EXPLORING THE EFFECT OF SCIENCE "WONDER" VIDEOS

ON HIGH SCHOOL STUDENT ATTITUDES

IN SCIENCE

by

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ABSTRACT

Student attitudes toward science affect their engagement with required learning in STEM courses, future career choices, and basic science literacy. My study worked with high school students enrolled in two classes each of Chemistry 1 and Integrated Chemistry-Physics and looked at the effect of a regular weekly program of a short, “wonder” science video combined with a reflection journal to promote positive attitudes toward science and to develop student curiosity about science topics. Data was gathered through a variety of Likert-like surveys and written reflections about the videos. The results showed a definite increase in curiosity as evidenced by an increase in student-initiated questions and in positive responses to the surveys for both boys and girls in both classes but were especially strong for the girls. Additional effects included an increase in student discussion of science topics outside of class and an improvement in student perception of their ability to learn science. There was little observed effect on career plans as a result of this program. In conclusion, a regular program of weekly wonder science videos that present engaging science topics outside normal curricular topics is a minimally intrusive but effective way to increase student curiosity about science, to provide an opening for promoting and addressing student-initiated questions and to develop student science literacy.

INTRODUCTION AND BACKGROUND

Context of the Study

I teach at Cloverdale High School in a Midwestern rural public school district which had as of the school year 2018-2019, according to the Indiana DOE Compass website (n.d.), a student population of 359 students composed of White 93.3 %, Hispanic 1.7 %, multi-racial 4.7% and 0.3% black. There is a high rate of poverty with 41.8% of the students qualifying for free lunch and an additional 6.1% on reduced lunch. The school population includes 10.6% that are classified as requiring special education services but none that require ESL services. Cloverdale School Corporation's own website (2019) adds that approximately 31% of the population in our area have less than a high school education and about 26% of the households with children are single-family. In addition, the population is highly transient and in the course of the year about 20% of the students will move either in or out, transferring between districts or between school and homeschooling. Although the number is not published, within a given class, some students live with friends rather than with family or have been placed in foster care; a few are homeless or have relatives in jail. These social factors affect the students' ability to concentrate on academics and their interest in the subjects taught in school which they perceive as irrelevant to their lives.

The high school has two science teachers which limits the number and variety of courses that the school can offer. All students are required to take Biology 1 and either Integrated-Chemistry-Physics (ICP) or Chemistry 1 (CHEM 1). To get the third required science course for an academic diploma, students often take Biology 2 which is a dual-credit course taught by the biology teacher or Earth Science through the online PLATO platform. Some seniors are allowed to take Anatomy & Physiology and a very few of the advanced students have the math skills and interest to take Physics 1. Faced with the limitations imposed by the reality of state-mandated course requirements, the limited resources of the school in which I taught, and the needs of my students who themselves sometimes had little family support for education, I felt frustrated. How could I introduce my students to a wider range of science disciplines than what the school could offer as official courses? How could I create an excitement for science and kindle curiosity in the students that might prompt them to explore further on their own? How could I create a classroom where students felt free to ask questions and get answers about science topics of personal interest that were not related to the curriculum? Was there any way to tackle and turn around the students who declared, “I hate science!” And finally, was there something I could do to keep my own excitement for science alive so as to prevent burnout as I taught the same material year after year, often to students that made it clear they didn’t want to be in my class?

I already used short videos in my teaching to show experiments that were too hazardous for the classroom, to provide animated versions of concepts, or to act as “field trips” to places that we were unable to visit in person. Yet I often came across a science video that struck me as engaging such as “Secrets of the Snowy Owl” or showcased some fascinating research such as “How Do Ducks Hear?” but was outside our regular curricular topics. Since student reponses to my first-day questionnaires had indicated that they enjoyed watching videos, I decided to introduce the idea of a “Wonder Wednesday” in which we would watch a video for the sheer enjoyment of it. After doing this for one year with my CHEM I classes with good results, I expanded the idea to include my ICP students as well with a matching "Fun Friday" program. To measure the real effect of these videos with hard data, I decided to make it the subject of a classroom research project based on the action research model.

Recent articles in the high school level journal of the National Science Teaching Association had focused on how to promote interest and engagement in science among students (Mackenzie, 2019; Schatz, 2019) so I knew this was a topic that would interest a wide range of teachers if it was found to be successful to improve attitudes. In fact, in her editorial, Mackenzie speaks of "wonder" as a driver of science learning.

> We are all used to Googling our "I wonder" questions. But how many "I wonder" questions are your students posing each class period? If the answer is few, then what can you do to foster more questions, inquiries and curiosity? After all, aren't these attributes what drive the scientific process forward? (p. 6)

Although much research indicates that the early years are critical for developing lifelong interests in science (Schatz, 2019, p. 11), I hoped that my research would indicate that the window was still open to influence student attitudes, even into the high school years.

Focus Question

The focus question for this study was, What is the effect of showing a weekly short "wonder" science video on student attitudes in science?

Sub-questions included the following:

1. What is the effect on students' enjoyment of class and on their desire to take more advanced science courses?
2. What is the effect on students' curiosity about the science topics highlighted in the videos and on their initiating discussions on science topics of personal interest?
3. What is the effect on student career interests?
4. How do the videos affect the overall use of class time?
5. How do the videos affect my interactions with the students?

CONCEPTUAL FRAMEWORK

The Importance of Student Attitudes Toward Science

Numerous reports, articles, and researchers have called attention with growing concern to the projected discrepancy between the number of openings in STEM careers versus the number of students training for these positions (Tai, Liu, Maltese, & Fan, 2006; Wyss, Heulskamp, & Siebert, 2012). In addition, Swarat, Ortony, and Revelle (2012) point out that “a genuine interest in science is not only an obvious prerequisite for a career as a scientist, but also a necessary component of science literacy” (p. 515) such that students lacking an interest in science will be unable to deal knowledgeably or intelligently with science-related issues which affect them. Instead, they will be the prey of others who manipulate their ideas and opinions for political or financial gain.

Osborne, Simon and Collins (2003), working in the UK, investigated student attitudes towards studying science in order to better understand what influenced their formation and how they impacted subject choice in their education pathway. Their first step was to draw a distinction between “attitudes towards science” which are the feelings, beliefs, and values held about some aspect of science and “scientific attitudes” which are the questioning approach, search for data and patterns, respect for logic and evidence, and a longing to know and understand that are characteristic of “the scientific method” and the object of the new NGSS framework for teaching science. The more difficult second step was to tease apart the many subcomponents and specific factors that influence the more general “attitude toward science.” These include gender, societal stereotypes and cultural attitudes, classroom/teacher interactions, curriculum variables including how the science is taught (e.g. through lectures, Socratic discourse, inquiry labs), perceived difficulty of a course, prior achievement in science courses, and self-image in relation to science. Each of these has been the subject of numerous studies and interventions.

Operating under this same idea, that interest and attitude toward science are crucial factors in leading students toward STEM careers, Potvin and Hasni (2014) built on the work of Osborne et al. by reviewing 228 educational research articles published in English between 2000 and 2014 to summarize and synthesize their findings on the topic of interest, motivation, and attitude. Part of their findings was to note the heavy reliance on questionnaires for information with very little data obtained from other sources. They found that declines in positive interest and attitudes were linked to many variables including self-efficacy, lack of context/connection with real-world issues, and years in school. Proposals were made to provide contact with real scientists, increase inquiry-based learning, and add novelty.

Previous Research on Interventions That Influence Attitudes

These proposals mirror the three main themes that emerge from any survey of the underlying premise of studies using interventions to increase student interest in and respect for science. The first research theme focuses on incorporating more inquiry learning in order to give students a sense of themselves acting as scientists as they engage in directing their own research. The most advanced form of this type of intervention is to create space for a “genius hour” which allows students to design and carry out a project from start to finish based on a personal interest (Reuer, 2017). A second theme works to introduce students to real scientists either through guest speakers (Hopwood, 2012; Ward, 2011), internships (Thompson-King, 2014), or video interviews (Wyss et al., 2012). The third theme focuses on creating a sense of wonder to kindle or rekindle a child's innate curiosity (Carson, 1956; Hadzigeorgiou, 2011; Milne, 2010; Silverman, 1989). The simplest intervention of this type can take the form of using exciting demonstrations before teaching a lesson (Sherburn, 2012). More complex interventions can involve changing the teaching style to more frequently incorporate creative exploration during lessons or to consciously present science content within a context calculated to evoke wonder such as using discrepant events or phenomena (Hadzigeorgiou, 2011). Perhaps it is the teaching of science through the presentation of sterile, predetermined facts and formulas that is responsible for discouraging and dampening that innate sense of wonder.

Looking specifically at the potential for videos to influence behavior and beliefs of students, one finds several promising lines of research. As part of Bandura's work to investigate the effect of role models on children's behavior, he did a series of studies. One study compared student behavior after watching a live person doing a certain aggressive action, a video of the same person doing that action, and finally a cartoon version of the action (Bandura, Ross, & Ross, 1963). They found that all three were sufficient to elicit the action from the child given a similar setting and an initial level of frustration to "prime the pump" for provoking an aggressive act.

Although Bandura's group was studying the transmission of behavior for aggression, this study did provide evidence that students could learn behavior from videos as well as from live people. As an outgrowth of this, Ryan and Steinke (2010) investigated how the portrayal of scientists in various television shows affected middle school students' perception of scientists and whether particular aspects promoted their "wishful identification" with the character. These and other research studies (Wyss et al., 2012) support the idea that a video of a scientist may be effective to create a personal link between a student and a scientist even though he/she is not directly present in the room.

Several studies indicate that student opinions and attitudes toward science are malleable and can be changed, even during their high school years (Aschbacher, Li, & Roth, 2009; Hulleman & Harackiewicz, 2009). High school is a crucial time in a student's life for if he/she fails to take the courses required as prerequisites for a science major, valuable time will be lost in taking remedial courses in college if it is even possible to do so (Tsu et al., 2006). Although there are many factors that influence a student's interest in science and a desire for a science career, evoking the emotion of wonder can be a powerful help to increase the innate desire to learn (Carson, 1956). This classroom research project combines these two threads by using videos to both create a sense of wonder around some aspect of science and to provide an opportunity for students to take a "field trip" to meet and engage with a scientist and his/her research.

METHODOLOGY

Demographics

My research sample originally consisted of a total of 68 students of which 33 students were from CHEM 1 classes and 35 students were from ICP classes. Both classes were about evenly split between boys and girls and were primarily (over 90%) Caucasian. Most students were in the sophomore class. Roughly half of each group was on reduced or free lunch status. The demographics of these classes are shown in Figure 1.

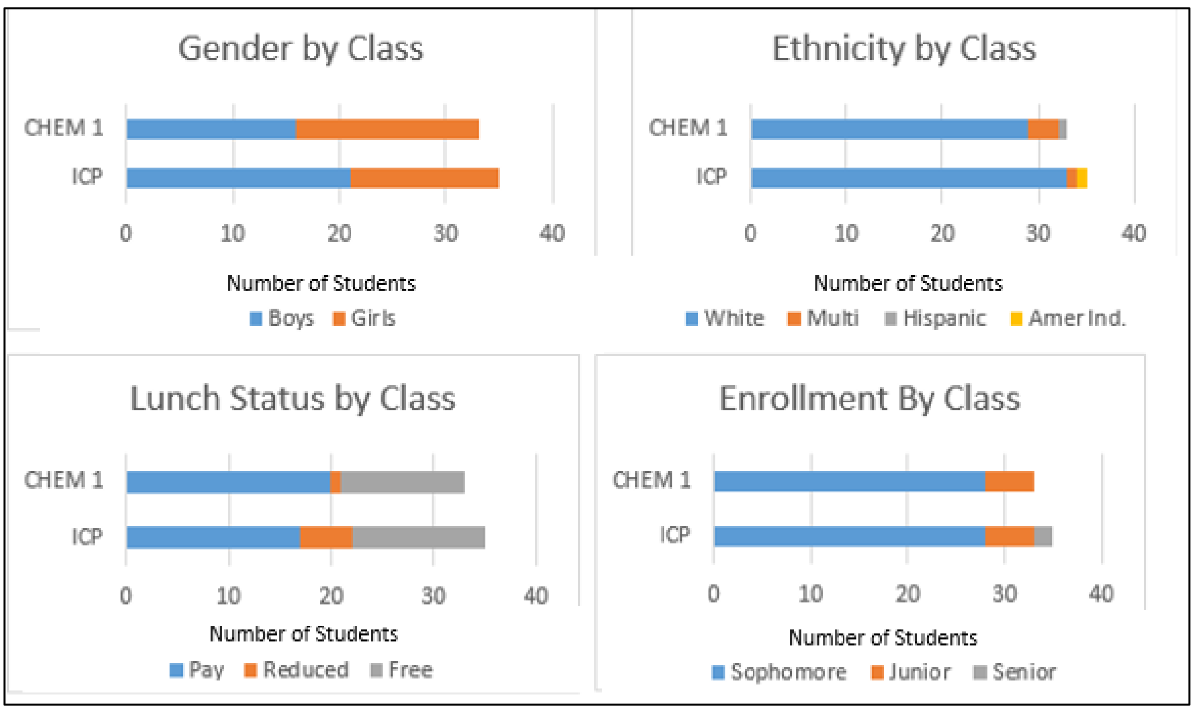


Figure 1. Demographics of student sample by class.

Treatment

In line with my belief that creating a sense of wonder would influence student attitudes toward science and that videos would be an effective means of engaging students and bringing students into contact with scientists, I developed a list of videos that explored various questions that required science to answer or that highlighted some intriguing scientific research. The first part of my treatment consisted of showing a short (about 5-8 minutes long) video once a week to my CHEM 1 (33 students) and ICP (35 students) classes over the course of 20 weeks. The classes watched the same videos in the same order but not on the same day: CHEM I students had a midweek "Wonder Wednesday" and ICP students had an end-of-the week "Fun Friday." When the school schedule did not allow for this routine, the video was shown a different day.

The videos were chosen primarily from among those produced by NPR (Skunk Bear), the NYTimes, PBS/NOVA (What the Physics, NOVA Wonders, I Contain Multitudes, The Secret Life of Scientists and Engineers), Nature Video, and TED-ed. They explored topics in biology, geology, chemistry, physics, engineering, and environmental science that are not covered in any of our classes but that I believed would intrigue the students. A list of the videos that were shown is given in Table 1. The URLs for each video are given in Appendix A.

Table 1. List of "wonder" videos for treatment period.

Title	Source	Subject
Why Microwaved Grapes Explode	NYTimes science video	Physics
Whose Bones Are These?	NPR's Skunk Bear	Anthropology, Forensics
Chris Hadfield: Space Oddity	NOVA: Secret Life of Scientists and Engineers	Space Science
Insect-Sized Robot Takes Flight-RoboBee X-Wing	Nature Video	Engineering
Can Apes Really Talk to Humans?	NPR's Skunk Bear	Biology, Anthropology
Lava Affair	NPR's Skunk Bear	Geology, Art
Secrets of the Snowy Owl	NPR's Skunk Bear	Biology, Env. Sci.
What Ducks Hear Underwater	NYTimes science	Biology, Physics
How Birds Get Oxygen Inside Their Eggs	NPR's Skunk Bear	Human and Animal Biology
The Animals of Chernobyl	NYTimes Science Video	Biology, Physics
How Do Pregnancy Tests Work?	TED-Ed	Human Biology, Chemistry
5 of the Biggest Puzzles of the Universe	NOVA: What the Physics	Physics, Astronomy
Invention of Warfarin	Nature.video	Biology, Medicine
Bringing a Fossil to Life: Reverse Engineering	Nature Video	Geology, Paleontology, Movie Making
Whale Songs	NOVA PBS video	Biology
Fecal Microbiota Transplants	PBS: I Contain Multitudes	Biology, Medicine
Human-Powered Helicopter	NPR's Skunk Bear	Engineering
Saving the Island Fox	NPR's Skunk Bear	Biology, Env. Sci.
Buildings and Earthquakes	IRIS Earthquake Science	Geology, Engineering
The Tragedy of Thalidomide	NYTimes Retroreport	Biology, Medicine

To promote deeper engagement in the video, the treatment included a companion writing assignment in a personal reflection journal for each video. The framework for this written reflection is shown in Figure 2 and was inspired by the Wonder-Full exercise developed by B. Kingore (2001, p. 92) for gifted students.

Date ____________ Title/Subject of Video: ___________________

1. What was new to you or surprised you in this video?

   ____

2. Was this video interesting for you? Why or why not?

   ____

3. What is something that you will remember from this video?

   ____

4. Could you imagine yourself doing this kind of work/research?

   ____

5. What question would you like to ask the person in this video?

   ____

6. Finish one or more of the following sentences:

- I wonder how ______________________________________
- I wonder if ____
- I wonder what ______________________________________
- I wonder why _______________________________________
- I wonder ____

Figure 2. Sample page from "Wonder Wednesday" video reflection journal.

The period allotted to written reflection was also open to students to exchange comments, questions, or personal experiences related to the video with each other or with me and to pose questions about some science topic about which they were curious. During these interactions focusing on student-initiated questions about the video or any other topic of their curiosity, I would provide, as called for, additional information by drawing diagrams, explaining a more advanced concept, or providing a quick internet search and projecting the answer on the smartboard. Sometimes I could provide personal knowledge of the work being shown in the video or would share my own questions about the topic.

The final aspect of the treatment program was a career research project given at the midpoint of the treatment (in January). The project asked students to investigate two out of five science-related careers that interested them from among those presented on https://www.sciencebuddies.org . After this first superficial examination, they were to choose one in particular that they would then research more deeply in order to create an illustrated report for the class. The presentation would introduce the entire class to that career, how to train for it, a typical day in that profession, and the benefits of working in that field. The careers available spanned classical "scientist" careers such as chemist as well as those that required scientific knowledge but were not generally thought of as science related such as diver, pilot, and welder. In this way, students were introduced to the daily life of a person working in a wide range of science careers, discovered uses of science beyond those that they recognized, and could follow wherever their curiosity led them. The instructions for the science career project are included as Appendix B.

Data Collection and Analysis Strategies

Since I was focusing on how attitudes were changing rather than grades, I understood that my data would be primarily subjective rather than objective. Although degrees of agreement could be quantified and compared, opinions were not inherently numerical as would be "number of correct answers" on a quiz or "minutes engaged" in an activity. I therefore envisioned my study as primarily being an example of qualitative research with only a minor component suitable for quantitative analysis and I developed my instruments accordingly. Thus, when planning my data analysis strategies based on a qualitative research design, I worked to provide myself with data from a number of different sources and types of instruments to counterbalance any bias that would be introduced due to the self-reporting nature of surveys.

Instrumentation

A variety of Likert-type surveys were used to determine initial student interests and attitudes and to measure changes subsequent to the treatment that could be analyzed both qualitatively and quantitatively. Although each survey was developed independently and targeted a different aspect of my research questions, there was some overlap to provide for triangulation and to increase confidence in the results. Entries in the student journals and from a corresponding teacher journal also provided a source of qualitative data on attitudes and interests. A summary of the different sources of data used is shown below in Table 2.

Table 2. Triangulation of data sources.

Research Question "What is the effect of the wonder videos on…."	Hoffmann Attitude Survey	CLASS Survey	Wonder Video Rating Survey	Student Wonder Journal Entries	Teacher Journal Entries	Post-Career Project Report
#1: Students' enjoyment of science class & desire for more courses	X	X		X	X	
#2: Students' curiosity	X	X	X	X	X	
#3: Student career interests	X			X		X
#4: Use of class time					X	
#5: Teacher-student interactions					X	

The primary and foundational survey was the Hoffmann Attitude Survey. After researching how to construct an instrument suitable for gathering data on student attitudes (Hopwood, 2012; Lovelace & Brickman, 2013; Moneim, Hassan & Shrigley, 1984; Patten, 2001; Thompson-Krug, 2014), I developed the Hoffmann Attitude Survey composed of 14 Likert-type questions of which 6 requested further explanation. In order to increase validity, several of the questions addressed the same idea but were inverted such that agreement with one would correspond to disagreement with a second.

The questions explored student attitudes toward the class they were taking, learning from videos, talking with a scientist, and taking science courses in college. Other questions asked if their parents showed interest in their science studies and if they ever tried to investigate a science topic on their own. The post-treatment version of the survey changed the wording of several questions to specifically ask about the effect of the wonder videos. For example, the original version "Sometimes I talk to my parents or friends about something I have seen or learned about in science class" was changed to "Sometimes I talk to my parents or friends about something I have seen or learned about in one of the wonder science videos." The post-treatment survey also asked the students to identify what science course, if any, they would be taking next year and to evaluate whether the wonder science videos had influenced their decision on whether or not to take a science course the next year and/or their choice of science course. The full text for both the pre and post-treatment questionnaires are included as Appendix C.

A second Likert-type survey, the Colorado Learning About Science Survey (CLASS) was used to measure changes in student attitudes and beliefs about learning chemistry (for my CHEM 1 students) and physics (for my ICP students) and to compare them to norms established by the responses of experts in the field. The CLASS surveys are taken from https://www.colorado.edu/sei/class. This survey was administered in identical form before and after the treatment period. The CLASS survey had the advantage of having been validated with a sample of over 2400 students (Adams, Perkins, Dubson, Finkelstein, & Wieman, 2005) and analyzed for the correspondence between student beliefs about science with their interest in it (Perkins, Adams, Pollock, Finkelstein, & Wieman, 2005) and with their future choice of a science major (Perkins & Gratny, 2010).

My third survey was a simple list of the videos that had been watched to date combined with a 5 point (1=Great!, 2=Good, 3=It was OK, 4=Not much, 5=Not at all) rating scale for each video and a line to record one detail or fact remembered from the video. Students were permitted to write “I don’t remember” or “Absent” for any given video if either was the case. At the end, students were asked to give their top three choices out of the 9 or 10 videos watched during the past two months and to explain their choice in a sentence or two. A fourth survey asked students to rate their interest in the career they chose for their project and what had influenced them to choose it.

In addition to the surveys, student reflection journals provided a written record of student thinking about the videos. Since I also desired to see how the videos were affecting me and my interactions with the students, I kept a parallel teacher journal that recorded the total time used for the video break along with my reasons for having chosen the video, my observations of student attention during the video, student-initiated questions and my own behavior and comments made after the video and a summary of my overall impression of the interaction. In addition to recording data on my own feelings about the videos and the subsequent interactions in order to answer my research question #5, the teacher journal provided a back-up record of student engagement and response to the videos that could be compared to their own self-reported interest in them. A sample page of the guiding questions used in the teacher journal is shown in Figure 3.

This Week's Video

1. Date: ____________________________

2. Title of Video: ____

3. Why I chose this video: ___________________________________

4. Length of video: ____

Individual Class Notes for Each Showing

5. Time at start of introduction of video: _________________________

6. Notes on student engagement during the video__________________

7. Any comments I initiated during or directly after the video? _______

8. Any questions asked or comments made by students? ___________

9. My response to each of the above? __________________________

10. Time at which switch was made back to regular classwork? ______

11. My feelings about today's interactions in this class?

____

12. Additional thoughts about this showing?

____

End-of Day Reflections

What went well with today's video?

____

What improvements or follow-up could I make?

____

Additional thoughts for Action Research project:

____

Figure 3. Sample page from teacher video reflection journal.

The research methodology for this project received an exemption by Montana State University's Institutional Review Board (Appendix D) and compliance for working with human subjects was maintained throughout the course of the study.

Analysis Strategies

Despite the fact that the Likert-type surveys I used provided numerical data, the fact that they were measuring attitudes, relied on self-reporting, and were obtained from a relatively small number of students made me believe that my data would be more appropriate for qualitative analysis than for quantitative. Therefore, I followed the general procedure of classifying a response as positive vs negative, tabulating them in order to derive percentages of favorable vs unfavorable responses and then comparing the data from before or after the treatment. This is characteristic of the strategy known as "content analysis." I also used "discourse analysis" to look for themes and commonalities as I read through the student entries in their journals and their explanations to the open-ended questions on the surveys. All data from the Hoffmann Attitude Survey and the CLASS survey was coded and entered into an EXCEL program for easier manipulation. The data was then analyzed in both aggregated form and by matching individual students' before and after responses. In accordance with analyzing the data using qualitative strategies, the data was presented in the form of bar graphs rather than line graphs.

There were several specific issues that I needed to deal with before analyzing the data and attempting to draw conclusions. The first was to obtain evidence to support the validity of the Hoffmann Attitude Survey that I had developed. The CLASS survey had already been validated by research studies. The second was to determine criteria for rejecting certain surveys as invalid, that is, surveys in which the respondent seemed to be making choices haphazardly or jokingly rather than as a reflection of their actual beliefs and attitudes. A third issue I examined was to discern what groupings for aggregated data would be most useful and accurate indicators of the effect of the treatment.

To test for the internal validity of the Hoffmann Attitude Survey, I examined the responses from the pre-treatment survey results and compared the choices made for the statement used for Q1: “I look forward to coming to this class” to those for Q2: “I would take this class even if it were not required” and found that they were consistent for both positive and negative responses (Figure 4).

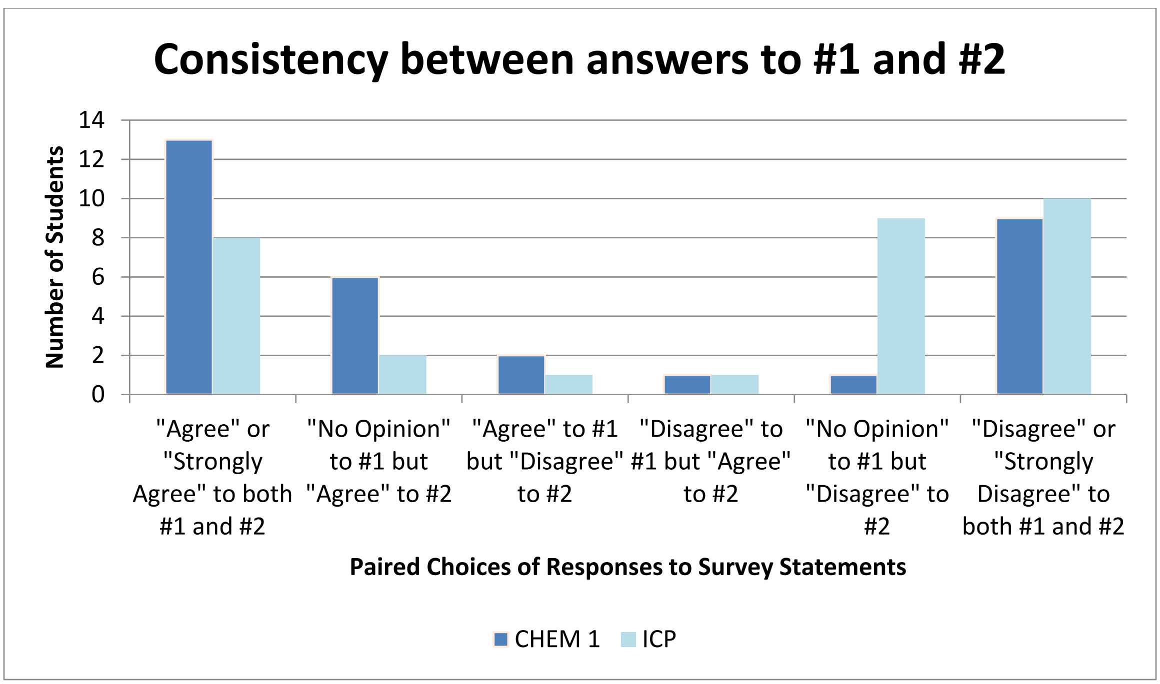


Figure 4. Validity test for Hoffmann Attitude Survey.

Determining criteria for recognizing invalid surveys was made easier in that the CLASS survey came with a statement that required a specific response. Students who failed to give that response showed that they were not actually reading the statements and therefore were giving invalid responses. In the Hoffmann Attitude Survey, responses to the statement #5, “Science videos bore me” were compared with those to statement #8, “I prefer to read about something instead of watching a video about it” and to #10, “I learn new things from watching videos.” The last two statements also asked for explanations. If the answers to the three statements were inconsistent without a logical explanation given, the survey was ruled invalid. Three students submitted surveys with the same answer for every single statement and were discarded. After further explanation of the purpose of the study and that there would be no consequence for “negative” answers, two of them redid their surveys and were able to be part of the sample. The criteria for rejection of the video rating survey was that if the student said they didn’t remember any of the videos individually yet gave a rating of the “best” at the end or if they used the rating code to form a word that was a class joke (“DAB”), the survey was rejected as invalid.

The final issue I examined was what grouping would be most meaningful when aggregating data for analysis. I had expected that I would need to analyze the data from CHEM I students separately from that coming from the ICP students because of the differences in the academic abilities of the students who took each class, which is reflected in their grades shown in Figure 5.

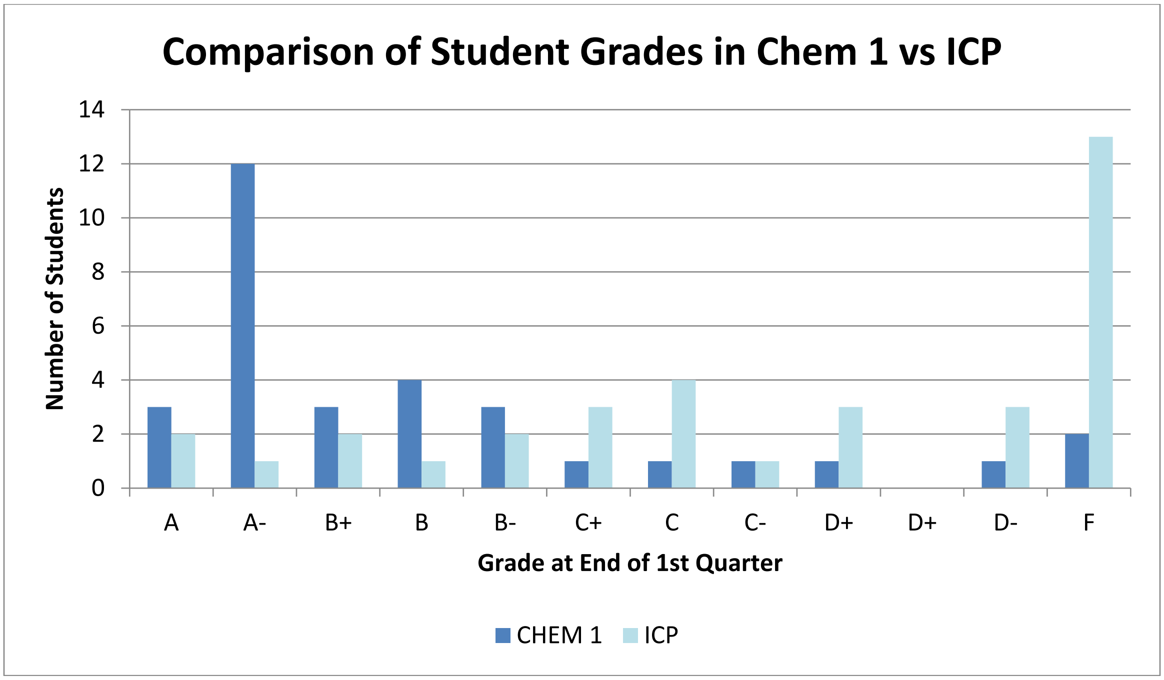


Figure 5. Comparison of grades for students in Chemistry 1 vs ICP classes.

There were also significant differences in their initial attitudes. Whereas a number of CHEM 1 students wrote in their free-response that, "I am interested in science," several students in ICP openly declared verbally and on their surveys that, "I hate science."

As expected, there were significant differences between the responses of the students coming from the two different classes. However, I discovered that differences in gender also correlated with differences in response which would have been hidden if I had only analyzed the aggregated data for each class. For example, Figure 6 shows that when asked to respond to the statement "I look forward to coming to this class," the aggregated data indicated that there were students in both classes who gave a negative response (bottom bar). However, this similarity masked the fact that the negative responses in the CHEM 1 data were primarily due to girls (top bar) whereas the negative responses in the ICP data was primarily due to boys (middle bar).

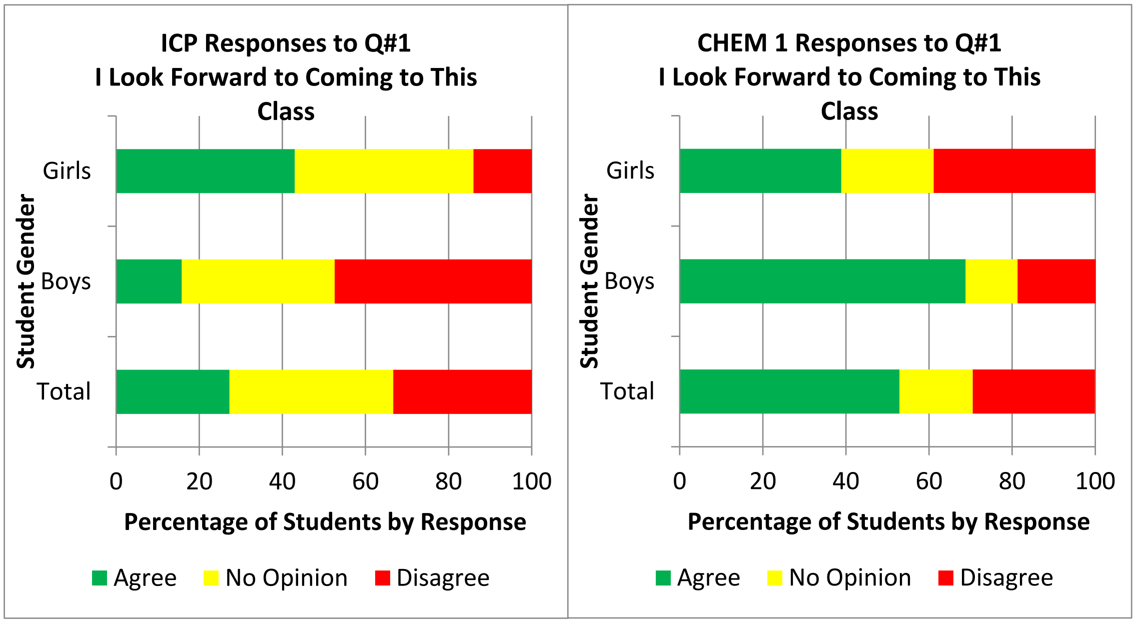


Figure 6. Responses to Q#1 broken down by class and gender.

This finding was in line with numerous research studies that had found that gender plays a significant role in attitude towards science (Osborne, Simon, & Collins, 2003; Potvin & Hosni, 2014). This confirmation between prior research findings and my initial analysis gave me confidence that this was an important distinction to make when aggregating data and drawing conclusions on the effects of my treatment.

DATA ANALYSIS

Analysis of Pre-Treatment Data

To establish a baseline against which I could measure change, I first grouped the questions in the Hoffmann Attitude Survey by theme and then looked at the aggregated data broken down by class and then by gender. For some themes, I was able to glean additional insights from the open-ended questions that helped clarify the reasoning behind the student's choice of his/her Likert response. The first theme (Q #1, 2, and 3) examined students' attitude toward class. As seen in the previous Figure 6, a greater percentage of CHEM 1 students looked forward to class than did ICP students. Yet, although only 27.3% of the ICP students had positive responses, 45.7% admitted that they were learning interesting things in class. This was also true for the CHEM 1 girls: 38.9% had negative attitudes toward class, yet 83.3% admitted learning interesting things.

The second theme (Q #5, 8, and 10) examined student attitudes toward videos. Overall, the answers were consistently positive with many students writing that they felt that videos helped them learn better, gave them a chance to "learn new things," and better matched their learning style because they were "kinesthetic" or "hands-on" learners. Although some of the girls in CHEM 1 (16.7%) and of the boys in ICP (38.1%) declared that videos were boring, one ICP boy explained why: "I get too sleepy watching videos."

The third group of questions (#11, 12, and 14) examined students' interest in taking additional science coursework in either high school or college. A majority of CHEM 1 students (52.9%) indicated that they would like to take science courses in college. In contrast, a similar majority of ICP students (51.4%) stated that they would not want to. Nevertheless, 38.9% of the CHEM 1 girls did not intend to take science courses in college vs 18.8% of the boys who would not. In ICP, 57.1% of the boys were not interested in such courses but only 42.9% of the girls felt that way. These differences may reflect the fact that the majority of the CHEM 1 students intend to go to college, whereas many of the ICP boys intend to go directly into the workforce. The higher approval for girls may reflect the interest of many of the ICP girls in entering a health-related profession such as nursing or child care.

The fourth theme used questions #4, 6, and 13 to get a sense of the students' level of curiosity about science topics outside of the class curriculum. As expected, CHEM 1 students showed more interest in finding out about new science discoveries (85.3%) than did ICP students (37.1%). But although both CHEM 1 boys and girls had high levels of curiosity (93.8% and 72.2% respectively), the percentages dropped considerably when asked if they pursued their interest and tried to find out more on their own. Only 50% of the boys agreed and 38.9% of the girls. Even in ICP with its supposed low level of interest, 57.1% of the girls indicated that they enjoyed finding out about new science discoveries although that lowered to 42.9% of those who tried to find out more.

This discrepancy between desire and follow-through indicates the importance of having the school itself provide opportunities for students to act on their curiosity by asking and getting answers to their questions and to be exposed to the cutting edge of science research because even when the interest is there, the students may not have the resources, the knowledge, or the encouragement to be able to explore it on their own. As an example, although many students indicated some interest in finding out what motivates scientists to do their work, with an ICP boy writing, “I think they could have some interesting stories,” there is a lack of access as well as misconceptions that hinder that interaction. A CHEM 1 girl wrote, “I wouldn’t understand what they say.” The videos provided a means to break down those barriers by allowing students to hear scientists with whom they would not normally interact speak about and show off their research in engaging ways that drew students in.

The fifth theme, which explored parental-student interactions around science class, revealed that many students did not get the reinforcement of parental interest in their studies. When asked if parents ever asked them about what they were learning in science class, only 32.4% of the CHEM 1 students and 20% of the ICP students agreed. A higher percentage of girls than boys recorded that parents asked about class (38.9% vs 25% in CHEM 1 and 35.8% vs 9.5% in ICP).

A number of student responses to the Hoffmann Attitude Survey revealed attitudes that would hinder learning if left unchanged. One CHEM 1 boy wrote, “I was always told that [a science course] was super hard” and one ICP boy who wrote that “I think science is a hoax.” Among the responses to the initial video shown to the ICP students, several wrote that the video was uninteresting because there was “just no point in it.” Although several students wrote that the video was interesting because “I’ve never seen anything like this,” many wrote as their questions “Why did they do this?” and some questioned “Is this real?” Since this was the very first wonder video they had seen, I regarded these comments as part of my baseline for pre-treatment attitudes.

The CLASS survey also grouped its questions by themes of which four had bearing on the questions I was researching:

- Do students feel a personal interest in connection with physics/chemistry?
- Do students see a connection between physics/chemistry and real life?
- Do students have confidence in their problem-solving skills in physics/chemistry?
- Do students feel that exerting the effort needed toward sense-making is worthwhile?

As with the results of the Hoffmann Attitude Survey, student responses of the CHEM 1 classes to the CLASS survey showed an overall favorable viewpoint of science including that more students agreed than disagreed that it was personally interesting, relevant to real life, able to be learned, and worth the effort to master. Again, it was found that there was a noticeable difference between the responses of boys vs girls, with the boys' percentage of agreement consistently higher than that of the girls.

The data for the students taking ICP were taken from a much smaller subgroup, since only 10 students submitted valid responses to both pre-treatment and post-treatment surveys so that they could be used for my study. Within this group, the percentages showed that very few of the students came in with favorable attitudes. Indeed, percentages for the girls were in single digits for statements reflecting personal interest and relevance to real life. Interestingly, the girls had higher percentages for confidence in their problem-solving skills and the value of effort than did the boys. The specific percentages of favorable responses to the CLASS survey themes, broken down by class and gender, are shown in Table 3 below.

Table 3. Science favorable responses to CLASS themes from pre-treatment data.

Theme	CHEM 1 Student Percentages			ICP Student Percentages		
	Overall	Boys	Girls	Overall	Boys	Girls
Personal Interest	46.4	54.2	40.6	20.4	33.3	4.2
Real-World Relevance	50.9	66.7	39.1	22.2	35	6.3
Problem-solving Confidence	54.4	68.8	43.8	25.0	20	31.3
Worth the Effort	56.3	59.3	54.2	22.2	17.1	28.6

Analysis of Post-Treatment Data

Whereas the pre-treatment data was limited to students' responses on the Hoffmann Attitude and the CLASS surveys, the post-treatment data came from a wider variety of sources including the student and teacher reflection journals, the video rating survey, and the career presentations and career survey responses resulting from the final research project. I began by analyzing the changes observed in the responses to the two surveys by comparing the pre- and post-treatment percentages of agreement with statements that reflected a positive attitude toward science. Subsequently, I analyzed the students' reflections recorded in their journals and by the open-ended questions used in the surveys so as to get confirmation for the changes and to find information on the underlying reasoning behind their attitudes.

Hoffmann Attitude and CLASS Surveys

Post-treatment responses to the Hoffmann Attitude Survey were again analyzed by groupings of questions that reflected general themes. A series of graphs were constructed that compared the responses given to the pre-treatment vs post-treatment administration of the survey. To clarify the interpretation of the results, agreement on each graph signified a positive attitude toward science rather than just an agreement with the statement as originally given. The data was graphed separately by class and was further broken down by separating the responses of boys vs girls. This is included as Appendix E.

Student attitudes toward class continued to be overall positive for the CHEM 1 students with little change. Nevertheless, there were changes for individuals that went unnoticed in the aggregated data. One girl's response to the statement, "I would take this class even if not required" went from "strongly disagree" to "agree" and another went from "agree" to "strongly agree." Similar to the pre-treatment survey, a greater percentage of students agreed that they were learning new things in class than looked forward to class overall.

In contrast to the relative stability of the CHEM 1 responses, the ICP surveys did show change. A seeming stability of overall score (28% → 30%) on the first statement, "I look forward to coming to class" was actually due to an increase in the percentage of boys agreement (16% → 26%) being wiped out by an almost equal decrease among the girls (43% → 36%). There was also a sizeable decrease across the board in students stating that they would take the class if it were not required for graduation. Nevertheless, the percentage of ICP students that felt they were learning new things in class increased from 46% to 58% overall and reflected increases for both the boys and the girls. One girl wrote, “Some things we watch, I had no clue about.”

In the area of the second theme, the CHEM 1 students had begun the treatment with high percentages of approval of the statements focusing on attitudes toward learning from science videos. These percentages increased for all three questions and for both boys and girls, reaching 100% approval among the boys for the statement, “I learn new things from watching the science wonder videos.” This positive attitude was reflected in the written comments that ran from “The videos were just fun to see,” (girl) to “I’ve seen things I didn’t know existed” (multiple students) and even “I do learn new things even if they don’t interest me” (boy).

ICP students had come in with less positive attitudes toward learning from videos, but the post-treatment survey showed that these had improved overall, often rising over 10 percentage points (39% → 48%, 67% → 79% and 48% → 76%). Specifically, both boys and girls increased their agreement with the statement, “I learn new things from watching science wonder videos.” The increases in the other statements were due to increases in the boys’ percentage of agreement that outweighed the decrease seen in the girls’ responses. This was meaningful in light of the continuing antipathy that a number of the students had to all things science, as evidenced by the comments of three boys who wrote, “I sleep during the videos,” “I forget about it [the wonder video] before I leave,” and “They don’t help me in life.”

CHEM 1 students showed an increased interest in taking advanced science courses or doing a research project to explore a topic from the wonder videos more fully.

It did not, however, change the percentage of students who planned to take science courses in college. Comparing individual answers showed that, in general, students who were only taking the course because it was required and not out of interest, did not change that opinion when planning for future courses in high school or college. Those who had shown an initial interest in taking more courses continued that interest with little change. An exception to this was a student who had originally written, “What I want to do after high school has nothing to do with science” to “I decided to take science next year because it will help me with college.” Interestingly, her career interest was in becoming an EMT or paramedic which she had originally not considered to be science-related. The agreement percentages of ICP students to these statements remained largely unchanged over the course of the treatment. As explained by one boy, “I just take what I’m required to.”

The fourth theme attempted to measure the students’ level of curiosity in science. The post-treatment survey responses showed that although the boys’ curiosity about new science discoveries seemed to decrease (94% → 81%), the girls’ curiosity had increased (67% → 72%). However, although boys increased their attempts to try to find out more on their own through their own efforts (50% → 56%), the increase for girls was even greater (39% to 67%). In addition, boys increased their interest in actually talking with a scientist about his/her research (38% → 50%). Among the ICP students, the percentages remained constant or increased slightly, with the only one exception – girls decreased their agreement with the statement “I like to find out about new science discoveries” (57% → 50%).

Finally, the data showed an increase for students of both classes for the fifth theme which explored the effect of the videos on discussions about things learned in class with parents and friends outside of class. This was particularly noticeable for the boys which had started out with lower scores than the girls. CHEM I boys' agreement that they sometimes talked about something seen or learned in class increased from 44% to 63% whereas CHEM 1 girls remained stable at 61%. For ICP students, boys' agreement increased from 11% to 21% and girls from 43% to 50%. Several students wrote detailed comments about the interactions. In CHEM 1, one boy wrote, "I asked my dad if he remembered anyone using thalidomide," another stated, "We talked about the earthquake ones," and a girl recorded "After class, I and my friends will chat about the video." There continued to be negative comments from some students such as an ICP boy who wrote, "No one cares – I talk about guns and bikes" and an ICP girl who recorded that, "I don't talk about science with anyone…I don't like science." Nevertheless, a number of students wrote of conversations about the videos: a girl wrote, "I told my parent about the poop pill," and a boy mentioned that he talked to his parents about "the fox one, and the cow blood clover thing too." One boy mentioned "My sister didn't think you could make lava," and one girl wrote, "I tell my mom about some things I learn" while another said, "If the topic is interesting, my friends and I usually discuss it after class."

The data from the CLASS surveys showed little change in personal interest for the CHEM 1 students who had come in with relatively high values, but showed a decrease among the boys in perception of relevance of the science class to the real-world. There was a noticeable increase in the confidence among the girls of their ability to solve a problem in chemistry but a decrease among the boys that the effort to make sense of chemistry was worth the effort required. On the ICP side, there can be less confidence in the results since the majority of CLASS surveys had to be discarded and the final sample only consisted of 10 students. Nevertheless, for those 10 whose surveys were able to be matched and compared, there were major changes between the pre- and post-treatment surveys, especially among the girls. The results mirrored those found through the Hoffmann Attitude Survey, with a marked increase in the agreement across all categories: personal interest (20.4% → 37.5%), perception of real-world relevance (22.2% → 40.6%), confidence in problem-solving skills (25% → 50%), and value of effort to make sense of the science topic (22.2% → 43.8%). The results for girls were particularly striking in the areas of personal interest agreement (4.2% → 31.3%) and real-world relevance (6.3% → 40.6%). The results for boys were equally striking in the areas of confidence in problem-solving skills (20% → 50%) and belief that the effort to understand content was worth it (17.1% → 41.1%). The values for all groups and categories is summarized in Table 4 below. Changes greater than 5 percentage points were indicated by an arrow showing increase (↑) or decrease (↓). A double arrow (↑↑) signified an increase of over 20 percentage points.

Table 4. Science favorable responses to CLASS themes from post-treatment data.

Theme	CHEM 1 Student Percentages			ICP Student Percentages		
	Overall	Boys	Girls	Overall	Boys	Girls
Personal Interest	46.6	56.9	39.2	37.5 ↑	43.8 ↑	31.3 ↑↑
Real-World Relevance	47.4	54.2 ↓	42.6	40.6 ↑	40.6 ↑	40.6 ↑↑
Problem-solving Confidence	62.9 ↑	66.7	60.3 ↑	50.0 ↑	50.0 ↑↑	50.0 ↑
Worth the Effort	53.3	53.7 ↓	52.9	43.8 ↑	41.1 ↑↑	46.4 ↑

Video Rating Surveys and Reflection Journals

I had not chosen the videos based on pre-assessment of student interests or request because I desired to enlarge their understanding of science and increase the range of their interests. Nevertheless, it was interesting to see the results of the surveys that rated the videos over each two-month period. As would be logical, students remembered videos that had been recently viewed better than those from the first weeks of the surveyed time period. Although my personal teacher reflection journal recorded that students in both CHEM 1 and ICP classes were highly engaged, calling out answers to the questions posed during the “5 Puzzles of the Universe” video and bragging to each other when they got one right, only 2 out of 27 ICP students recorded that they remembered it for the survey and only 7 out of the 30 CHEM 1 students who saw the video remembered it. This video had been shown 9 weeks before the survey was given. The percentages improved for the next video which was the story behind the creation of warfarin and for each subsequent video. There were seven videos included in the other rating survey and even the first one, "Insect-sized Robot Takes Flight – RoboBee X-Wing" had a high rate of being remembered (22 out of 27 ICP students and 24 out of 31 CHEM 1 students), leading me to believe that eight weeks is probably the limit for memory of a video without some further follow-up activity or reinforcement. Interestingly, several students remembered specific details of the video such as the fact that it used solar panels for energy and that it was difficult to make the wings light enough to carry it.

When rating videos, students in both classes correlated the ability to remember a video with whether it interested them or not. One CHEM 1 student wrote, "I remember them so they must have been interesting to me." This seemed to be confirmed by the fact that the two ICP students who remembered the "5 Puzzles" video not only remembered it but said that they liked it "a lot" and one considered it his favorite! Nevertheless, the notes that recorded what a student remembered of the video often did not correspond directly with the student's own impression of liking it. Some students gave detailed notes on videos that they rated as liking "Not much" or "Not at all" while others that they rated "Good" wrote "I don't remember" when asked for a detail. Another potential problem for the validity of the ratings is that there were several instances where one student showed off his/her choices to another student who then recopied it on their paper. I noticed this especially occurring in the ICP classes.

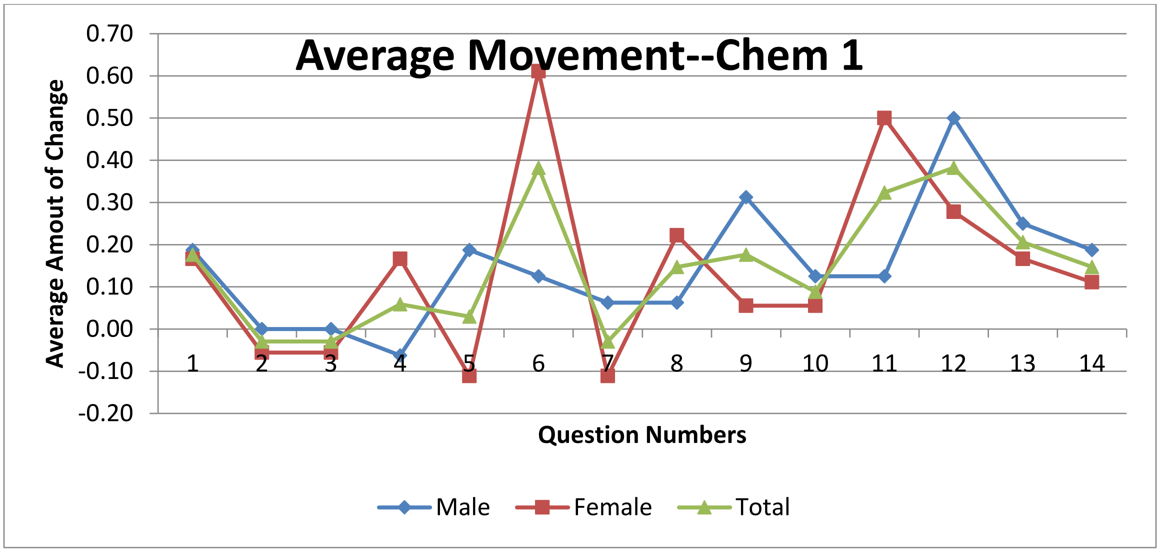
Because of the issues of memory differences between videos shown at the beginning and end of each survey period and the possibility of copying of choices between friends, I do not give much weight to the results. Nevertheless, tabulating the results showed that both CHEM 1 and ICP students preferred videos that featured animals (whales, Island foxes, duck, Snowy owls) as well as being impressed by the scientist who was able to make lava "at home" and the human-powered helicopter. One ICP girl wrote about the "Whale Songs" video that, "These videos were interesting to me because they weren't only about science" and a CHEM 1 girl wrote that, "I love how the real world can be so scientific. I would never think about those studies."

My teaching journal provided data on the time commitment required for the video program. The videos themselves varied in length from the shortest at 2:26 minutes for a NY Times science video to the longest at 12:08 minutes for a NYT RetroReport video. The SkunkBear videos from NPR were in the range of 7-8 minutes and the TedEd videos were shorter, between 3 and 5 minutes. The overall time for the video break varied with the length of the video and ranged from 6 minutes to 18 minutes with a mode value of 10 minutes.

CLAIM, EVIDENCE, AND REASONING

Claims for the Study

When responses were compared between the pre-treatment and post-treatment administrations of the Hoffmann Attitude Survey and the differences were graphed, as seen in Appendix E, it was clear there was no consistent pattern of change that applied to all questions, although overall, there was more movement in the positive direction than in the negative. Therefore, to clarify the amount of change per question and see which areas were most affected, a new series of graphs was prepared while keeping the breakdown by class and gender. These graphs, included here as Figure 7, map the average amount of change in attitude toward science where a positive value indicates a change toward more positive attitudes and a negative value indicates a change toward more negative attitudes. The spikes in the graphs directed my attention to changes in particular questions that I then correlated with my original research questions along with the data from my other sources.



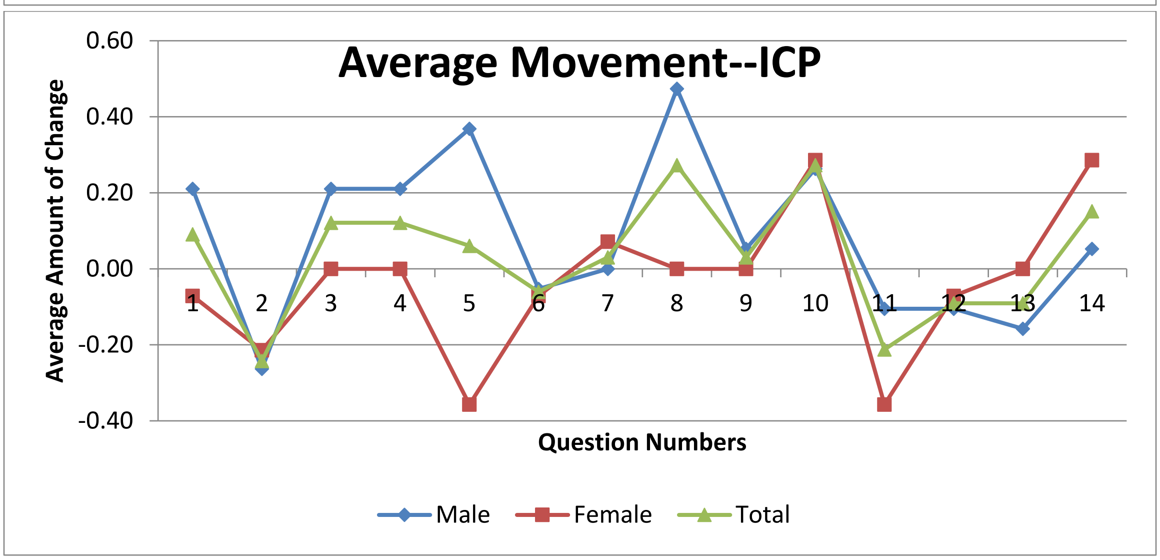


Figure 7. Average movement for change of responses to Hoffmann Attitude Survey.

For example, my first research question sought to explore the effect of the program of wonder videos on students' enjoyment of class and on their desire to take more advanced science courses. These are actually two different questions that may or may not be directly related. For the first, agreement with the first statement on the Hoffmann Attitude Survey that measured enjoyment of class showed an increase for CHEM 1 students and for ICP boys. The CLASS data showed an increase in personal interest in science for both ICP boys and girls and held fairly steady for CHEM 1 students who had come in with higher positive ratings in their preliminary responses.

The second part of the research question had looked for any effect of the wonder video program to increase interest in more advanced science courses. The evidence for this is less straightforward since there is limited availability of such courses at our school and most students concentrate on completing the required courses for graduation, leaving them with little extra time in their schedules. Nevertheless, I believe there is some evidence to say that it has had a positive effect. I was given the opportunity to teach AP Environmental Science next year and six students signed up for it, several of whom are current students. I will also be offering a class of Physics I and a dual-credit Chemistry II class next year and these also have students from my current classes that have enrolled, even though these courses are not required. Survey questions on the post-treatment version of the Hoffmann Attitude Survey found that 12% of the CHEM 1 students and 15% of the ICP students claimed that the videos influenced their desire to take additional coursework even though several went on to say that they were constrained in their choices by the graduation requirements. One CHEM 1 girl wrote in a reflection that, "It made me more interested in taking another chemistry class" and another, who had originally written that her future career had "nothing to do with science" later wrote, "I decided to take science next year because it will help me with college."

My second research question looked at the effect of the wonder videos on students' curiosity about the science topics highlighted in the videos and on their initiating discussions on science topics of personal interest. From the graphs shown in

Figure 7, it was clear that the treatment had different effects on the students in CHEM 1 versus those in ICP and different effects on the boys versus the girls. The most noticeable effects toward a positive change occurred for the CHEM 1 girls in the area of an increase in reported initiative to find out more about a science topic on their own. Another large spike was seen in an increase in desire to learn more about some of the topics seen in the wonder videos. I had hoped that an increase in curiosity would translate into an increase in enrollment in more science courses. Although most students said that their class choice was dictated by the school's requirements for graduation, the positive response for Q#14, especially noticeable for ICP girls, indicated that there were students who had increased their desire to take additional science classes and attributed it to having watched the wonder videos. This increased interest translated into the school administration allowing me to teach ACP Chemistry, a dual-credit course, concurrently instead of alternating with Physics 1 and to offer a new course in AP Environmental Science. This represents a significant increase in the offerings of our school's science department.

This initial impression of increased interest in science was corroborated by data from the journal responses. My own teaching journal recorded numerous instances of students asking a question to get more information about a science topic both immediately after a video and at unrelated times. I was especially struck by the fact that the discussions were sometimes initiated by students who had shown no prior interest in class but were now coming to me to get an answer to something science-related from outside of class.

Indeed, the same girl in CHEM 1 who had written in the survey that she did not like class, that science videos bored her, that she had no interest in taking science courses in college, and that she wouldn't ask a scientist a question because she wouldn't understand their answer, wrote in her video reflection journal that the video about the "RoboBee-X-Wing" was interesting because "I liked seeing them figure out a way to get it to work." Over and over, students from both classes wrote in their reflection journals that "I never knew this existed before" and a CHEM 1 girl mentioned, "It is rare that we talk about [this topic].

This increase in curiosity is also seen expressed in responses that indicated a greater willingness to undertake a research project and an increase in interactions with family and friends over topics of science discussed in class. Both of these improvements were seen especially in the CHEM 1 boys. Although CHEM 1 girls also increased their interest, neither group of ICP students saw this effect. The evidence seems to support the conclusion, therefore, that when the videos build on a pre-existing interest and academic confidence, students will move on to the next step of interest in doing actual research. When, however, there was little interest prior to the treatment, the videos do have a positive affect to begin to build a foundation of interest, which will be manifested in increased engagement in class and in questions, but not yet in increased interest in formal academic work, such as a research project. Evidence for this was seen in the increase in enjoyment of class for ICP students seen in the post-treatment responses from both the Hoffmann Attitude Survey and the CLASS survey.

My fifth question investigated the effect of the wonder video program on my interactions with the students. This was another area where the wonder videos seemed to have a strong positive effect, improving my interactions in two ways. First of all, it indicated to the students that I was open to discussions on any topic of science and that the class was not limited to material that was part of the required curriculum. My teacher journal recorded numerous occasions where a student question or comment based on the video we had just watched morphed into a whole conversation that opened up new areas of learning or explored some personal interest of the student. One girl stayed after class to ask about solar panels and the wildfires in California that she had heard about in the news. On another day, a student asked what "El Nino" was because he saw it written on the board from the notes left over from another class that I teach. A CHEM 1 boy started a conversation with me about whether dinosaurs had feathers because no one believed him when he talked about it at home. One ICP student wanted to know "Why don't people use the money they spent on this [to save the Island fox] to cure diseases like lung cancer?" which opened up a whole discussion on how and why different areas of science are funded.

Another aspect of the interactions sparked by the videos is that it often prompted me to share some aspect of my own background which made a personal connection between me and the students. For example, I was a graduate student at Columbia University during the time of one of the group of researchers highlighted in the video "Can Apes Really Talk to Humans" and I actually saw them carrying the young chimpanzee in a baby carrier on their chest as I entered an elevator. When students watched the video “Whose Bones Are These?”, I shared with them the skeleton we used in my Physical Anthropology college class that had also come to the US through the bone trade with India. All of these connections and personal reminiscences contributed to making me more approachable such that one girl was able to confide in me her interest in becoming an anthropologist and ask me for career advice.

My third question sought to discover what effect the treatment of wonder videos combined with a career project would have on student career interests In contrast to previous positive results for curiosity and interactions, the wonder videos seemed to have little overall effect on student choice of future career as self-reported through explicit questions on the post-treatment version of the Hoffmann Attitude Survey and on the Post-Career Project Report survey (Appendix F) given as a follow-up to the career project presentation. Although 12% of the CHEM 1 students and 15% of the ICP students agreed with the statement on the Hoffmann Attitude Survey that said watching a wonder video influenced their choice of whether or not to take a future science course, only two students checked that their choice of career for the project was influenced by a wonder video. Most students attributed their choice of career to the influence of a relative who worked in the field or to someone they met who talked with them individually about it. This seems to indicate that it is direct contact with someone in the field, most notably within the family, that most influences these students’ career choices. Indeed, a number of students, especially boys in ICP, plan to go into a family-run construction business. Nevertheless, one CHEM 1 girl did write in a reflection that, “These topics interest me….and I would probably try to have a job [in one of them].”

The length of time students reported being interested in their career varied; a few chose "since I was little" but most responses were split between "since high school" and "for several years." A number of students were influenced in their choices by the frequent contact with recruiters from the military or the opportunity to earn a certification through the school's vocational center (as a certified nurse assistant, welder, emergency medical technician, or as a programmer).

My fourth research question sought to find out how implementing a program of weekly videos would affect the overall use of class time. This is an important concern since many teachers have strict time constraints combined with a large amount of required curriculum to teach and have little room for extra activities. The investment of time required for a wonder video program in relation to its benefits in increased curiosity and interest was found to be minimal, even with the extra time allotted for writing in a reflection journal. The videos themselves lasted from just over 2 minutes (What Ducks Hear Underwater) to a little over 8 minutes (Secrets of the Snowy Owl). The one exception was the RetroReport video on thalidomide that was over 12 minutes long.

The total time that I spent on a video and writing period was usually 15 minutes and that included several areas in which my efficiency could be improved. I noticed that it was important to have the video preloaded and the smartboard ready since on several occasions I failed to do this, wasting time and allowing students to get distracted. I was not using any bellringers or morning work during this year, but set-up could be done during this type of introductory work period. My use of wonder videos also required more time than would normally be necessary because, for the sake of my research, I kept all the student journals in my cabinet when not in use. This required me to spend time handing them out after the video finished before the students could begin writing. On a few occasions, I did experiment with handing them out ahead of time but found this to be counterproductive. When given the journal at the start of the video, students would begin writing before the video was over so as to finish earlier and would no longer be engaged in watching it.

Value of the Study and Consideration for Future Research

The discrepancy between desire and follow-through seen in the pre-treatment data indicates the importance of having the school itself provide opportunities for students to act on their curiosity by asking and getting answers to their questions and to be exposed to the cutting edge of science research because even when the interest is there, the students may not have the resources, the knowledge, or the encouragement to be able to explore it on their own. As an example, although many students indicated some interest in finding out what motivates scientists to do their work, with an ICP boy writing, “I think they could have some interesting stories,” there is a lack of access as well as misconceptions that hinder that interaction. A CHEM 1 girl wrote, “I wouldn’t understand what they say.” The videos provided an easy means to break down those barriers and allow students to hear scientists with whom they would not normally interact speak about and show off their research in engaging ways that drew students in. Many students commented on an increase in their curiosity and desire to know more about topics they had encountered through the videos. A CHEM 1 boy wrote, “Some of the videos leave me with many questions,” and another wrote “It encouraged me to want to take science." A CHEM 1 girl wrote, "There are things I would not have thought to research."

Given the importance attached to parental input found by Ashbacker, Li, & Roth in their article, "Is Science Me?" (2009), the pre-treatment data results that showed very little interaction with parents over the learning done in science classes was alarming and again highlights the important role that a teacher plays in giving students opportunity, encouragement, and approval for student exploration of questions in science that explore personal interests or go beyond the required curriculum.

It was exciting to see that both the survey data and individual written comments gave evidence that students were bringing home and sharing things they had seen and learned about in the wonder videos. One CHEM 1 girl wrote, "When my mom asks me about my day sometimes I tell her about the videos we watch" and a girl in ICP wrote, "My parents ask me every day, 'What'd you learn at school' and I tell them about the videos." By discussing the videos with their parents, the students can receive validation that they are indeed learning something interesting and worthwhile.

Another area that has potential value is the increases seen in ICP students' confidence in their problem-solving ability and in their perception of the effort to learn being worthwhile as well as the increase in their interest and in their perception of the relevance of science to the real-world. It is unfortunate that the sample showing these effects was so small, since it came from the CLASS survey that only had 10 valid matches. Most ICP students were overwhelmed by the length of the survey (4 pages with 42 questions) and did not read it through. If these increases are significant, this would be very meaningful since I have found that when students complain that an assignment "is boring" or ask "When will I ever use this in real life?" it is usually a cover for the fact that they don't know how to do it. The complaining stops when they realize that they actually can do it.

It remains to be determined, however, what is the real cause of these effects. Are they the result of the videos because they are entertaining and thus engage student interest and they are easy to follow such that the students grow in confidence of their ability to understand science? Or, is it the case that some or all of these effects are actually due to the many months of teaching that they have received which increased their skills? I would like to pursue this research by developing a shorter version of the CLASS survey so that more students would be willing to read and answer it. In addition, I think it would be necessary to compare a class taught with the video treatment to a similar population and class taught without the videos so as to tease out what amount, if any, of the effect was simply due to my normal teaching style and class routine.

Given these benefits, I see this intervention of a regular program of wonder science videos as being a valuable tool for teachers in rural schools that lack the funding or resources to provide direct contact between students and working scientists. It is inexpensive, requires only a small investment of time, and pays large dividends in increased awareness of the value and interesting nature of science. It does not involve retraining teachers to use a different teaching style or require equipment beyond an internet connection and a projecting device such as a smartboard.

During the time of my treatment, I found that it was important to have a regular day of the week for the wonder video. When, on occasion, the videos were shown on an irregular basis because of conflicts with the greater school schedule, the momentum and some of the interest was lost. I did wonder, however, whether it was important to have a written journal in order to get the full effect of the videos. I am going to experiment next year with having the CHEM 1 students write in a shorter version that they keep themselves and by eliminating the reflection journal altogether for the ICP students and instead having them write and turn in one question each that we can discuss together. I have also wondered if reinforcing the videos with a follow-up research opportunity based on investigating one of the questions they wrote down for a video, perhaps for extra credit, would encourage some students to go even further and encourage them to engage even more deeply in science.

A final possibility for future research is based on my finding that memory of a video, without subsequent reinforcement, faded after about 6 weeks. This has bearing on much of our standard teaching which often involves somewhat disjointed units that are not revisited apart from review during preparation for semester finals and would argue for the need for periodic reinforcement of past teaching. Although such studies have probably been done in the past, it would be interesting to me to investigate the time frame required and the most effective activity to keep lessons within students' memory.

When I first envisioned making my wonder video program a subject for an action research project, I mentioned it to the superintendant of a neighboring district who was conducting a Leadership Academy training for our district at the time. He encouraged me to proceed and asked for the results when I finished. The recent articles in NSTA journals before mentioned (Mackenzie, A.H. 2019; Schatz, D. 2019) on the importance of creating a sense of wonder and promoting curiosity and openness to student-initiated questions show that there is interest in such an intervention. Thus I believe that my research is a first step to address that interest and can provide a useful tool to successfully promote curiosity, develop science literacy, and provide an openness to student-initiated questions.

Impact of Action Research on the Author

I have been aware all through this research study that the videos have improved my interactions with the students. They have allowed me to keep my teaching fresh, to give an outlet for my own curiosity, and to live out my self-concept of acting as a pollinator, that is, of bringing ideas from one subject area into the scope of learning of students in another area. As I prepare lessons for each of my classes, I run up into videos that strike me as fun and intriguing and many of them don't fit the standard model of the content assigned for each class. It pushes me to explore as one video leads me to another and then to even more resources. I grow in knowledge myself and I get excited at the chance to share these interests and discoveries with others.

As mentioned before, some of the videos allow me to share aspects of my own life experiences with the students, establishing the personal connection that is so important for building the trust that undergirds students' willingness to learn from a teacher. Research has shown that there is a relationship between teacher enthusiasm and student motivation (Patrick, Hisley, & Kempler, 2000) and that this relationship is reciprocal (Frenzel, Goetz, Lüdtke, Pekrun, & Sutton, 2009). Students respond to the enthusiasm of their teacher by becoming intrinsically motivated themselves but conversely, student enthusiasm can motivate a teacher and the lack in either direction can depress and discourage existing motivation of the other.

I have seen this relationship confirmed in my own interactions with the students. Student questions and expressions of interest motivate me to bring in even more interesting activities and lessons. When students have mocked, talked over, or ignored my attempts to interact with them and share something that has value to me, I begin to shut down, reverting to assignments of worksheets and the most basic, low-level lessons that minimize my own engagement with them. Thus, the benefits to the teacher of showing the wonder videos act to create a positive feedback loop as they promote the student curiosity that will, in turn, attract and encourage greater teacher interactions and build teacher enthusiasm which will then increase student motivation and so on.

When I undertook this study, I valued the video program I was developing because of how it allowed me to grow. I believed it would have value for the students but did not have any objective way to support my belief. By undertaking an action research project, I have not only gained evidence to support my use of wonder videos as part of my teaching, but I have also gained the knowledge of how to conduct and the confidence to undertake research on any teaching strategy that I might want to explore or test out.

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APPENDICES

APPENDIX A

SOURCE URLS FOR WONDER VIDEOS

Title	Source
Why Microwaved Grapes Explode	https://www.nytimes.com/video/science/100000006374883/why-microwaved-grapes-explode.html
Whose Bones Are These?	https://www.youtube.com/watch?v=PJ7A6Nw0My4
Chris Hadfield: Space Oddity	https://www.youtube.com/watch?v=XR5G5keqVt4
Insect-sized robot takes flight- RoboBee X-Wing	https://www.youtube.com/watch?v=loHzoeFP9Io
Can Apes Really Talk to Humans?	https://www.youtube.com/watch?v=uYWSXRUGxDQ
Lava Affair	https://www.youtube.com/watch?v=25tYMaB70AI&list=PLKqe_oheltic XwpJAc9ADbdnyG4HgHztq&index=4
Secrets of the Snowy Owl	https://www.youtube.com/watch?v=HXwrB216bgE
What ducks hear underwater	https://www.youtube.com/watch?v=FbCBrkzDFLQ
How birds get oxygen inside their eggs	https://www.youtube.com/watch?v=w-M33PtwtM4
The Animals of Chernobyl	https://www.youtube.com/watch?v=TG-nwQBBfmc
How do pregnancy tests work?	https://www.youtube.com/watch?v=aOfWTscU8YM
5 of the Biggest Puzzles of the Universe	https://www.youtube.com/watch?v=Hiu0Ahs-Ork
Invention of Warfarin	https://www.youtube.com/watch?v=OnzF0oJkYe0
Bringing a Fossil to Life: Reverse Engineering	https://www.youtube.com/watch?v=-Fz3JlGABrs
Whale Songs in the South Pacific	https://www.youtube.com/watch?v=P99CR4y-TYw
Fecal Microbiota Transplants	https://www.youtube.com/watch?v=ZZxRp-f3ElY&t=171s

Human-Powered Helicopter	https://www.youtube.com/watch?v=emK-qIbuJ-k&t=3s
Saving the Island Fox	https://www.youtube.com/watch?v=2AVRSGkartg&t=17s
Buildings and Earthquakes	https://www.youtube.com/watch?v=6IJ99phNArM
The Tragedy of Thalidomide	https://www.youtube.com/watch?v=41n3mDoVbvk

APPENDIX B

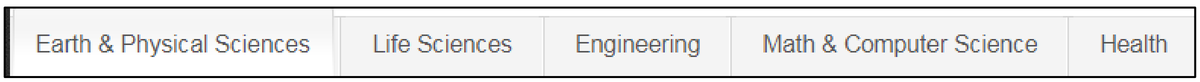
STUDENT INSTRUCTIONS FOR CAREERS IN SCIENCE PROJECT

Name ________________ ICP/ CHEM 1 Date ______

CAREERS in SCIENCE PROJECT

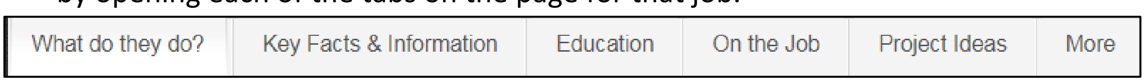
As you have seen in the Wonder Wednesday videos, there is a lot more to working in science than lab coats and test tubes although that is one potential path. Now take the time to explore one or more other paths you might follow to a career that makes use of science. Go to: https://www.sciencebuddies.org/science-engineering-careers

1. Click on each of the tabs and read through all the different job titles listed.



2. Pick five job titles that might interest you and list them below – they can all be from the same heading or from different headings.
   a. ____
   b. ____
   c. ____
   d. ____
   e. ____

3. Explore each of the five jobs. Click on the job and explore what this career is like by opening each of the tabs on the page for that job.



4. After looking at what they do and some key facts about the job, pick two that still interest you and record their titles below.
   a. ________________________________ b. ____________________________

5. Now, choose one of these two careers and prepare a Powerpoint or GoogleSlides report for yourself and the class. The report will include the following and should be heavily illustrated. You may also link to a short video about this career:
   a. Correct name of the career/vocation;

b. Job description – what does the person in that job do, where will you work in this job – in an office, a lab, or outside, will you work alone or in a team, etc.

c. Daily responsibilities and/or activities – Describe and illustrate "A Day in the Life of …."

d. Education required: Use a graphic organizer or arrows to show what happens after high school to get into this job. What major is necessary in college? Are advanced degrees also required or specialized training?

e. Investigate colleges that train for this job: Include three colleges – at least one should be in Indiana and at least one should be a public college (these can be the same or different).

f. Suggested high school classes that would prepare you for this job.

g. Pictures of a person working in this field/job.

h. Read about suggestions under the Projects tab. Provide a description of a project that you could do in class or at home that relates to this career.

NOTE: At some point in your presentation, explain what attracted you to this field or position. You may do this verbally when presenting your project or include it in a slide.

LAST BUT NOT LEAST!-- Make sure to "Share" your report with me so that we can project it in class.

APPENDIX C

HOFFMANN ATTITUDE SURVEY QUESTIONS

Pre-Treatment Version

Participation in this research is voluntary and participation or non-participation will not affect a student's grades or class standing in any way.

Name ____________________________

DIRECTIONS: Read each statement below. Then circle the response to show how you agree or disagree with it. Some statements are followed by a request to explain your answer.
EXAMPLE: Answers by Mrs. Hoffmann

I like cats.				
(Agree strongly)	Agree	No opinion	Disagree	Disagree strongly
Why did you give this answer?				
I think cats are clean and friendly and nice to pet.				

1. I look forward to coming to this class.
Agree strongly Agree No opinion Disagree Disagree strongly

2. I would take this class even if it were not required to graduate high school.
Agree strongly Agree No opinion Disagree Disagree strongly

3. I am learning interesting things in this class.
Agree strongly Agree No opinion Disagree Disagree strongly

4. I like to find out about new science discoveries.
Agree strongly Agree No opinion Disagree Disagree strongly

5. Science videos bore me.
Agree strongly Agree No opinion Disagree Disagree strongly

6. Sometimes I try to find out more on my own about a science topic that interests me.
Agree strongly Agree No opinion Disagree Disagree strongly

7. Sometimes my parents ask me about what I am learning in science class.
Agree strongly Agree No opinion Disagree Disagree strongly

8. I prefer to read about something instead of watching a video about it.

Agree strongly Agree No opinion Disagree Disagree strongly

9. Sometimes I talk to my parents or friends about something I have seen or learned about in science class.

Agree strongly Agree No opinion Disagree Disagree strongly

Please explain your answer to #9:

___

10. I learn new things from watching videos.

Agree strongly Agree No opinion Disagree Disagree strongly

Please explain your answer to #10:

___

11. I would like to learn about science topics that are not taught at Cloverdale.

Agree strongly Agree No opinion Disagree Disagree strongly

Please explain your answer to #11:

___

12. I would enjoy doing a science research project.

Agree strongly Agree No opinion Disagree Disagree strongly

Please explain your answer to #12:

___

13. I would like to ask a scientist questions about what they do and how they got into their career.

Agree strongly Agree No opinion Disagree Disagree strongly

Please explain your answer to #13:

___

14. I am interested in taking science courses in college.

Agree strongly Agree No opinion Disagree Disagree strongly

Please circle the areas of science that would interest you. (Circle all that apply)

Biology Chemistry Physics Earth Science Plant Science

Environmental Science Forensics Marine Biology Genetics

Pre-medical, Pre-pharmacy, or Pre-Veterinary Engineering

Science Education (Teaching) Other ____________________

Post-Treatment Version

Participation in this research is voluntary and participation or non-participation will not affect a student's grades or class standing in any way.

Name ______________________________

DIRECTIONS: Read each statement below. Then circle the response to show how you agree or disagree with it. Some statements are followed by a request to explain your answer.

EXAMPLE: Answers by Mrs. Hoffmann

I like cats.

(Agree strongly) Agree No opinion Disagree Disagree strongly

Why did you give this answer?

I think cats are clean and friendly and nice to pet.

1. I look forward to coming to this class.
Agree strongly Agree No opinion Disagree Disagree strongly

2. I would take this class even if it were not required to graduate high school.
Agree strongly Agree No opinion Disagree Disagree strongly

3. I am learning interesting things in this class.
Agree strongly Agree No opinion Disagree Disagree strongly

4. I like to find out about new science discoveries.
Agree strongly Agree No opinion Disagree Disagree strongly

5. Science videos bore me.
Agree strongly Agree No opinion Disagree Disagree strongly

6. Sometimes I try to find out more on my own about a science topic that interests me.
Agree strongly Agree No opinion Disagree Disagree strongly

7. Sometimes my parents ask me about what I am learning in science class.
Agree strongly Agree No opinion Disagree Disagree strongly

8. I prefer to read about something instead of watching a video about it.
Agree strongly Agree No opinion Disagree Disagree strongly

9. Sometimes I talk to my parents or friends about something I have seen or learned about in one of the wonder science videos.
Agree strongly Agree No opinion Disagree Disagree strongly

Please explain your answer to #9:

____

10. I learn new things from watching the wonder science videos.
Agree strongly Agree No opinion Disagree Disagree strongly

Please explain your answer to #10:

____

11. I would like to learn more about some of the science topics that were shown in one of the wonder science videos.
Agree strongly Agree No opinion Disagree Disagree strongly

Please explain your answer to #11:

____

12. What science course(s) will you be taking <u>next year</u>? (*Circle all that apply)*

Biology II ACP Chemistry Physics AP Environmental Science

Health Careers at Area 30 An Ag course (which?) _____________

None

13. Watching the wonder science videos influenced my decision whether to take a science course next year and/or my choice of course.

Agree strongly Agree No opinion Disagree Disagree strongly

Please explain your answer to #13:

____

14. I would enjoy doing a science research project to explore something I saw in a wonder video.
Agree strongly Agree No opinion Disagree Disagree strongly

Please explain your answer to #14:

____

15. I would like to ask a scientist questions about what they do and how they got into their career.

Agree strongly   Agree   No opinion   Disagree   Disagree strongly

Please explain your answer to #15:

____

16. I am interested in taking science courses in college.

Agree strongly   Agree   No opinion   Disagree   Disagree strongly

Please circle the areas of science that would interest you. (Circle all that apply)

Biology   Chemistry   Physics   Earth Science   Plant Science

Environmental Science   Forensics   Marine Biology   Genetics

Pre-medical, Pre-pharmacy, or Pre-Veterinary   Engineering

Science Education (Teaching)   Other ________________

APPENDIX D

INSTITUTIONAL REVIEW BOARD EXEMPTION

INSTITUTIONAL REVIEW BOARD
For the Protection of Human Subjects
FWA 00000165

MONTANA STATE UNIVERSITY

2155 Analysis Drive
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MEMORANDUM

TO: Kathryn Hoffmann and Walter Woolbaugh

FROM: Mark Quinn *Mark Quinn CJ*
Chair, Institutional Review Board for the Protection of Human Subjects

DATE: November 1, 2019

RE: *"The Effect of 'Wonder' Science Videos on Student Attitudes in Science" [KH110119-EX]*

The above research, described in your submission of November 1, 2019, is exempt from the requirement of review by the Institutional Review Board in accordance with the Code of Federal regulations, Part 46, section 101. The specific paragraph which applies to your research is:

_X_ (b) (1) Research conducted in established or commonly accepted educational settings, involving normal educational practices such as (i) research on regular and special education instructional strategies, or (ii) research on the effectiveness of or the comparison among instructional techniques, curricula, or classroom management methods.

_X_ (b) (2) Research involving the use of educational tests (cognitive, diagnostic, aptitude, achievement), survey procedures, interview procedures or observation of public behavior, unless: (i) information obtained is recorded in such a manner that human subjects can be identified, directly or through identifiers linked to the subjects; and (ii) any disclosure of the human subjects' responses outside the research could reasonably place the subjects at risk of criminal or civil liability, or be damaging to the subjects' financial standing, employability, or reputation; and (iii) the information obtained is recorded by the investigator in such a manner that the identity of the human subjects can readily be ascertained, directly or through identifiers linked to the subjects, and an IRB conducts a limited IRB review to make the determination required by section 16.111(a)(7).

___ (b) (3) Research involving the use of educational tests (cognitive, diagnostic, aptitude, achievement), survey procedures, interview procedures, or observation of public behavior that is not exempt under paragraph (b)(2) of this section, if: (i) the human subjects are elected or appointed public officials or candidates for public office; or (ii) federal statute(s) without exception that the confidentiality of the personally identifiable information will be maintained throughout the research and thereafter.

___ (b) (4) Research involving the collection or study of existing data, documents, records, pathological specimens, or diagnostic specimens, if these sources are publicly available, or if the information is recorded by the investigator in such a manner that the subjects cannot be identified, directly or through identifiers linked to the subjects.

___ (b) (5) Research and demonstration projects, which are conducted by or subject to the approval of department or agency heads, and which are designed to study, evaluate, or otherwise examine: (i) public benefit or service programs; (ii) procedures for obtaining benefits or services under those programs; (iii) possible changes in or alternatives to those programs or procedures; or (iv) possible changes in methods or levels of payment for benefits or services under those programs.

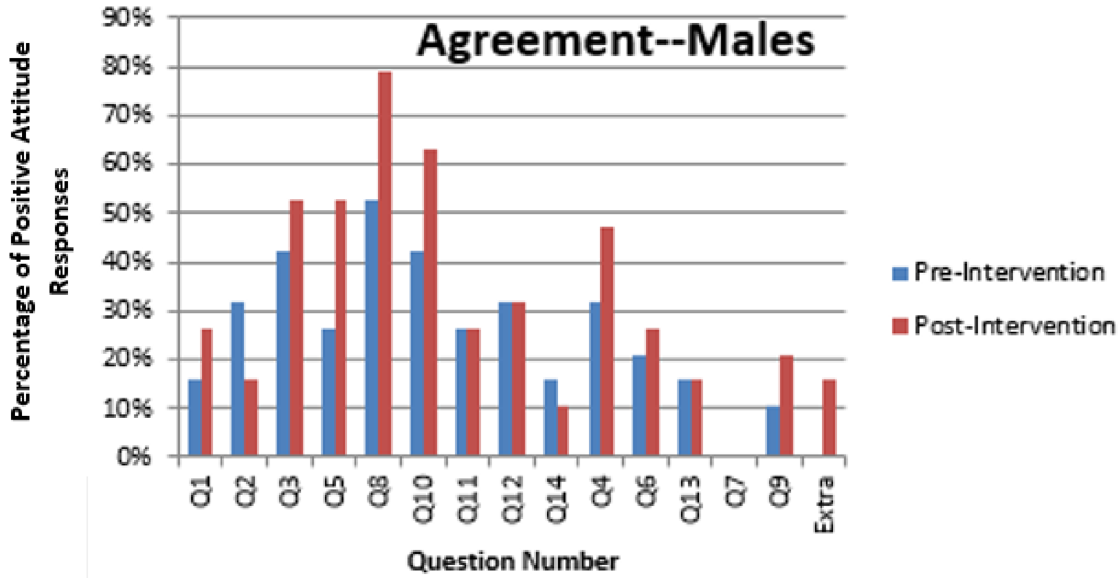
___ (b) (6) Taste and food quality evaluation and consumer acceptance studies, (i) if wholesome foods without additives are consumed, or (ii) if a food is consumed that contains a food ingredient at or below the level and for a use found to be safe, or agricultural chemical or environmental contaminant at or below the level found to be safe, by the FDA, or approved by the EPA, or the Food Safety and Inspection Service of the USDA.

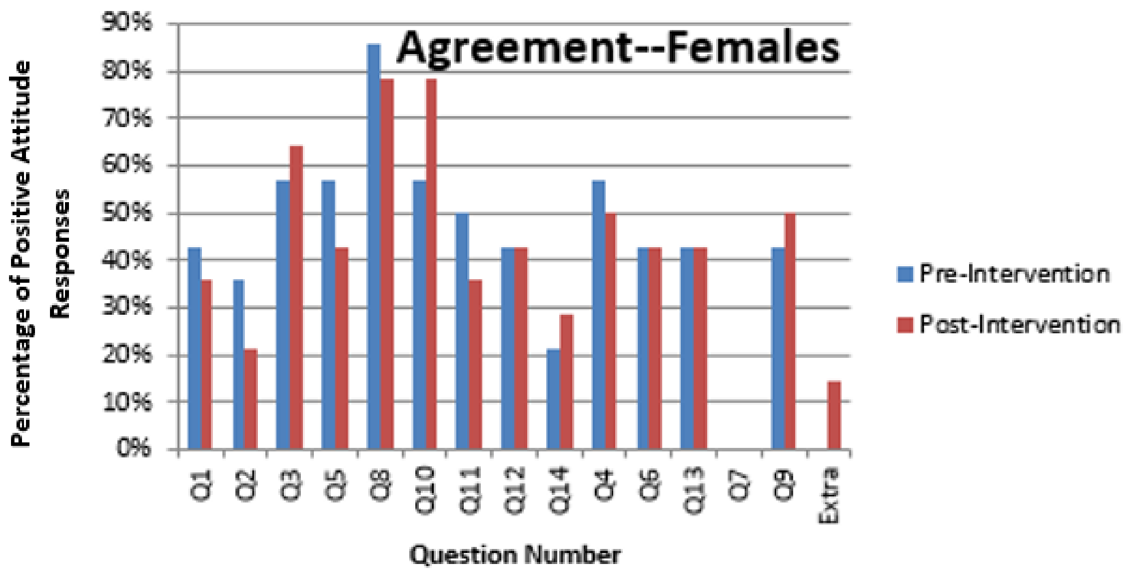
Although review by the Institutional Review Board is not required for the above research, the Committee will be glad to review it. If you wish a review and committee approval, please submit 3 copies of the usual application form and it will be processed by expedited review.

APPENDIX E

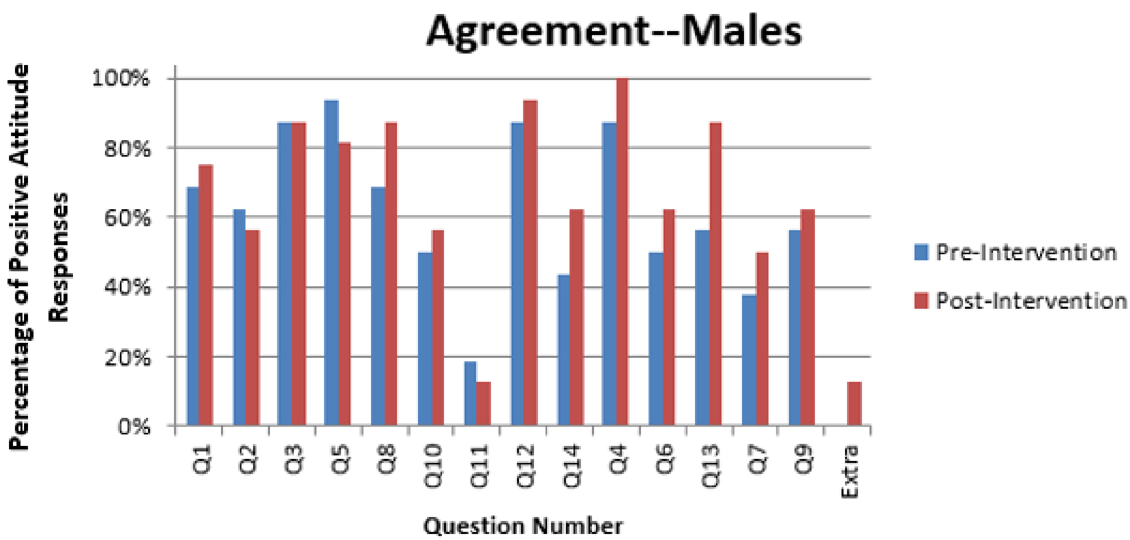
GRAPHS COMPARING RESPONSES TO HOFFMANN ATTITUDE SURVEY

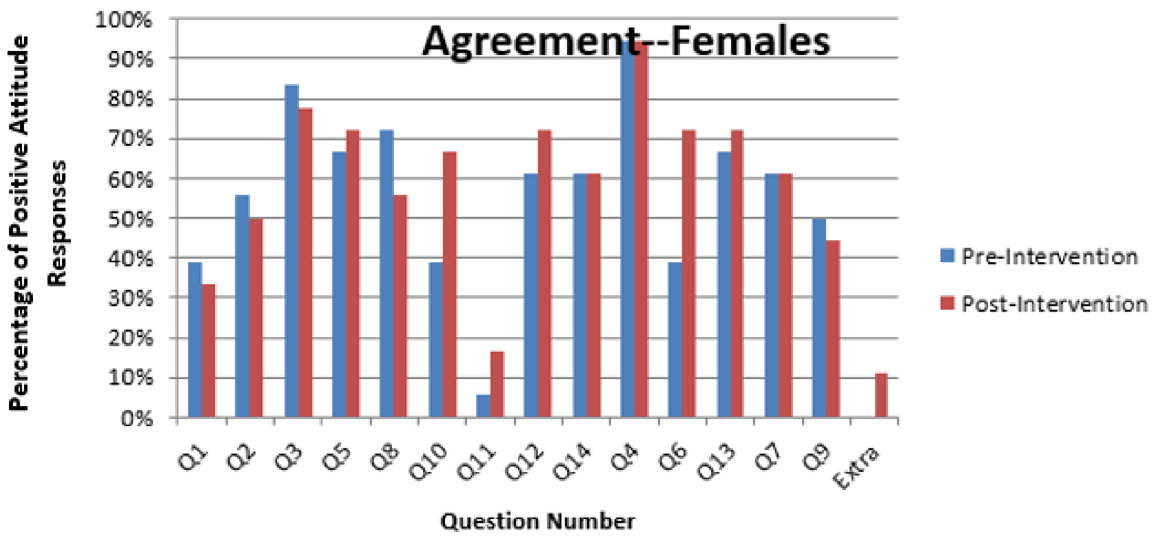
Data from ICP Classes





Data from CHEM 1 Classes





APPENDIX F

POST-CAREER PROJECT REPORT

Name ______________ **Career Chosen for Project ______________**

Post-Career Project Report

1. How serious is your interest in the career you did your project on?
    a. I really think I might do this as a career __________
    b. I'm interested in this career but not sure __________
    c. I have another career I prefer but did this for fun __________
    d. I have no interest in this career and only did it for the assignment ________

2. How long have you had an interest in this career?
    a. Since I was little _________
    b. For several years __________
    c. Since high school _________
    d. Just recently __________
    e. I only just found out about it when doing this project ________

3. How did you find out about this career? (You may check more than one)
    a. I have a relative in this career ___________
    b. I have a friend/neighbor in this career _________
    c. I met someone in this field who helped me or talked with me ______
    d. At Area 30 or JAG __________
    e. I saw it in a wonder science video ___________
    f. I discovered it on the sciencebuddies site ________
    g. Other ____

4. What attracts you to this career? (Rate 1 = most, 5 = least)
    a. The money I would earn in it ___________
    b. How easy it is to train for this career __________
    c. The places I would go if I worked in it ___________
    d. The things I would do as part of my job _____________
    e. The skills I would develop in this job _____________
    f. It builds on a personal interest I have ______________
    g. Where I would live if I worked in this job ______________
        i. (near my family ___________) ii. (leave Indiana _________)
    h. Other ____