World of VIRUSES

Front End Evaluation Report

Amy N. Spiegel, Ph.D.
April 2009

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World of Viruses Front End Evaluation
Executive Summary

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The World of Viruses Front End Evaluation was undertaken to provide planning and baseline data about youths' understanding of viruses. The information was gathered to help project staff with the design of the World of Viruses educational materials on virology topics. A survey of mostly open-ended items was designed around the "Essential Questions" identified as central to a basic understanding of viruses. This brief, one-page survey was administered in science classes to a total of 126 middle and high school students, ranging in age from 13 to 16 years, from public schools in Lincoln, Nebraska.

The majority of students responding to this survey had a basic grasp of viruses as disease agents, and most were also able to provide other specific information. Almost all students knew that viruses are found in animals and in the air, and over half agreed that viruses are found in plants, the ocean, and soil. One-third described viruses as attacking cells, and one-fifth mentioned the role of the immune system or white blood cells in fighting viruses. A much smaller number identified the need of a virus for a host, named specific viruses, and/or noted that viruses have their own genetic material.

Over three-quarters of the students correctly identified an image of a bacteriophage as a virus, and most indicated they had seen pictures of bacteriophages at school. Half of the students correctly identified an image of HIV as a virus. However, half of the students incorrectly identified images of a cell and/or bacterium as viruses.

When asked how viruses could be helpful, 28% of students did not know and 10% did not believe that viruses could have a positive role. Of the remaining students, the most frequent response was that "good" viruses could somehow counteract or protect us from "bad" viruses. Students also thought viruses could be helpful for use in vaccines or to strengthen the immune system, or could be used in research to develop cures or other kinds of medicine.

When asked to explain how modern-day vaccinations help prevent disease, students' responses revealed a range of understanding. About 30% of the students did not respond or gave no meaningful response to this question. Another 30% indicated that a vaccine contains medicine, or works by killing, fighting off, or blocking the virus. However, nearly 40% of students did include more relevant information about how vaccines work. These responses reflected one or more of the following: that a vaccine includes a *"weakened version"* or *"part of"* the virus; that a vaccine strengthens the immune system; and that the body learns to recognize a particular virus and responds by fighting it off. Some students mentioned antibodies. With respect to misconceptions about vaccines, some students said that vaccines themselves create or contain antibodies, and one student stated that s/he did not believe vaccines help prevent disease.

The last item on the survey asked students what they would ask a virus expert if they had the opportunity. Nearly two-thirds of the students had questions, and most of these fell into four major areas. The most frequent were questions about the origin, survival, or fundamental functions of viruses, such as *"where do they come from?"* Other questions pertained to personal health and protection, including how to avoid viruses and how to tell if you have one. Another area of interest focused on virus identification and categorization, including information about their appearance, how many types exist, and what the worst virus in existence is. Finally, students also asked about virus behavior and pathogenicity, with questions like *"what do viruses exactly do to a human's body?"*

Overall, students' responses indicated an interest in and a familiarity with viruses. The vast majority were able to offer some relevant information about viruses, and a smaller subset displayed a basic understanding of what a virus is, how viruses cause disease, and how vaccines help to control them. There were, however, significant gaps in knowledge for many of these students, and some misconceptions. These results illuminate both strengths and weaknesses in student understanding and should provide useful data to help in the design of educational materials for this population.

Introduction

World of Viruses (WoV) is an educational project funded by the National Center for Research Resources at the National Institutes of Health through the Science Education Partnership Award (SEPA) Grant No. R25 RR024267-01 (2007- 2012). WoV was funded to develop documentaries and features for public and satellite radio stations. These products are complemented with a sophisticated outreach package for public libraries, educators, and middle and high school students. The planned educational package now includes essays, graphic novels, and cartoon panels, in addition to the radio documentaries—all focusing on a variety of virology topics.

The World of Viruses Front End Evaluation was designed to provide planning and baseline data about youths' understanding of viruses. The purpose of this front end evaluation study was to gather initial data on what youth in the targeted age range already know about viruses. This will help with the planning and design of the World of Viruses educational materials on virology topics by establishing some baseline data about the information needs of the targeted audience.

To discover what middle and high school students currently know and understand about viruses, a front end evaluation survey was undertaken. Instead of offering only multiple-choice or true/false options, this survey was designed as an open-ended instrument to solicit youths' responses in their own words. A survey constructed of these types of questions requires articulation of concepts rather than simple recognition; responses will yield a richer understanding of students' thinking and misconceptions.

The planned educational materials for WoV are being designed around several different viruses, tentatively including human papillomavirus (HPV), West Nile Virus, Ebola, and HIV, among others, and other virology topics, such as the role of viruses as natural regulators, tracking viruses, and developing new vaccines. Given the diversity of viruses, three fundamental questions about viruses were identified as a means to guide the material development. These "Essential Questions," identified as central to a basic understanding of viruses are: 1) what is virus? 2) what is the mechanism through which viruses infect, reproduce and cause illness? and 3) how can viruses be controlled or regulated? The educational materials will be designed to help students answer these questions about the different viruses. Using these Essential Questions as a guide, the following evaluation questions were identified:

1. What is the current understanding among the target group in regard to the following:
    a. the nature of viruses?
    b. virus replication, infection, and disease?
    c. human regulation of viruses?
2. What is the target group interested in learning about viruses?

Methods

A brief, one-page survey was developed (see appendix) to address the evaluation questions. The survey was developed, reviewed, and extensively revised in consultation with WoV project staff, including educators, virologists, and educational material developers. Some additional questions—involving other basic knowledge about viruses and identifying what youth want to learn about viruses—were deemed useful by project staff and added to the survey. The survey was trial tested with a group of students, and revisions were incorporated prior to final administration.

A total of 126 students from Lincoln Public Schools in Lincoln, Nebraska took part in the survey. Two schools, a high school and a middle school, were selected based on the diversity of their students, with over 30% minority enrollment and about 50% of the student population participating in the free and reduced lunch program. Six classes of students, three from 8th grade (middle school) and three from 10th grade (high school), took the survey. All classes were required science-related courses and thus included a representative cross-section of the student population in these schools. Students were asked to complete the questionnaire in their classrooms at the beginning or end of the class period.

The mean age of the student sample was 14 years old, with ninety-nine percent of the students ranging in age from 13 to 16 years old. Fifty-two percent of the participants were male, and 46% female (two did not indicate gender). With respect to race and ethnicity, the percentages in the individual racial categories below include those students who selected a single category. Those who selected multiple categories are counted in the multiracial group.

Ethnicity	Hispanic	11%
	Non-Hispanic	78%
	Did not indicate	11%
Race	White (only)	68%
	American Indian or Alaska Native (only)	4%
	Asian (only)	3%
	Native Hawaiian or Other Pacific Islander (only)	1%
	Black or African American (only)	9%
	Multiracial (selected more than one racial category)	10%
	Did not select a racial category	6%

Prior to administration, the instrument, assent forms, and all procedures were approved by the University of Nebraska Institutional Review Board and by the Lincoln Public Schools Evaluation Director. For the analysis of the qualitative data, a simple categorical coding system was developed and all questions were coded by two raters. Ninety-six percent agreement or higher was reached on the first coding for each question, and discrepancies were subsequently discussed and resolved.

Results

What is the current understanding among the target group about the nature of viruses? The large majority of students (95%) attempted responses for most of the items. This suggests a general interest in the topic and furnishes a relatively complete set of responses. When asked to describe a virus, 86% of students provided some written response. Over two-thirds (71%) indicated that a virus makes you sick, is a disease or infection, or is harmful to the body. Nearly all of the remaining students who responded to this question included some other relevant information about viruses, and this is described in more detail below. Altogether, 97% of students came up with some relevant or accurate information about viruses, even if it was only that they are found in people or that they multiply.

What is the current understanding among the target group about virus replication, infection, and disease? Combining responses to the question items "Describe a virus" and "How do viruses make you sick?", 36% of students indicated that viruses "get inside" your body, with responses such as:

It lives in living things…

Infect you.

…a disease that can enter your body and make you ill.

It gets into your system and can make you really sick.

One-third of the students were specific in saying that viruses "attack," "penetrate," or "infect" cells, with responses such as:

They take over your cells in order to reproduce.

They get in your body, multiply, then attack good cells.

They attack your body and your cells to weaken your body systems.

They attack your cells.

Some of the respondents (17%) specified that viruses attack blood cells in particular, or that they enter the bloodstream as their means of infection; one-fifth (21%) of students described viruses as attacking the white blood cells or weakening the immune system.

Almost one-quarter (23%) included statements about viruses multiplying or reproducing *("it gets into your body and blood stream, multiplies and causes harm to your health.).*" Fifteen percent indicated that viruses were contagious or infectious *("it is something that you catch and get sick,"*and "*some come from the air and … you breathe it in and that is how you get sick.)."*

Several responses gave evidence of a more thorough understanding of viruses, with 8% indicating that viruses need a host or host cell and 4% mentioning that viruses have their own genetic material. One of the more complete responses was:

> *Viruses don't have a cellular structure, but they can and do reproduce, usually by invading a host cell and using its own genetic material to make copies of itself.*

Six percent named a particular virus, with half of these mentioning flu and the others naming HPV, cold, and West Nile. Only a small number (6%) specifically referred to the tiny size of viruses, although this was implied in the responses indicating that viruses enter cells. Eight percent described viruses as nonliving, and a couple of students addressed this by saying a *"quasi life form"* or *"neither living nor nonliving."* A few students included other accurate information about viruses, such as:

> *…can be found almost anywhere…*
>
> *…some are incurable.*

A small number of students claimed that viruses are bacteria (4%) or cells (2%). A few students also stated that viruses *"can't be cured," "our body can't fight them off,"* or *"there is no medicine to cure them."* Similar to these were the few responses that indicated that *"you have to let it pass through the system"* or *"let it run its course."*

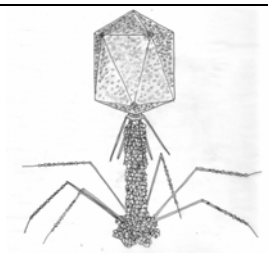
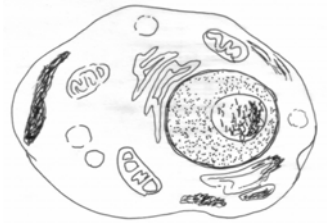
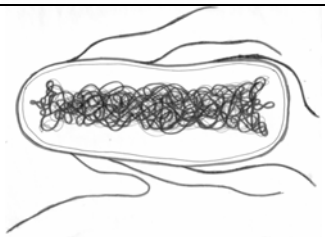
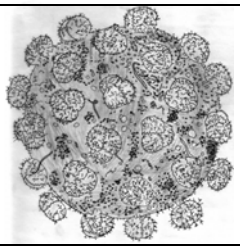
Overall, a large proportion of the responses were limited in scope, suggesting an incomplete understanding of the primary concepts about viruses.

Other information about viruses: Where are they found and what do they look like? When asked where viruses are found, 34% of students endorsed all of the places listed in the question (they were instructed to "check all that apply"). The following percentages of students endorsed each place:

96%	in animals
72%	in plants
57%	in soil
86%	in the air
58%	in the ocean
37%	other (please describe)

Of the students who indicated that viruses are found in other places, 7 students (6%) correctly maintained that viruses are ubiquitous, writing *"everywhere"* or *"anywhere."* Placing humans in a category separate from animals, 26 students (21%) wrote that viruses are found in *"humans," "us,"* or *"people."* Other places listed included *"dirty places," "public surfaces," "furniture," "water," "food,"* and *"tables."* A couple of students also listed *"computers"* as places viruses can be found. While this shows that students recognize that viruses are found in many places, it also shows that nearly two-thirds of the students surveyed don't grasp that viruses are constantly present everywhere around us.

The survey contained a series of four hand-drawn images, and students were asked to select which of them were viruses. These images are shown below, along with their correct identity and the percentage of students who endorsed each image as a virus.

	Bacteriophage Virus 79% correctly selected this as a virus. (21% did not select this as a virus.)
	Human Mammalian Cell 74% correctly did not select this as a virus. (26% selected this as a virus.)
	Bacterium 60% correctly did not select this as a virus. (40% selected this as a virus.)
	Human Immunodeficiency Virus (HIV) 53% correctly selected this as a virus. (47% did not select this as a virus.)

Twenty percent of the students not only correctly labeled the two viruses pictured, they selected just those two images as viruses. Another 19% endorsed the two viruses as well as one or both of the other images. Twenty students (16%) selected only the bacteriophage, while 10% selected only the HIV image as a virus. Half of the students incorrectly identified the cell and/or the bacterium as viruses.

When asked why they selected the images that they did, about one-third of the students indicated that they had "*learned it in science*" or had "*seen a picture of a virus in a science book.*" Virtually all the students who referenced learning about viruses in school endorsed the bacteriophage as a virus, so this image was familiar to many of them, but not all. However, most of the students who recognized the bacteriophage either failed to identify the HIV image as a virus or identified the other images as viruses, or both. Other explanations given by students for their selections included seeing them on "*a cartoon show [Jimmy Neutron]*" or "*in pictures.*" However, many students seemed to be guessing or were uncertain, giving explanations such as:

> *Because they look like something that could be a virus.* (chose cell, bacteriophage, and bacterium)
>
> *They look infected.* (chose HIV and bacteriophage)

Because they look like little things moving and floating around that's kinda what viruses are. (chose HIV and bacterium)

While a few students recognized the cell and did not choose that image ("*the second picture is a cell*"), others were clearly conflating the different microscopic images ("*they look like they'd be bad cells*" and "*because they look like unhealthy bacteria*").

Some students did try to apply what they knew about viruses in selecting the images and offered the following explanations:

I chose them because of the 'legs' or rather tentacles. (chose bacteriophage and bacterium)

Because it has all this different stuff inside. (chose HIV and bacterium)

I chose these ones because they are the virus that I think can enter the body. (chose HIV, bacteriophage, and bacterium)

It has tiny particles that look like it is attacking a cell. (chose HIV)

Because a virus can look like anything. (chose all images)

Other information about viruses: How can viruses be helpful? One important concept that some of the World of Viruses educational materials will highlight is that not all viruses are harmful, and that some play an essential role in ecological systems. To gain insight into students' current understanding of this concept, we asked, "How, if at all, can viruses be helpful?" Over one-quarter (28%) did not answer or indicated that they did not know. Another 10% said that they did not think that viruses could be helpful. However, the remaining responses fell into three general categories. The most frequently cited idea (27%) was that "good" viruses somehow counteract "bad" viruses, or that these "good" viruses fight disease or prevent illness. Some examples included:

They could counteract other viruses.

They fight other bad things that can harm us.

They can get rid of some sicknesses.

The second most frequently cited way that students thought viruses could be helpful was for use in vaccines or to "*strengthen the immune system*" (18% of responses), with comments that included "*they can sometimes be used in vaccines to prevent illnesses*." Finally, 13% of students thought that viruses may be used in research or medicine to develop cures for diseases *("they might be used to cure something maybe*." None of the responses made reference to anything about the possible regulatory role of viruses in ecological systems.

What is the current understanding among the target group with regard to human regulation of viruses? To address this third major evaluation question in a manner that students could understand and respond to, we asked them to explain how modern-day vaccinations help prevent disease. One-quarter of the students did not respond to this question. Another 6% mimicked the question in their response by stating that these shots prevent disease, with little additional information. Eleven percent responded simply by indicating that a vaccine contains medicine or something to help you, but provided no

real mechanism or process for disease prevention. Thirteen percent said a vaccine works to *"fight off"* or *"kill the virus"* or disease, while 7% said that vaccines *"block the virus"* or protect against disease. Thus, about 60% of students showed no understanding of how a vaccine helps prevent a virus from causing disease.

Almost 40% of students, however, did include some more relevant information about how vaccines work. Eighteen percent indicated that a vaccine includes a *"part of," "a little bit,"* or *"a weakened version"* of the virus. Over one-quarter (27%) mentioned that a vaccine somehow strengthens the immune system or helps the body build immunity to the virus. Thirteen percent said that the body learns to recognize a particular virus and responds by fighting it off, and 6% mentioned antibodies. Only 2%, however, put all those ideas together to articulate what this student did: *"They put a weaker version of the virus into your system, then let your defenses fight it and build an immunity to it."*

With respect to misconceptions about vaccines, a few students said that vaccines contain bacteria to fight against disease. Some of the students who mentioned antibodies said that vaccines *"create antibodies"* or actually *"contain antibodies."* A few students also described vaccines as being injected directly into the bloodstream. One student indicated that s/he did not believe vaccines help prevent disease.

What is the target group interested in learning about viruses? When asked what questions they would have for a virus expert, many students (64%) had questions about viruses that ranged across a variety of topics, and several students had multiple questions. Of the questions listed, over one-quarter (27%) were about the origin, survival, or fundamental functions of viruses. These were questions like:

What causes them?

Where do they come from? How do they spread?

How do viruses evolve into different types of virus?

How or where [does a] virus start?

One-fifth (22%) of the questions pertained to personal health and protection. These included:

How to avoid them.

Is it curable?

Will I get one? How can you tell?

How are they prevented?

Another group of questions (21%) focused on identification and categorization of viruses, including information about their appearance, how many types exist, and *"what is the worst virus?"* The last identified category of questions (19%) pertained to virus behavior and pathogenicity—how viruses make you sick—with questions such as:

What do viruses exactly do to a human's body?

How do they make you sick?

Does the same virus affect different people the same way?

How people get viruses.

Summary and Conclusions

Nearly all the students were able to generate at least one accurate piece of information about viruses. The majority of students responding to this survey had a basic grasp of viruses as disease agents, and most were also able to provide other specific information. Almost all students knew that viruses are found in animals and in the air, and over half agreed that viruses are found in plants, the ocean, and soil. One-third described viruses as attacking cells, and one-fifth mentioned the role of the immune system or white blood cells in fighting viruses. A much smaller number identified the need of a virus for a host, named specific viruses, and/or noted that viruses have their own genetic material.

Over three-quarters of the students correctly identified an image of a bacteriophage as a virus, and most indicated they had learned about bacteriophages at school. Half of the students correctly identified an image of HIV as a virus. However, half of the students incorrectly identified images of a cell and/or bacterium as viruses.

When asked how viruses could be helpful, 28% of students did not know and 10% did not believe that viruses could have a positive role. Of the remaining students, the most frequent response was about "good" viruses somehow counteracting or protecting us from "bad" viruses. The second most frequently cited way that viruses could be helpful was for use in vaccines or to strengthen the immune system. Finally, a smaller group of students thought that viruses could prove helpful in research for developing cures or other kinds of medicine.

When asked to explain how modern-day vaccinations help prevent disease, students' responses revealed a range of understanding. About 30% of the students did not respond or gave no meaningful response to this question. Another 30% indicated that a vaccine contains medicine, or works by killing, fighting off, or blocking the virus. However, nearly 40% of students did include more relevant information about how vaccines work. These responses reflected one or more of the following: that a vaccine includes a *"weakened version"* or *"part of"* the virus; that a vaccine strengthens the immune system; and that the body learns to recognize a particular virus and responds by fighting it off. Some students also mentioned antibodies. With respect to misconceptions about vaccines, some students said that vaccines themselves create or contain antibodies, and one student stated that s/he did not believe vaccines help prevent disease.

The last question on the survey asked students what they would ask a virus expert if they had the opportunity. Nearly two-thirds of the students had questions, and most of these fell into four major areas. Over one-quarter of the questions were about the origin, survival, or fundamental functions of viruses, such as *"where do they come from?", "how do they spread?",* or *"what causes them?"* Twenty-two percent of the questions pertained to personal health and protection, including how to avoid viruses and how to tell if you have one. The third area of interest focused on virus identification and

categorization, including information about their appearance, how many types exist, and what the worst virus in existence is. Finally, students also asked about virus behavior and pathogenicity, with questions like *"what do viruses exactly do to a human's body?"*

Overall, students' responses indicated an interest in and a familiarity with viruses. The vast majority were able to offer some relevant information about viruses, and a smaller subset displayed a basic understanding of what a virus is, how viruses cause disease, and how vaccines help to control them. A large proportion of these students, however, revealed significant gaps in knowledge of the primary concepts about viruses. Some misconceptions were also evident. The results of this survey illuminate both strengths and weaknesses in student understanding and should provide useful data to help in the design of educational materials for this population.

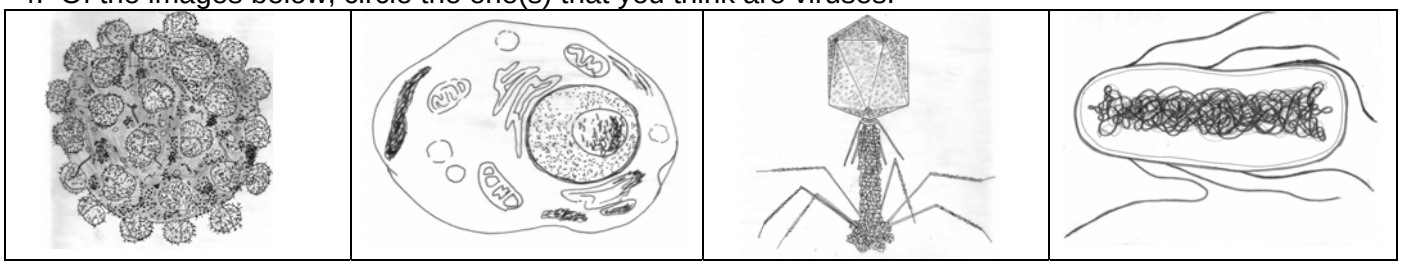
World of Viruses Survey

1. Where can viruses be found? (check all that apply)
   ___ in animals ___ in plants ___ in the soil
   ___ in the air ___ in the ocean ___ other (please describe):_____

2. Describe a virus (what is it and what does it do?).

3. How, if at all, can viruses be helpful?

4. Of the images below, circle the one(s) that you think are viruses.



5. Please explain why you chose the image(s) you circled.

6. How do viruses make you sick? Please explain your answer.

7. Describe, as best you can, how modern-day vaccinations help prevent disease.

8. What question(s) would you ask a virus expert to learn more about viruses?

<table>
<tr><td colspan="2">9. What is your age? _____ years</td><td colspan="3">10. What is your sex? Female Male</td></tr>
<tr><td colspan="2">11. Select the ethnic category with which you most closely identify:</td><td colspan="3">12. Select one or more racial category with which you most closely identify:</td></tr>
<tr><td rowspan="2">Hispanic or Latino</td><td rowspan="2">Not Hispanic or Latino</td><td colspan="2">White</td><td>Asian</td></tr>
<tr><td>American Indian or Alaska Native</td><td>Native Hawaiian or Other Pacific Islander</td><td>Black or African American</td></tr>
</table>