Assessing Preservice Teachers’ Understanding of Disease and its Spread using Scientific Illustrations and Virtual Labs - Preliminary Findings

Introduction

Drawing methods have been utilized for a variety of purposes. Scientists have been using methods of illustrations in science education since the early 20th century (Landin, 2015). They have found that discoveries that have been captured through drawings could have never been captured through words. Teacher education has been the most effective way of providing knowledge and skills to preservice teachers to understand the complicated parameters related to the subject areas and pass them on to growing minds. The study assessed preservice teachers’ understanding of disease and its spread through a series of assessments, virtual labs, and surveys. The study identified certain indicators, common terminology, and illustrations that were used to address research questions: 1. Did preservice teachers increase their knowledge and understanding of disease and its spread? 2. How did preservice teachers’ perception of disease and its spread change? 3. How did preservice teachers’ visual representation of disease and its spread change?

Methods

Preservice teachers enrolled in science methods for teachers’ course were the participants in the study: Virtual lab: twenty-one participants (pre-post) multiple-choice questions; Final survey: fourteen participants; and Virtual worksheet: fifteen participants (worksheet data has not been analyzed yet). The study was first conducted with a pilot survey that consisted of 2 open-
ended questions. Following the pilot survey, the final survey and post-assessment were developed and administered. Twenty-one preservice teachers participated in virtual interactive labs (pre-and-post-assessments) consisting of 5 multiple choice questions on disease and its spread content knowledge assessments (explorelearning, 2022). Nineteen preservice teachers participated in explaining their understanding of disease and its spread by drawing. Pre-post assessments were administered in the 2nd and 4th week of the spring semester, respectively, preservice teachers were given 40-45 minutes to complete the virtual lab and survey based on the disease spread.

Findings

The study findings are represented by three different instruments as stated below: A pilot survey, virtual pre-post assessments, and a final survey.

Pilot Survey Results

Table 1: Survey conducted with open-ended questions to assess the knowledge of preservice teachers' understanding of disease and its spread.

<table>
<thead>
<tr>
<th>Questions</th>
<th>Responses</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Explain the understanding of disease and its spread by drawing.</td>
<td>The preservice teachers answered this question using the method of drawing and by this, there were many common indicators used such as, coughing, sneezing, touching, etc. Broadness of the illustrations also were demonstrated by how the preservice teachers exactly pictured disease and its spread. For example, some would demonstrate disease and its spread by drawing more than 3 people, as for some would just draw 2 or 3 people making interactions. Depicted in image 1 and 2.</td>
</tr>
<tr>
<td>2. Provide a brief description of the drawing.</td>
<td>Since many of the preservice teachers used the method of labeling on the pictures, it was quite easy to explain what they saw. However, even with the different illustrations the preservice teachers drew out, everyone used similar vocabulary. This showed that most students used the same terminology when describing disease and its spread but when it came to illustrating their knowledge on disease and its spread, they all had different viewpoints.</td>
</tr>
</tbody>
</table>
Images 1 & 2: Preservice Teachers’ Understanding of Disease and its Spread (Pilot Survey)

**Virtual Lab (Pre-Post Online Assessment) Results**

Pre-post online assessment results indicate as shown that most of the preservice teachers were able to incorporate their knowledge from the first assessment and virtual lab worksheets into the post-assessment and achieve a higher score. Therefore, the preservice teachers were able to get a better understanding of disease and its spread through virtual assessments. Results are depicted in Figure 1.

*(Paired T-Test)*

![Figure 1: Pre-Post Content-Based Knowledge](image-url)
Final Survey Results:

Table 2: The survey conducted a series of questions to assess the knowledge of preservice teachers’ understanding of disease and its spread.

<table>
<thead>
<tr>
<th>Questions (Q)</th>
<th>Answers (A)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Below draw and reflect upon your understanding of disease spread?</td>
<td>Many of the preservice teachers answered this question by indicating the causes of diseases such as touching, coughing, sneezing, etc. This is reflected in the viewpoint of the students and how they identified the spread of disease.</td>
</tr>
<tr>
<td>2. What is your definition of disease spread?</td>
<td>Most of the preservice teachers would describe what is portrayed in question number one and go off the image they drew out as reference while others would go in more of an in-depth explanation to how and why diseases spread.</td>
</tr>
<tr>
<td>3. What type of vocabulary would you use to describe this?</td>
<td>The preservice teachers chose terms such as contagious, germs, bacteria, contact, sickness, etc. Their usage of these terms defined their knowledge of disease and its spread.</td>
</tr>
<tr>
<td>4. Would you learn better about a specific disease using pictures or reading off content? Or both?</td>
<td>Most preservice teachers chose terms such as contagious, germs, bacteria, contact, sickness, etc. Their usage of these terms defined their knowledge of disease and its spread. Figure 2 represents the results from this question.</td>
</tr>
<tr>
<td>5. What are some diseases that you are familiar with?</td>
<td>Diseases such as coronavirus, flu, cold, etc. were commonly used by the preservice teachers.</td>
</tr>
<tr>
<td>6. What are the common symptoms of these diseases?</td>
<td>Symptoms such as coughing, pain, nausea, fatigue, and vomiting were often used as an answer.</td>
</tr>
</tbody>
</table>

Images 1 & 2: Preservice Teachers’ Understanding of Disease and its Spread (final survey)
Virtual Lab Worksheet Results

1. Prior Knowledge Questions (PKQs)

**Question 1: Why do you think it is important to cover your mouth when you cough?**

**Question 2: Why should you always wash your hands before you eat?**

<table>
<thead>
<tr>
<th>Students</th>
<th>Question 1 Responses</th>
<th>Question 2 Responses</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>To prevent the spreading of germs to others.</td>
<td>Clean hands to avoid collecting germs after eating.</td>
</tr>
<tr>
<td>2</td>
<td>To prevent germs from spreading.</td>
<td>To kill the germs before eating and avoid ingesting the bacteria.</td>
</tr>
<tr>
<td>3</td>
<td>Avoid the spread of germs and getting others infected.</td>
<td>Wash hands to be aware of the bacteria that might get on the food.</td>
</tr>
<tr>
<td>4</td>
<td>Prevent spread of germs and avoid infecting others.</td>
<td>Importance of washing off germs and pathogens before eating.</td>
</tr>
<tr>
<td>5</td>
<td>It helps prevent the spread of germs and sickness.</td>
<td>To avoid consuming germs from the hands.</td>
</tr>
<tr>
<td>6</td>
<td>Important because germs and sickness can be spread through the air.</td>
<td>People touch many dirty surfaces; therefore, it is good to wash hands to avoid germs.</td>
</tr>
<tr>
<td>7</td>
<td>Germs are contagious, therefore covering the mouth will prevent germs from spreading.</td>
<td>Germs are caught by touching surfaces and can cube transferred to food.</td>
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<td></td>
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<td>---</td>
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</tr>
<tr>
<td>8</td>
<td>To avoid spreading droplets that come orally.</td>
<td>Wash away germs so they don’t transfer to the food.</td>
</tr>
<tr>
<td>9</td>
<td>To limit the number of germs and bacteria that are spread onto different surfaces.</td>
<td>To wash away bacteria and germs on hands, to avoid ingesting harmful germs.</td>
</tr>
<tr>
<td>10</td>
<td>Covering the mouth when coughing avoids the number of germs spreading through the air.</td>
<td>Washing hands reduces the chance of getting sick.</td>
</tr>
<tr>
<td>11</td>
<td>It’s important to cover the mouth because it keeps pathogen from spreading.</td>
<td>To keep disease from transferring onto food and into someone’s mouth.</td>
</tr>
<tr>
<td>12</td>
<td>It is important to cover the mouth to prevent germs from spreading.</td>
<td>Germs on the hand can transfer into the body causing sickness if hands are not washed.</td>
</tr>
<tr>
<td>13</td>
<td>Covering the mouth helps to prevent spreading sickness to others.</td>
<td>Hands need to be washed in order to get rid of germs that have been collected overtime.</td>
</tr>
<tr>
<td>14</td>
<td>Covering the mouth decreases the spread of sickness.</td>
<td>Washing hands before eating helps get rid of germs from others.</td>
</tr>
<tr>
<td>15</td>
<td>It is important to cover the mouth in order to reduce the spread of germs.</td>
<td>People should always wash their hands before eating because before they eat, they may have germs on their hands that could contaminate their food.</td>
</tr>
</tbody>
</table>

**Gizmo Warm-up Results**

The Gizmo Warm-up was a virtual lab that asked the pre-service teachers to observe a video of various pathogens that can spread through a group of students in a school cafeteria after reading about diseases, infectious diseases, and pathogens. After they completed watching the video, they were asked the following questions: 1. Describe what happens on the stimulation pane; 2. Look at the color key on the bottom right of the Gizmo. What is happening when a person changes color?

For Question 1, the pre-service teachers mostly answered that within 48 hours all but two of the students in the video were infected with foodborne. This indicated pre-service teachers’ understanding of disease and its spread through virtual representation.

For Question 2, All the pre-service teachers were able to understand that the change in color represented the health of the students and how rapidly the foodborne infected them. Blue indicates health and green or orange indicates infection.
Activity A: Person-to-person Transmission Results:

Overall Question: What factors affect how quickly a pathogen spreads from person to person?

1. **Predict**: Some pathogens are spread directly from one person to another. This can happen when people come into direct contact or share items, such as drinking glasses. What do you think might affect how quickly a pathogen is spread from person to person?

   Response: 53% of pre-service teachers responded with direct to direct contact with people and approximately 47% answered with people who don’t wash their hands get infected easily which makes the pathogen spread faster.

2. **Identify**: select the TABLE tab. (You will want the table tab open to answer Question C.)
   
   A. What does the orange person represent?

   All of the pre-service teachers were able to identify that when a student had turned orange in the stimulation, they have had person-to-person contact or have gotten infected.

   B. Click Play and oversee the stimulation for a while. What must happen for the disease to spread from one person to another?

   The pre-service teachers answered with close contact or touching, representing their knowledge on how disease spreads visually.

   C. How long did it take to infect all ten people?

![Figure 1: Pre-Service Teachers’ Identification on Time Range of Disease and its Spread.](image)

Figure 1: (referring to part C) Pre-Service Teachers’ Identification on Time Range of Disease and its Spread.
3. **Experiment**: Click Reset. Change the number of people to 20. Click play and record how long it takes to infect 10 people. Repeat this number for a total of 5 trails, then calculate the mean time. Repeat the experiment when there are 20 people and 40 people in the room.

Answers varied, however, as the number of people in the cafeteria increased, the “mean time” of how fast infections were spreading increased. Indicating to the pre-service teachers that the number of people in a certain area reflects how fast a disease spreads.

4. **Interpret**: Study the data you collected. What trend do you see in the data, and how would you explain it?

Response: As students increased, the rapidness of the disease spreading increased due to the contact between people becoming more common as the people increased in the room.

![Figure 2](image.png)

Figure 2: (referring to part 3 and 4) Pre-service Teachers’ Experimental Data Analysis from Activity A.

5. **Experiment**: Not all pathogens are equally contagious or likely to spread. The probability of transmission is the chances that a contact between two people will result in transfer of the disease. Click reset and set the number of people to 20. Set the probability of transmission to 20%. Record data for transmission probabilities of 20%, 50%, and 80%.

Response: Data analysis of probability of transmission and mean time (h).
6. **Interpret**: Study the data in the table. What trend do you see, and how would you explain it?

Response: As the probability of transmission increased, the time required to infect five people decreased. The pre-service teachers were able to interpret from the experiment that the more the chances are of the disease being contagious, the less time it takes for most people to get infected.

7. **Experiment**: For certain pathogens, mask-wearing can greatly reduce the probability of transmission. Click reset, select students wearing masks, and set probability of transmission (without masks) to 50%. Check that the number of students is still 20.

Response: Data analysis of how long it would take in order for 10 people to get infected if 50% of students in the stimulation are wearing masks and 50% aren’t. Mean time value increased.

8. **Compare**: Compare the mean time to infect ten people with masks to the mean time to infect ten people without masks. (Use the 50% line from the table in question 5) How do these times compare?

Response: All pre-service teachers answered that the rate and how fast the disease spread positively decreased showing the importance of mask wearing.

9. **Infer**: Why do you think masks have this effect on the rate at which a person-to-person disease spread?

Response: It creates a barrier between people, pathogens responsible for infection are less able to be spread, avoids germs to be spread, reduces chance of diseases spreading, slows the spread, etc.

10. **Think and discuss**: Suppose you were a public health official. Based on the data you have collected; how would you slow the spread of a person-to-person disease?

Response: Approximately 53% answered to wear masks and 47% answered to wear mask and limit capacity of people in a room or social distancing.
Activity B: Food-borne Transmission

Overall Question: How do food-borne pathogens spread?

1. **Predict**: How do you expect the spread of a food borne disease to be similar to and different from the spread of a person-to-person disease?

Response: 40% of pre-service teachers responded that a foodborne disease would be faster to spread and 27% said person-to-person contact disease spreads faster and 33% compared foodborne and person-to-person contact disease by addressing that they both occur by pathogens but foodborne comes from food.

2. **Observe**: Click play and closely watch the students moving around the cafeteria.
   
   A. What does each student do before becoming infected?

Response: They go to the buffet table or food first. This indicates the cause of foodborne disease to the pre-service teachers.

   B. How are foodborne pathogens transmitted?

Response: Foodborne pathogens are transmitted by eating or drinking something containing foodborne pathogens.

   C. If a student in the stimulation never eats or drinks anything, is it possible for them to become sick with the foodborne disease? Explain.

Response: 80% of the pre-service teachers said no because to be infected with foodborne disease they would have to eat something. The other 20% of the students said yes because the students could still get infected with other diseases. This showed the uncertainty of pre-service teachers’ knowledge on disease and its spread, indicating their answers might change after the experiment and interpretation.

3. **Experiment**: Click Reset. Check that the number of people is 10 and set the probability of transmission to 50%. Click play and record how long it takes to infect 10 people. Repeat four times, then calculate the mean. Repeat the experiment for 25 and 40 people.
Response: Pre-service teachers recorded analytic data of the time it took to infect food-borne disease on 10 people as food-borne increased with the probability of transmission at 50%.

4. **Interpret**: What trend do you see in your data? Why do you think this is the case?

Response: The greater the number of people, the more quickly 10 people got infected showing more people were eating the infected food.

5. **Experiment**: Set the number of people to 20. Using the same method, find the mean time for each transmission probability.

Response: Pre-service teachers recorded analytic data of how the mean time changes if transmission probability is increasing.

6. **Interpret**: Study the data in the table, what trend do you see, and how would you explain it?

Response: As the transmission probability increases, the time to infect 10 people decreases.

7. **Experiment**: Click reset. Select students wearing masks and set the probability of transmission (without masks) to 50%. Check that the number of students is still 30. Using the same method as before, collect data to see the effect of masks.

Response: Preservice teachers recorded data on how the average amount of time it would take for a foodborne disease to spread will take if the students in the stimulation wore a mask. *All of the pre-service teachers’ answers did not change from their previous data analysis.*

8. **Compare**: Compare the mean time to infect ten people with masks to the mean time to infect ten people with masks (use the 50% from the table in question 5.)

Response: The time was similar or did not change. The preservice teachers were able to understand that a foodborne disease cannot be spread from person-to-person and that masks do not make a difference in the process of it spreading.

9. **Infer**: Why do masks have no effect on the rate at which a foodborne disease spread?
Response: Masks have no effect on the rate at which a foodborne disease spreads because a foodborne disease occurs when a person at a food containing pathogen and if the pathogen is entering the body by eating, masks do not make a difference.

10. **Compare**: How is the spread of a foodborne disease like the spread of a person-to-person disease? How are they different?

Response: The foodborne and person-to-person disease spread faster when number of people increase and when probability increases, however masks do not slow down the spread of foodborne disease.

The Virtual Lab worksheets demonstrate that the pre-service teachers’ answers changed from their prediction of person-to-person and foodborne disease from analytic data and virtual representation. They were able to understand the differences and similarities between both disease types and how they are both spread. This also reflects how they based their knowledge from the virtual lab worksheets into the post-assessment and final survey about disease and its spread.

**Discussion**

The findings from the current study which is related to drawings and their relation to understanding the scientific content are related to the findings of Chambers (1983), Frick (1990), Mason *et al.* (1990) because they discuss the social image of a scientist similarity like the present study, which is to discuss the viewpoint of disease and its spread through the perspective of preservice teachers. The conclusions of Chambers (1983) identified at what age children first developed distinctive images of the scientist but did not address drawing out a scientific illustration and were not tested with preservice teachers. Frick (1990) attempted to investigate Greek Children’s impression of scientists and their work through drawings and semi-structured interviews. This article addressed students' perception of scientists but did not use the idea of preservice teachers' understanding of scientists. Mason, Kahle, & Garnder (1990) extra listed a study showing the need for the image of a scientist to change because of the effect it has on a
students’ learning environment. Although this article demonstrates the element of drawing it does not discuss the viewpoint of preservice teachers towards the spread of disease. Similarly, the instruments and conception of the current study, Vamos, Xie, & Yeung (2020) recent study concluded that health education is beneficial for the preservice teachers to increase their knowledge and preparation for teaching school health. Although the research assesses pre-service teachers' knowledge of health education through surveys and quantitative data, it lacks assessing preservice teachers' knowledge of disease and its spread.

Furthermore, Darling-Hammon, Branford, Lepage, Hammerness, and Duffy (2007) explain how teachers learn certain teaching methods and the targeted audience of the article is preservice teachers that are interested in the education field. The study shows interest in how teachers learn; however, it does not regard information on the teaching of diseases and its spread. Landin (2015) explains that drawing was a social science research method that began in the early 20th century and was required as part of the school curriculum. This research article showed the significance of drawing in science, however, does not specifically ask students to picture their knowledge of disease and its spread by using the method of drawing. Mosley’s et al. (2002) study shows the effects of teaching outdoor environmental education on preservice teachers, this study also relates to Darling-Hammon et al. (2007) which also explained the learning environment preservice teachers. Although both studies use the knowledge of preservice teachers as an important element, they did not mention their knowledge of the disease and its spread which is mentioned in the current study. After comparing and contrasting, it has been concluded that there is a limited amount of research done over assessing preservice teachers’ understanding of scientific illustration and no research done on their understanding of disease and its spread.

Conclusions

The purpose of this study was to assess preservice teachers' understanding of disease and its spread through scientific illustrations and virtual labs. Furthermore, the survey responses revealed interesting findings such as 95% of preservice teachers prefer both content and illustration-based knowledge because every description requires a picture, and every image requires an explanation, as well as 76% of students, scored higher on the post-assessment than the pre-assessment, and 24% of preservice teachers' results did not change.
Acknowledgments

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Bibliography


