities (A, B, and C) in the virtual laboratory according to the instructions given in the worksheets in Appendix A. The application was carried out synchronously with the video conferencing platform Zoom. Elodea, an aquatic plant, snail, test tubes, bromothymol blue (BTB), and light were given to use in practice. Next, pre-service science teachers designed a laboratory procedure and recorded their data and observations. This virtual laboratory application was completed in eight lesson hours in a period of 2 weeks.

In this experiment, pre-service science teachers tested the following hypothesis by predicting results based upon the experimental setup.

**Hypothesis.** *Animals require the presence of plants to provide them with oxygen (via photosynthesis) needed for cellular respiration.*

In the experiment, the snails and Elodea produce carbon dioxide via cellular respiration. The Elodea use this carbon dioxide in photosynthesis to produce sugars. The oxygen required for cellular respiration is generated by the Elodea via photosynthesis. Each of the test tubes in Gizmos contains water and a small amount of BTB. BTB is a chemical indicator. An indicator changes color when the chemicals in the water change (blue—no carbon dioxide, green—medium level of carbon dioxide, yellow—high level of carbon dioxide). In the first series of experiments, the tubes (1D–4D) are left in the dark for 24 h, while in the second series of experiments, the tubes (1 L–4 L) are exposed to light.

The pre-service teachers predicted the possible outcomes before performing the virtual laboratory applications. After the application, they corrected their wrong predictions with the correct ones (Table 1).

Some mistakes were noticed in the predictions made by the pre-service teachers before the application. In the 3D tube, it is thought that the color will be blue instead of green. This is explained as the absence of light for photosynthesis. In the 4D tube, it was thought that the color would be green instead of yellow, and it was explained that the reason for this was that the snail would produce carbon dioxide, but Elodea would use this carbon dioxide. In the 4 L tube, it was thought that the color would be yellow instead of green; the reason for this was explained as the snail would produce carbon dioxide, but Elodea would produce both carbon dioxide and oxygen. After completing the virtual lab activities, these wrong ideas were corrected.

It was observed that during the teaching of respiration in the virtual laboratory environment, the interest of the pre-service science teachers in the course increased and their motivation increased in terms of providing the opportunity to repeat the mistakes they made. In addition, pre-service science teachers were provided with information on how to teach their students about respiration with virtual laboratory when they became teachers.

As a result, despite all the negativities of the pandemic process, pre-service science teachers were able to carry out their original designs without losing their motivation toward the lesson, thanks to the virtual laboratory application. Due to the Covid-19 epidemic or events that may disrupt any kind of education, educational institutions should develop curricula and content suitable for the distance education method for applied courses. In this context, it can be stated that the world in terms of distance education will not be the same as before.

| Test tube | Contents          | Starting color | End color | Predicted end color |
|-----------|-------------------|----------------|-----------|---------------------|
| 1D        | 0 snails, 0 Elodea| Green          | Green     | Green               |
| 2D        | 1 snails, 0 Elodea| Green          | Yellow    | Yellow              |
| 3D        | 0 snails, 1 Elodea| Green          | Green     | Blue                |
| 4D        | 1 snails, 1 Elodea| Green          | Yellow    | Green               |
| 1 L       | 0 snails, 0 Elodea| Green          | Green     | Green               |
| 2 L       | 1 snails, 0 Elodea| Green          | Yellow    | Yellow              |
| 3 L       | 0 snails, 1 Elodea| Green          | Blue      | Blue                |
| 4 L       | 1 snails, 1 Elodea| Green          | Green     | Yellow              |
CONFLICT OF INTEREST
The author declares no potential conflict of interest.

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REFERENCES
1. Daniel SJ. Education and the COVID-19 pandemic. Prospects. 2020;1-6:91–6. https://doi.org/10.1007/s11125-020-09464-3
2. WHO (2020) WHO timeline–COVID-19. https://www.who.int/newsroom/detail/27-04-2020-who-timeline-covid-19.
3. MEB (2020) Sosyal Etkinlik Müраacatlarının Déğerlendirilmesi. http://ogm.meb.gov.tr/meb_iys_dosyalar/2020_03/13133636_ Sosyal_Etkinliklerin__Red_YazYsY.pdf.
4. E. Karip (2020) “COVID-19: Okulların Kapatalması ve Sonrası”, https://tedmemorg/vurus/covid-19-okuların-kapatılması-ve-sonrası.
5. Y. Saraç (2020) “Basın Açıklaması”. Yükseköğretim Kurulu https://basin.yok.gov.tr/KonusmaMetinleriBelgeleri/2020/04- yok-baskan-saracuzaktan-egitime-iliskin-basin-toplantisi.pdf.
6. Anderson C, Sheldon T, Dubay J. The effects of instruction on college non majors conceptions of respiration and photosynthesis. J Res Sci Teach. 1990;27:761–7.
7. Mitra A, Hullet C. Toward evaluating computer aided instruction: attitudes, demographics, context. Eval Prog Plan. 1997;20: 379–91.
8. Chang CY. Enhancing tenth graders’ earth-science learning through computer-assisted instruction. J Geosci Educ. 2000;48: 636–41.
9. Huppert J, Lomask SM, Lazarowitz R. Computer simulations in the high school: students’ cognitive stages, science process skills and academic achievement in microbiology. Int J Sci Educ. 2002;24(8):803–21.
10. Gizmos https://www.explorelearning.com/index.cfm?method=cResource dspView&ResourceID=641.

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APPENDIX A

Name: _____________________________   Date: ________________________

Student Exploration: Plants and Snails

**Vocabulary:** aerobic respiration, bromothymol blue (BTB), carbon dioxide-oxygen cycle, indicator, interdependence, photosynthesis

**Prior Knowledge Questions** (Do these BEFORE using the Gizmo.)

1. What important gas do we take in when we breathe?

__________________________________________________________________________________

2. Why don’t we run out of the important gases that we need to stay alive?

__________________________________________________________________________________

**Gizmo Warm-up**

In the *Plants and Snails* Gizmo, each of the test tubes contains water and a small amount of bromothymol blue (BTB). BTB is a chemical indicator. An indicator changes color when the chemicals in the water change.

1. With the lights set to on, drag a snail into one test tube and a plant into another. Press Play ( ). After 24 hours, what is the color of each tube?

__________________________________________________________________________________

2. Select *Show oxygen and CO₂ values*. Place the O₂/CO₂ probe in each tube. The probe shows the levels of two gases, oxygen (O₂) and carbon dioxide (CO₂), in the tubes. We call these amounts the gas levels.

   A. When the water turns blue, which gas is most common?

   _________________________________

   B. When the water turns yellow, which gas is most common?

   _________________________________

   C. What does it tell you when the water is green?

   __________________________________

   _____________________________________________________________________

**Activity A:**

Gases in and gases out

| Activity A: | Get the Gizmo ready: |
|-------------|----------------------|
| Gases in and gases out | - Click Reset ( ). |
| | - Clear all of the test tubes. |
| | - Turn on *Show oxygen and CO₂ values*. |

**Question:** What gases do plants and animals take in and what do they give off?
1. **Collect data:** Use the Gizmo to learn what gases plants and animals take in and give off. Try it in both light and dark. Record your results below. If you do more than five experiments, write your extra results in your notebook or on separate sheets of paper.

| What is in the tube | Lights: on/off | Results |
|--------------------|----------------|---------|
|                    |                |         |
|                    |                |         |
|                    |                |         |
|                    |                |         |

2. **Analyze:** Study your data on gases given off by plants.
   
   A. What gas do plants give off in the light? ____________________________________________
   
   B. How about in the dark? ______________________________________________________

3. **Analyze:** Study your data on gases given off by animals.
   
   A. What gas do animals give off in the light? __________________________________________
   
   B. How about in the dark? ______________________________________________________
   
   C. How do these results compare to your plant results? ______________________________

4. **Infer:** Describe the **carbon dioxide-oxygen cycle** by completing the sentences below:

   _Animals breathe in _______ and breathe out _______._

   _In sunlight, plants take in _______ and release _______._

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**Activity B:**

**Interdependence**

**Get the Gizmo ready:**
- Click **Reset**.
- Clear all of the test tubes.
- Turn the light switch to **on**.
- Check **Show oxygen and CO₂ values**.

**Question: How do plants and animals depend on each other?**

1. **Observe:** Put one sprig of Elodea and one snail in a test tube with the lights **on**. Click **Play**.

   A. Does the color of the water in the tube change? _________________________________
   
   B. What happens to the **O₂** and **CO₂** levels? _________________________________

2. **Predict:** Without using the Gizmo, predict what you think will happen to the gas levels in each case listed below. (Leave the **Actual result** column blank for now.)

| Tube                  | Prediction | Actual result |
|-----------------------|------------|---------------|
| 2 snails, 2 sprigs, lights on |            |               |
| 1 snail, 2 sprigs, lights on |            |               |
| 1 snail, 2 sprigs, lights off |            |               |
3. **Run Gizmo**: Now run the Gizmo to test your predictions. Record your findings in the table.

4. **Generalize**: Describe how plants and animals each contribute to the survival of the other. (This type of cooperative relationship is called **interdependence**.)

__________________________________________________________________________________  
__________________________________________________________________________________  

5. **Challenge**: Simulate a 24-hour day (12 hours of light, 12 hours of dark). How many snails and plants do you need to keep a stable environment? Explain any discoveries you make.

__________________________________________________________________________________  
__________________________________________________________________________________  

### Activity C: The carbon-oxygen balance

**Get the Gizmo ready:**
- Click **Reset**.
- Clear all of the test tubes.
- Turn the light switch to **on**.
- Check **Show oxygen and CO2 values**.

**Question**: How are the amounts of oxygen and carbon dioxide related to each other?

1. **Observe**: Put two Elodea sprigs into a test tube. Put the O2/CO2 probe into the tube with the Elodea. Click **Play**. As the Gizmo runs, **Pause** it a few times.

   **A.** How do the oxygen (O2) and carbon dioxide (CO2) levels change over time?

   ____________________________________________________________________________

   **B.** What is always true about the **total** amount of O2 and CO2 in the test tube?

   ____________________________________________________________________________

   **C.** What happens when the CO2 reaches zero? ____________________________________

2. **Revise and repeat**: Click **Reset** and run the experiment again, this time with the lights off.

   **A.** How do the gas levels change? O2 _________________  CO2 _________________

3. **Revise and repeat**: Click **Reset**. Remove the plants. Repeat the experiment with two snails.

   **A.** How do the gas levels change? O2 _________________  CO2 _________________

4. **Challenge**: In the process of **photosynthesis**, plants use carbon dioxide (CO2), water (H2O), and light energy to produce a sugar (C6H12O6) and oxygen (O2). In the process of **aerobic respiration**, animals and plants release energy from sugar and oxygen and produce carbon dioxide and water. The chemical equations that describe these reactions look like this:

   \[
   6\text{CO}_2 + 6\text{H}_2\text{O} + \text{light} \rightarrow \text{C}_6\text{H}_{12}\text{O}_6 + 6\text{O}_2 \\
   \text{C}_6\text{H}_{12}\text{O}_6 + 6\text{O}_2 + 6\text{CO}_2 + 6\text{H}_2\text{O} + \text{energy}
   \]

How do these equations explain why the total amount of O2 and CO2 remains the same?

__________________________________________________________________________________  
__________________________________________________________________________________