# IMPACT OF DIGITALLY MEDIATED SCIENTIST-CLASSROOM

# PARTNERSHIPS WITH MIDDLE SCHOOL GIRLS

by

Annie Tête

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TABLE OF CONTENTS

# LIST OF TABLES

# LIST OF FIGURES

# ABSTRACT

Women are underrepresented in science and engineering fields. To address this disparity, I connected my middle school life science students at an all-girls school with female science professionals using Skype. A virtual field trip (VFT) augmented the digitally mediated experience. Research questions addressed the impact of Skype conversations on student perceptions of scientists, student attitudes towards science careers, student content knowledge, and teacher preparation and attitudes.

The scientist-classroom partnership consisted of a series of three Skype sessions with the same female science professional over the course of one unit on a human body system. Students were divided into two groups with treatment occurring with alternating units to control for content. Perceptions, attitudes, and content knowledge was measured before and after using the draw-a-scientist test (DAST), a modified version of the Test of Science Related Attitudes (TOSRA), content tests, interviews, student formative assessment responses, and teacher journal entries.

Data showed improvement in both student perceptions of scientists and attitudes toward science careers. While increased content knowledge was not correlated with the intervention, I argue that the scientist-classroom partnerships increased the relevance of the content thereby improving student perceptions and attitudes. Impact on teacher planning and preparation was minimal compared with the value of the student and teacher experience interacting with science professionals.

Unexpected outcomes include novel opportunities for teacher professional development and networking and the possibility of connecting other groups underrepresented in science careers with positive role models in science. Further studies should examine the importance of student pre-Skype planning and research and the feasibility of decreasing the student-scientist ratio.

# INTRODUCTION AND BACKGROUND

## Project Background

### School Context

Louise S. McGehee School is an independent, non-religious, all-girls school in New Orleans, Louisiana. With an enrollment of approximately 525 students in kindergarten through twelfth grade and 160 students in early childhood education program, minority students comprise 18% of the student population and 100% of graduates attend college. Class sizes are small with an overall student to faculty ratio of 8:1. The school is located in an urban residential neighborhood where it comprises approximately one city block with classes held in both modified historic homes and traditional school buildings. The mission of the school is "to provide a rigorous college-preparatory education to girls in an inclusive environment which fosters self-esteem, encourages high personal standards, addresses individual student needs, and emphasizes active student participation in the learning process" (Dry, 2015).

### Classroom Environment and Teaching Experience

I have taught for two years at Louise S. McGehee School where I instruct three classes of seventh grade life science along with one class of twelfth grade advanced biology. In addition to my duties as a science teacher, I advise a small group of eighth grade students, serve as the middle school robotics coach, and assist with the seventh grade service learning project. The seven day rotation schedule utilized across all grade levels allows for teachers to teach in multiple levels, myself included. A built-in activity period devotes school time to traditionally extra-curricular activities such as clubs, student-leadership, community service, and social-and-emotional learning.

I have focused on my seventh grade life science classes for the research study. The seventh grade science curriculum is divided by semester. During the first semester content is focused on basic life science including cell structure, cell energy and processes, genetics, DNA, and evolution. Second semester curriculum is a survey of human body systems with emphasis on the skeletal, muscular, integumentary, immune, circulatory, and nervous systems.

The seventh grade consists of 44 students divided into four sections of which I teach three with class sizes of 10, 11, and 12 students. Students of mixed abilities are grouped in order to avoid tracking students by their math courses. Classes meet on six days of a seven-day rotation at varying times throughout the school day. Of these six classes, there are four 50-minute periods and two 70-minute periods. As the school is non-public, students are not assigned Individualized Education Programs (IEP) but receive accommodations such as extended time on assessments and preferential seating. Some students with accommodations meet with the school's learning specialist on a rotational basis, approximately one time every seven school days. Of my 33 seventh grade students, nine receive accommodations for learning differences.

My previous teaching experiences include working as an informal science educator in a history museum setting. Drawing from my informal education experience, I seek out real-world experiences for my students in order to create a sense of wonder and provide relevance and context. My lessons frequently incorporate readings and videos about current science research, hands-on inquiry activities, and occasional on-site and virtual field trips. By combining this approach with my background in informal education, I look for opportunities to connect classroom content with current topics in science and engineering.

Rationale

At the end of the previous school year, I was approached by a student about arranging a Skype session with her uncle, a cardiac surgeon. The interaction fit into the current curriculum as we were just completing a unit on the circulatory system. I was amazed by my students' engagement in the Skype session. Each time the surgeon mentioned a vocabulary term or concept from our unit, the students looked at me in amazement. It was as if a light bulb went off in their minds, realizing that these terms did not exist in isolation in their workbooks but were used every day by real scientists and medical professionals. I immediately recognized the power of engaging with science professionals in the classroom to improve both student perceptions about science and content knowledge.

My small class setting allows for intimate interaction using synchronous digital software (e.g. Skype, Google Hangout, and FaceTime) to connect with science professionals while providing an opportunity for a sustained scientist-classroom partnership. Transportation is not necessary as with traditional field trips. The busy science professional only needs to take 15 to 20 minutes from her schedule to engage with the students using Skype's user-friendly platform. While Skype sessions provide a convenient, cost-effective method for connecting students to science experiences outside of the classroom, I anticipated potential challenges when scheduling the Skype sessions to match with a rotating class schedule. Based on my initial concerns, I have investigated the benefits for the students and the challenges for teacher planning and executing instruction in my investigation.

## Focus Questions

Exposure to positive experiences in science is linked to improved attitudes toward careers in science and engineering. Middle school girls, in particular, are developing their sense of self at this critical point of identify formation. While my students interacted with a male physician, I want to know if sustained digitally-mediated conversations with female science professionals will improve middle school girls' perceptions of women in science and lead to increased learning outcomes.

### Primary Research Question

- Does sustained interaction with female scientists using synchronous Internet video enhanced by a virtual field trip improve the perceptions of middle school girls about scientists?

  Sub Questions

  - How do student attitudes toward careers in science and engineering change as a result of interacting with female science professionals?
  - Do Skype conversations with scientists and virtual field trips improve student content knowledge?

- What is the relationship between the use of Skype to facilitate classroom-scientist partnerships and teacher preparation, planning time, and attitudes?

## CONCEPTUAL FRAMEWORK

A review of the literature revealed four areas of interest. First, research has reported positive influence of science professionals in the classroom (both virtually and in-person) on student perceptions of scientists. Second, strategies for engaging girls in science through interactions with female scientists are explored. Third, research has documented the role of immersive informal education experiences including traditional and virtual field trips (VFTs) to improve student interest and motivation. Finally, best practices for measuring student attitudes towards science and incorporating VFTs and Skype in the classroom are addressed.

Student interaction with science professionals in the classroom improves student perceptions about careers in science. Adedokun, Liu, Parker, & Burgess (2015) evaluated the impact of synchronous virtual interaction with scientists on student perceptions of scientists. The draw-a-scientist test (DAST) designed by Chambers (1983) and modified by Finson, Beaver, & Cramond (1995) was used as an instrument to evaluate student ideas about scientists as people. Using open-ended prompts, students are asked to draw a picture of a scientist and explain what the scientist is doing. The researchers found that students were less likely to include stereotypes of scientists (e.g., eye glasses, lab coat, and facial hair) in their drawings after interacting with a scientist online. Similar conclusions were found by Bodzin & Gehringer (2001) following in-person classroom visits by scientists to fourth and fifth grade classrooms. There was a significant decrease in the stereotypic features depicted in student drawings following the visits. While these visits included a hands-on demonstration, teachers and students did not follow up with the scientists after the interaction.

Duration of scientist and classroom partnerships may contribute to the amount of improvement in positive student attitudes and perceptions towards scientists. In a three-year sustained partnership between schools and scientists in New Zealand, Falloon & Trewern (2013) reported positive improvement in attitudes. Hillman, Bloodsworth, Tilburg, Zeeman, & List (2014) studied the impact of resident scientists in the classroom over a one year period. While the middle school students did not show a significant positive improvement, the drawings of both elementary and high school students reflected a significant decrease in scientist stereotypes. In reflection of the research, successful scientist-classroom partnerships should include sustained interaction, a hands-on component, or both sustained interaction and a hands-on component. In order for students to shift their perceptions and be able to see themselves in the shoes of the scientist, the experience must be engaging and sustained.

Numerous studies address the lack of women in STEM fields and explore strategies for engaging girls in science. A critical point emerges as students move into pre-adolescence and begin to develop a sense of identity. McCrea (2011) emphasizes the need for female scientists to serve as positive role models for female students. Allowing girls to identify with real women in science is a critical component of increasing the number of women who later pursue careers in STEM fields. Farland-Smith (2009) studied the impact of scientist-student partnerships during a five day science camp for girls. While significant increases in attitudes using DAST were not observed, student journal entries reflected a positive shift in perceptions about scientists including appearance, location of work, and daily activities. Bodzin & Gehringer (2011) reported four girl students who drew male scientists in the pre-test identified with females in the post-test. These four students were in the class visited by a female engineer. The authors suggest that interaction with female scientists improves girls' perceptions of scientists and might impact future career choices in science and engineering.

The timing of science exposure has been explored as a predictor of subsequent science interest. Alexander, Johnson, & Kelley (2012) used a longitudinal study tracking informal science learning opportunities in children ages four through seven to predict subsequent interest in science. In the study, early science interests proved to be strong predictors of subsequent informal science learning opportunities rather than early informal science learning opportunities predicting later interest in science. Gender differences emerged with boys often receiving science learning opportunities regardless of expressed interest while girls received science learning opportunities only in the presence of expressed interest. This work provides more support for young girls having positive interactions with female scientists regardless of interest.

Field trips are immersive experiences that provide students with opportunities to apply knowledge and skills in a novel setting, improving student interest and motivation. Nadelson & Jordan (2012) assessed student attitudes, interests, and motivations immediately following an all-day environmental science field trip and found that the level of student engagement during the field trip had a significant influence on student attitudes and recall of knowledge. Nadelson & Jordan measured student recall of events approximately one month after the field trip. The researchers asked students to recall, write about, and illustrate the field trip activities from one month prior. Responses were categorized and counted using a predetermined coding criteria. They found that student interest and motivation were higher for hands-on activities and these activities were more frequently recalled later than display or demonstration activities.

Similarly, Hurley (2006) assessed student learning during a weeklong field trip to Yellowstone National Park by documenting learning before, during, and after the experience. Bloom's Taxonomy was applied to student learning of four major goals: conceptual understanding of Yellowstone environmental issues, conceptual understanding of the flora and fauna of the Park, conceptual understanding of physical science of the Park, and appreciation for the Park and residents. Individual, small group, and whole group learning was assessed using a multifaceted approach. Hurley reported, "few other learning tools can provide richer resources or better real world experiences for learning than a well-selected location and a well-planned field trip" (p. 65). Adams, Gupta, & DeFelice (2012) called for a true collaboration between formal and informal education institutions. In their metalogue, they emphasized the authenticity of science learning when it occurs in a social situation.

While traditional off-campus field trips are valuable learning opportunities for teachers and students, virtual field trips (VFTs) provide an inexpensive and convenient option. Transportation costs are eliminated and less time is lost from the school day.

Teachers can incorporate VFTs into the curriculum, providing a rich experience within the context of current topics of study. In addition to the synchronous live interaction with a scientist, the treatment studied by Adedokun, Liu, Parker, & Burgess (2015) included a VFT component. The pairing of a VFT with online, live interaction with a scientist may prove to be a powerful tool for shifting student perception and interests towards science. I propose a similar model augmented by a minimum of three Skype sessions with the same science professional in order to develop a deeper relationship between students and scientist. By tying the science professional's field directly to the class content the interaction will be relevant to the students and enhance classroom teaching, potentially impacting student performance on content-related tasks.

Review of the literature revealed frequent use of variations of the draw-a-scientist test (DAST) when assessing student perceptions of scientists. Hillman, Bloodsworth, Tilburg, Zeeman, & List (2014) suggest using the DAST in concert with other tools like surveys and interviews for a well-rounded picture of student perception towards scientists. Farland-Smith (2009) found success in pairing the DAST with journaling to assess girls' attitudes and ideas about careers in science.

Planning videoconference experiences for students in the classroom requires careful preparation and attention to detail. Barniskis and Thompson (2012) emphasized the importance of shared goals and clear communication between the teacher and the expert. Testing the connection prior to the class is imperative. Morgan (2013) advises having students prepare questions in advance of the Skype session and teachers plan the order of student questions to ensure a more meaningful and smooth interaction. Falloon

& Trewern (2013) advise that partnerships between scientists and classrooms should begin small, minimize classroom disruption, and focus on one particular content area or skill. Likewise, Wyss, Heulskamp, & Seibert (2012) emphasize alignment of digital interaction with classroom curriculum.

# METHODOLOGY

## Introduction

For the purposes of my action research study, I investigated the impact of digital scientist-classroom partnerships augmented with a virtual field trip (VFT) with two groups of seventh grade students. The intervention occurred during alternating units on human body systems. The impact of the intervention on multiple aspects of student and teacher attitudes and knowledge was measured using: draw-a-scientist tests (DAST), attitude surveys, content pre-tests and post-tests, student interviews, and teacher observation and journaling.

## Participants

All students were female and divided into three classes (named class 1, 2 and 3) of mixed abilities. Nine of my 33 students (27%) were eligible for accommodations because of learning differences. Two students in class 1 (18%) received accommodations, four students in the class 2 (40%) received accommodations, and three students in class 3 (25%) received accommodations. In order to account for differences in the percentage of students with learning differences among the sections, I combined classes 1 and 2 for treatment and data analysis. Merging two classes brought the percentage of students with accommodations to 29% in Group A (N=21) in order to better match the percentage of students with accommodations Group B (formerly class 3), 25% (N=12).

<u>Treatment</u>

The study occurred during the spring semester beginning on February 3, 2016 and continuing through March 23, 2016. The duration of the intervention was planned to accommodate school breaks for the Mardi Gras and Easter holidays. Curriculum during this time included a unit on the skeletal and muscular system and a unit on the immune and integumentary systems. Social media was employed to identify three female science professionals, a physical therapist, a veterinarian, and a research scientist, with whom to collaborate. Each class partnered with the same science professional at the beginning, middle, and end of the unit most closely related to her field of study for a total of three Skype conversations per section. A virtual field trip (VFT) related to the content was presented at the conclusion of the unit. The skeletal and muscular systems unit VFT was a panoramic virtual tour of the Bones and Mummies exhibit of the National Museum of Natural History in Washington, DC while the immune and integumentary systems unit VFT was a virtual tour of "The Secret World Inside You" special exhibit addressing the human microbiome at the American Museum of Natural History in New York, NY.

The treatment unit of study was compared to the same unit of study in which students had no interactions with science professionals or VFT experiences. Because content differed for the treatment and non-treatment units, I alternated groups of students for treatment units. Group A (consisting of class 1 and class 2) received the intervention first during the skeletal and muscular systems unit. Class 1 partnered with a physical therapist focused on mind-body healing and a holistic approach to addressing chronic pain and class 2 partnered with an equine veterinarian. Group B (class 3) received the same content, labs, and assessments but did not Skype with scientists or view a VFT. During the second unit on the immune and integumentary systems, I reversed the groups receiving treatment with Group B partnering with a PhD candidate researching immunology and participating in a VFT while Group A had no intervention. Alternating groups for intervention allowed for the isolation of the content as a variable impacting student content knowledge and controlled for the percentage of students in each group with learning differences.

## Data Collection Methods

Multiple evaluation tools were employed before, during, and after treatment. The draw-a-scientist Test (DAST) was used to assess student perceptions of scientists before and after the intervention. Students were asked to draw what they imagine when hearing the word *scientist*. DAST results are scored by comparing the number of negative stereotypes drawn by the students (Appendix A).

A student survey tool was employed to assess student attitudes toward science before and after the intervention. This survey is modified from the Test on Science-Related Attitudes (TOSRA) (Fraser, 1981). While the TOSRA evaluates seven categories of attitudes towards science, I shortened the survey to focus on two of these categories, normality of scientists and career interest in science (Appendix B). TOSRA responses consist of a five point Likert scale scored in ascending order for negative questions and in descending order for positive questions. I decreased choices from five to four, eliminating "unsure" as a choice. In order to reduce the incentive for students to fake responses, I emphasized to students that the results were not used for grading purposes and participation was completely voluntary. Digitation of the attitude survey using Google Forms allowed for streamlined and instantaneous scoring.

A short pre and post-test consisting of six multiple choice questions was used to evaluate content knowledge (Appendix C). Administered at both the beginning and end of the unit, the content tests were identical for each unit and for treatment and non-treatment groups. All pre-treatment instruments, including the DAST, survey, and content test were administered two weeks before the first online interaction with the science professional. I developed a four digit coding system to anonymize all tools while allowing the matching of data sources for individual students.

During both treatment and non-treatment units, students responded to journal prompts about the content and metacognition (Appendix D). These formative journal responses evaluated the content learning process during both units, with intervention and without intervention. Prompts were completed in student science journals at the beginning of each class. The procedure of responding to journal prompts was already in place in the classroom and a normal part of students' existing routine. I chose one prompt from each unit to evaluate in terms of content knowledge. For the unit on the skeletal and muscular systems, students were asked to name one type of moveable joint and give an example. Correct responses included the successful identification of both the joint type and example. The question for the immune and integumentary systems unit was a comparison of the primary and secondary defenses of the immune system. Student responses were evaluated for both groups during treatment and non-treatment.

I interviewed students at the conclusion of the treatment unit to evaluate attitudes toward science and science careers and the acquisition of content knowledge (Appendix E). I used a semi-structured approach of planned questions while allowing students to add potentially important information for the study. Based on the content pre-test scores, I placed students into three groups (low, medium, and high) and selected two to four students from each group at random for interviews. In order to evaluate the impact of facilitating the classroom-scientist partnerships on teacher preparation and planning time, I journaled throughout the process to record my observations and attitudes. Additionally, my co-teacher observed a Skype lesson and completed a questionnaire after the completion of the treatment unit to provide an external perspective regarding the impact on limited teacher planning time (Appendix F).

Data collection tools were selected in order to answer the research questions using a triangulation matrix (Table 1). The research methodology for this project received an exemption by Montana State University's Institutional Review Board and compliance for working with human subjects was maintained.

Table 1
*Data Triangulation Matrix*

| Focus Questions | Data Source 1 | Data Source 2 | Data Source 3 |
|---|---|---|---|
| *Primary Question:*<br>1. Does sustained interaction with female scientists using synchronous internet video enhanced by a virtual field trip improve the perceptions of middle school girls about scientists? | Comparison of DAST pre and post-treatment | Comparison of science attitude survey pre and post-treatment | Student interviews |

| | | | |
|---|---|---|---|
| *Sub-Questions:*<br>2. How do student attitudes toward careers in science and engineering change as a result of interacting with female science professionals? | Comparison of DAST pre and post-treatment | Comparison of science attitude survey pre and post-treatment | Student interviews |
| 3. Do Skype conversations with scientists and virtual field trips improve student content knowledge? | Comparison of content test improvement for treatment and non-treatment units | Student interviews | Student journal entries |
| 4. What is the relationship between the use of Skype to facilitate classroom-scientist partnerships and teacher preparation, planning time, and attitudes? | Teacher journal entries for treatment and non-treatment unit | Student interviews | Co-teacher questionnaire |

## DATA AND ANALYSIS

Data sources indicate improved student perceptions of scientists following the scientist-classroom partnership. While content knowledge did not increase after treatment when compared with non-treatment, student attitudes toward careers in science improved following conversations with female science professionals. The impact of the intervention on teacher attitude was positive and the additional preparation time required to coordinate the Skype sessions and virtual field trips (VFT) was minimal.

### Student Perceptions about Scientists

Student perceptions about scientists as measured by the draw-a-scientist test (DAST) improved following sustained interactions with female scientists via Skype and participation in a virtual field trip. Before the intervention, students drew a mean of 7.1 stereotypical indicators of scientists, or 44.58% (SD = 25.57) of the possible 16 indicators, on the DAST. Following three Skype sessions with female scientists and a virtual field trip experience, students drew 3.4 stereotypical indicators on average, or

21.06% (SD = 14.72) of the possible indicators. The distribution of negative stereotypical indicators in student drawings after the treatment decreased (Figure 1). The range of baseline scores was broad (6.25% to 81.25%) compared to the treatment scores, (0% to 56.25% with one outlier) particularly the second quartile baseline results ranging from 21.88% to 56.25%.

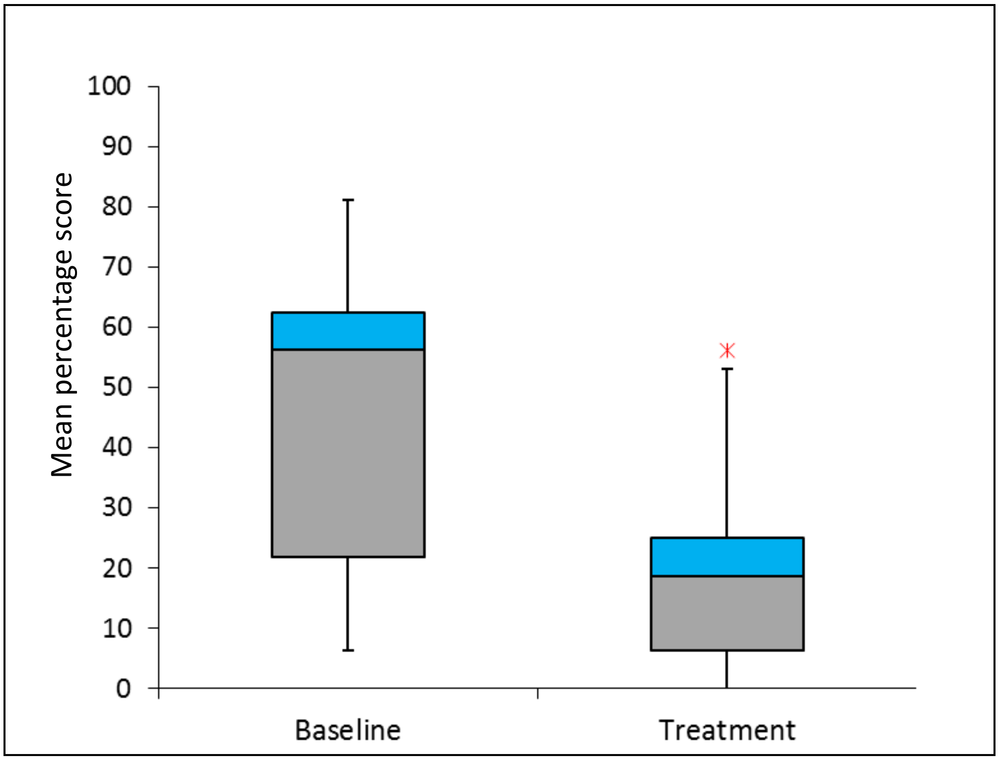


*Figure 1*. Box and whisker plot of draw-a-scientist test (DAST) distribution (*N*=33). Boxes represent the second and third quartiles with whiskers representing the first and fourth quartiles.

Student perceptions were also evaluated through the student attitude survey. Of the 20 total questions, 10 questions specifically addressed perceptions of scientists. These questions alternated with questions regarding attitudes towards careers in science. Topics addressed in these questions ranged from appearance to family life (Table 2). Responses are assigned a number score ranging from 1 to 4 with 1 indicating a negative attitude and 4 indicating a positive attitude. Student survey responses related to perceptions were aggregated among both groups and the mean responses compared by question (Figure 2).

Table 2

*Questions addressing student perceptions towards scientists on the attitude survey*

| Question number | Agreement Score |
|---|---|
| 1. Scientists usually like to go to their laboratories when they have the day off. | 1 |
| 3. Scientists are about as fit and healthy as other people. | 4 |
| 5. Scientists do not have enough time to spend with their families. | 1 |
| 7. Scientists like sports as much as other people do. | 4 |
| 9. Scientists are less friendly than other people. | 1 |
| 11. Scientists can have a normal family life. | 4 |
| 13. Scientists do not care about their working conditions. | 1 |
| 15. Scientists are just as interested in art and music as other people are. | 4 |
| 17. Few scientists are happily married. | 1 |
| 19. If you met a scientist, she would probably look like anyone else you might meet. | 4 |

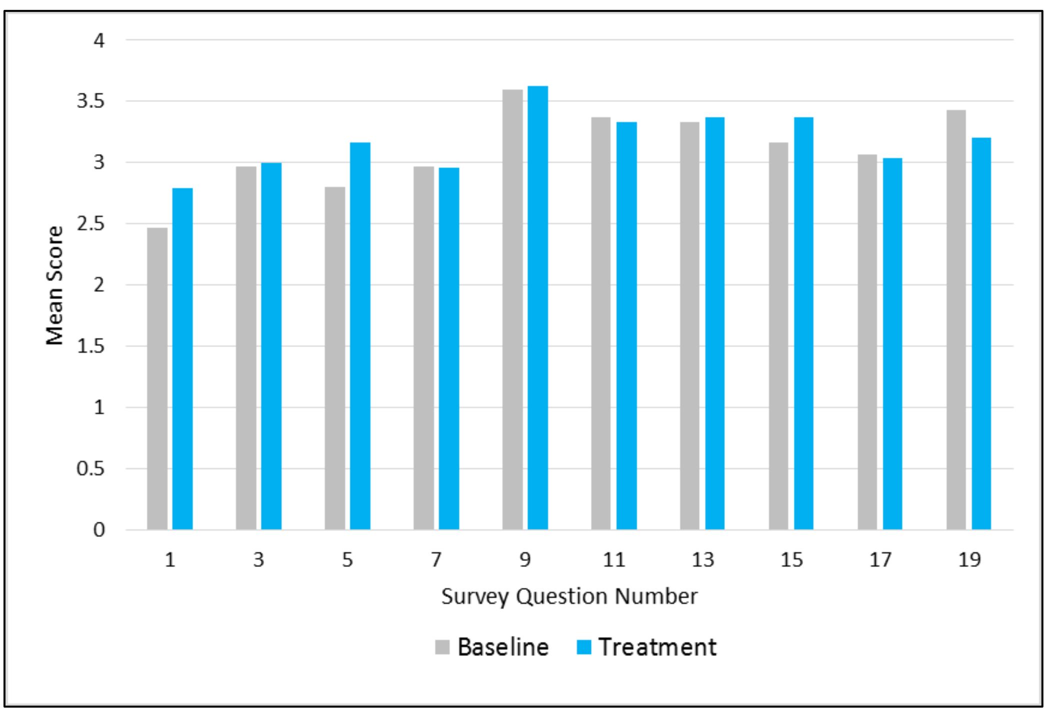

*Figure 2*. Mean student scores on survey questions addressing perceptions towards scientists before and after treatment. Responses are assigned a number score ranging from 1 to 4 with 1 indicating a negative attitude and 4 indicating a positive attitude.

Of the 10 questions regarding perceptions about scientists, student scores increased after treatment on six questions and decreased after treatment on four questions. Higher scores correlate to positive attitudes on the survey tool. Based on the maximum points possible, the mean of all student responses regarding perceptions increased from 77.91% (SD = 8.81) before treatment to 79.69% (SD = 8.76) after treatment (Figure 3).

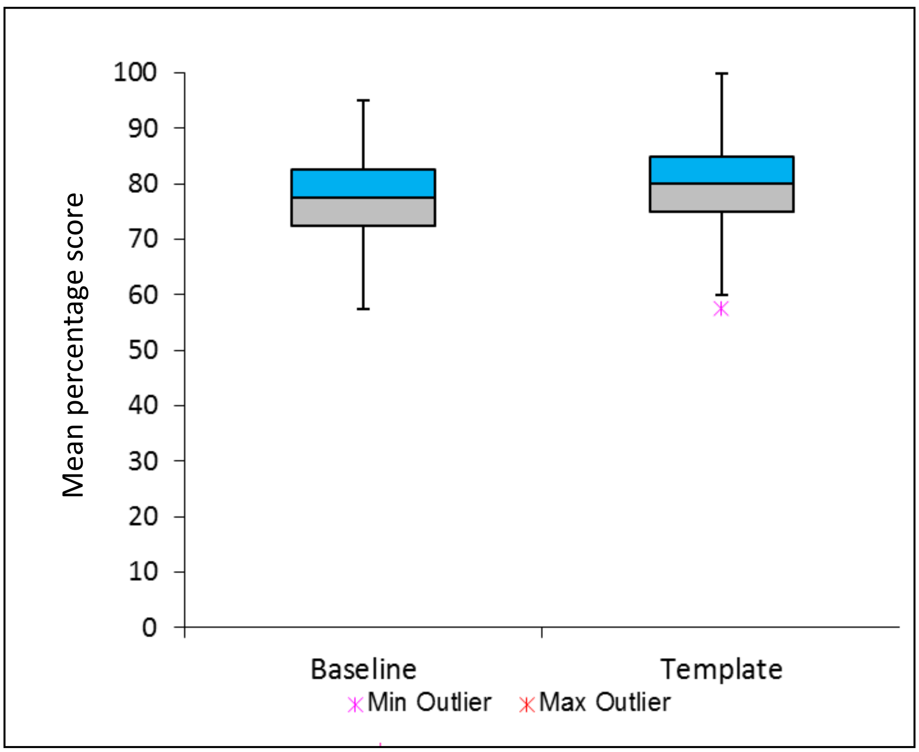


*Figure 3*. Box and whisker plot of the percentage positive total responses for student perceptions of scientists on attitude survey (*N*=33). Boxes represent the second and third quartiles with whiskers representing the first and fourth quartiles.

When asked about their feelings about science during interviews, two out of 12 students indicated that the Skype experience changed their feelings about science. One student stated that she “already liked science,” while another student said that the conversations “made science seem important.” One student indicated that the Skype sessions left her wanting to know more about the scientist’s work.

Student Attitudes toward Careers in Science and Engineering

Student attitudes regarding science and engineering careers improved following sustained Skype sessions with female scientists as measured by the gender and age of depictions draw-a-scientist test (DAST). Before the intervention, 19 students drew a person or people in the illustrations while 14 students drew inanimate objects such as lab equipment, planets and stars, or landscapes (N=33). Of the figure drawings, five students (26.32%) drew females compared with 12 students (63.16%) depicting female scientists following treatment (Figure 4). Student identification with scientists also shifted as evidenced by the DAST. Depictions of scientists as senior citizens or middle-aged decreased from 8 drawings to 5 following treatment. Likewise, 15 students drew young scientists after the Skype sessions compared with 12 students before treatment (Figure 5). The shift from depictions of middle-aged male scientists to young female scientists shows a change in attitude regarding careers in science and engineering (Figure 6).

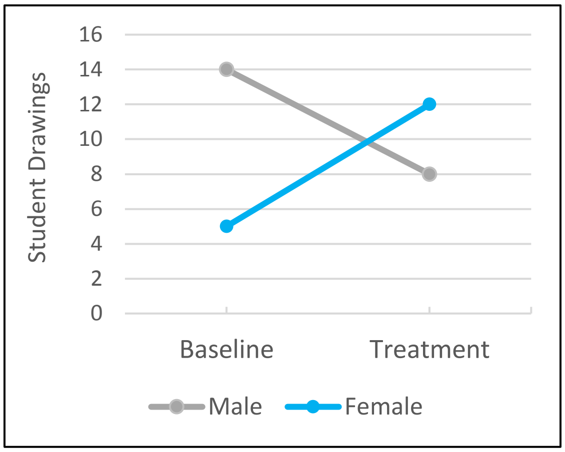


*Figure 4.* Student gender depictions of scientists on DAST

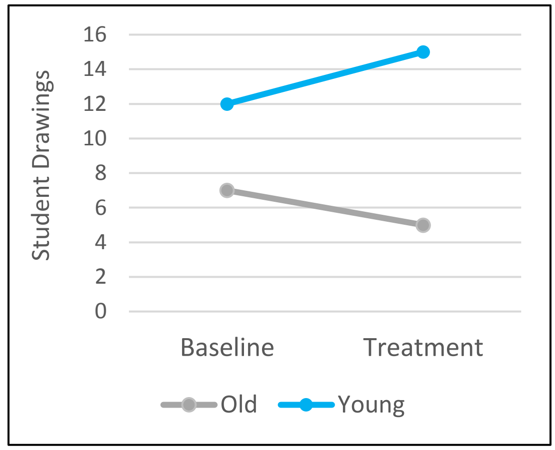


*Figure 5.* Student age depictions of scientists on DAST

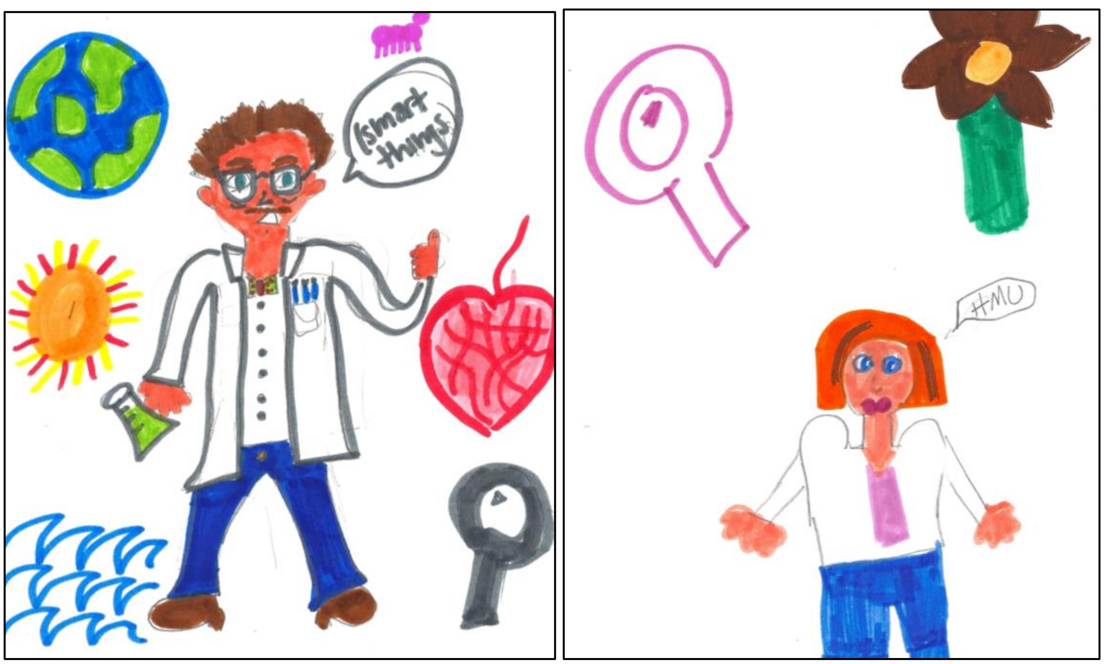


*Figure 6.* Examples of student depictions of scientists with pretreatment (left) and post-treatment (right).

Student attitudes towards careers in science and engineering were evaluated through the attitude survey. Of the 20 total questions, 10 questions specifically addressed attitudes regarding science careers (Table 3). Responses are assigned a number score ranging from 1 to 4 with 1 indicating a negative attitude and 4 indicating a positive attitude. Student survey responses related to science career attitudes were aggregated among both groups and the mean responses compared by question (Figure 7).

Table 3
*Questions addressing student attitudes regarding science careers on the attitude survey*

| Question number | Agreement Score |
|---|---|
| 2. I would dislike being a scientist after I leave school. | 1 |
| 4. When I leave school, I would like to work with people who make discoveries in science. | 4 |
| 6. I would dislike a job in a science laboratory after I leave school. | 1 |
| 8. Working in a science laboratory would be an interesting way to earn a living. | 4 |
| 10. A career in science would be dull and boring. | 1 |
| 12. I would like to teach science when I leave school. | 4 |
| 14. A job as a scientist would be boring. | 1 |
| 16. A job as a scientist would be interesting. | 4 |
| 18. I would dislike becoming a scientist because it needs too much education. | 1 |
| 20. I would like to be a scientist when I leave school. | 4 |

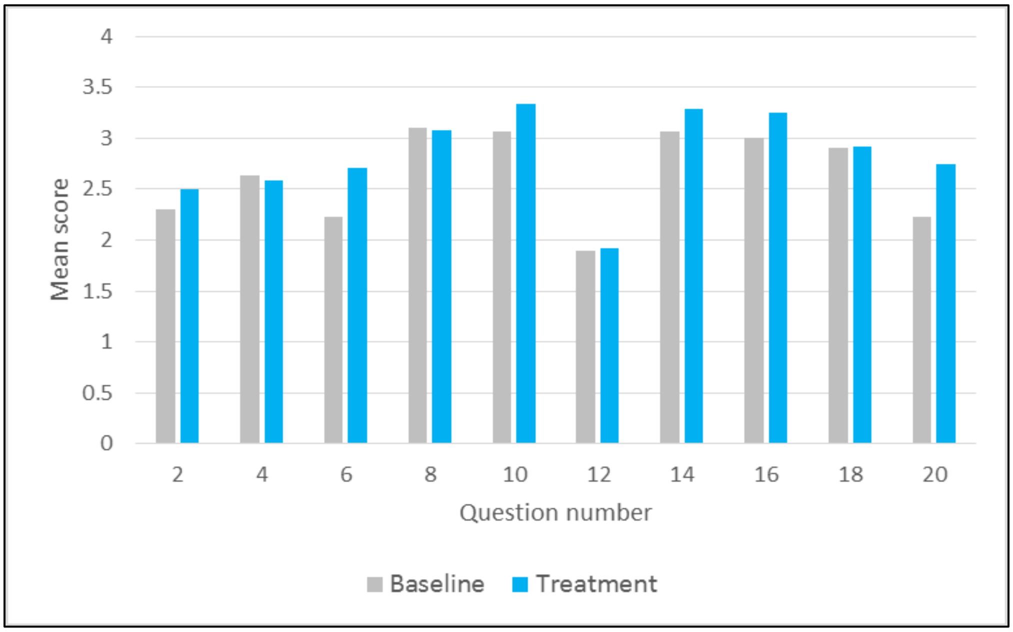


*Figure 7.* Mean student scores on survey questions addressing attitudes regarding science careers before and after treatment. Responses are assigned a number score ranging from 1 to 4 with 1 indicating a negative attitude and 4 indicating a positive attitude.

Student scores on career oriented survey questions increased after Skype sessions and VFT experiences on eight out of 10 questions. Higher scores correlate to positive attitudes on the survey tool. Based on the maximum points possible, the mean of all student responses regarding science careers increased from 66.08% (SD = 13.45) before treatment to 70.83% (SD = 11.93) after treatment (Figure 8).

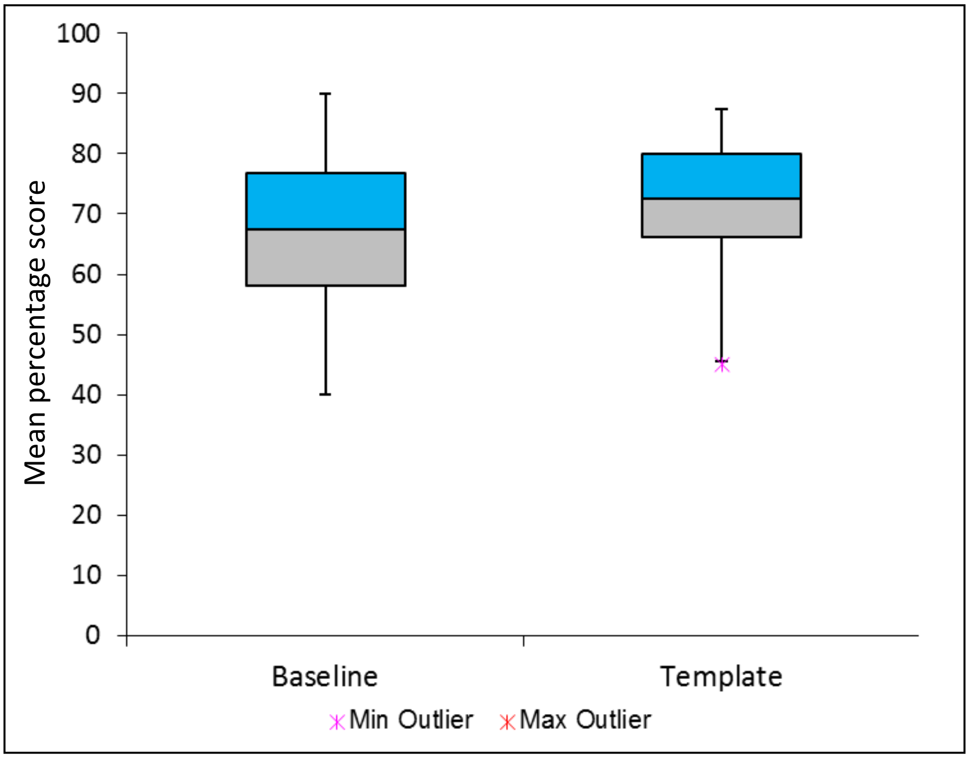


*Figure 8*. Box and whisker plot for the percentage positive total responses of student attitudes regarding science careers on survey (*N*=33). Boxes represent the second (gray) and third quartiles (blue) with whiskers representing the first and fourth quartiles.

Six of 12 students interviewed indicated interest in studying science after high school. Four students expressed interest in careers in physical therapy, one student liked astronomy, and another student indicated interest in a medical career.

Student Content Knowledge

Understanding of the content was assessed using brief content tests at the beginning and conclusion of each unit, for both the treatment and non-treatment groups. Content knowledge increased for both treatment and non-treatment groups. The improvement during the treatment unit was consistent with the improvement for the non-treatment group; content learning was not impacted by the scientist-classroom partnership. Scores on the content tests were analyzed by combining treatment units for both groups regardless of unit content (Figure 9). The mean percentage correct on the aggregate treatment units increased 30.82% from 44.44% on the pretest (SD = 20.22) to 75.27% on the post-test (SD = 20.13). For the aggregate non-treatment units, scores increased 27.48% from 49.40% on the pretest (SD = 21.02) to 76.88% on the post-test (SD = 15.32).

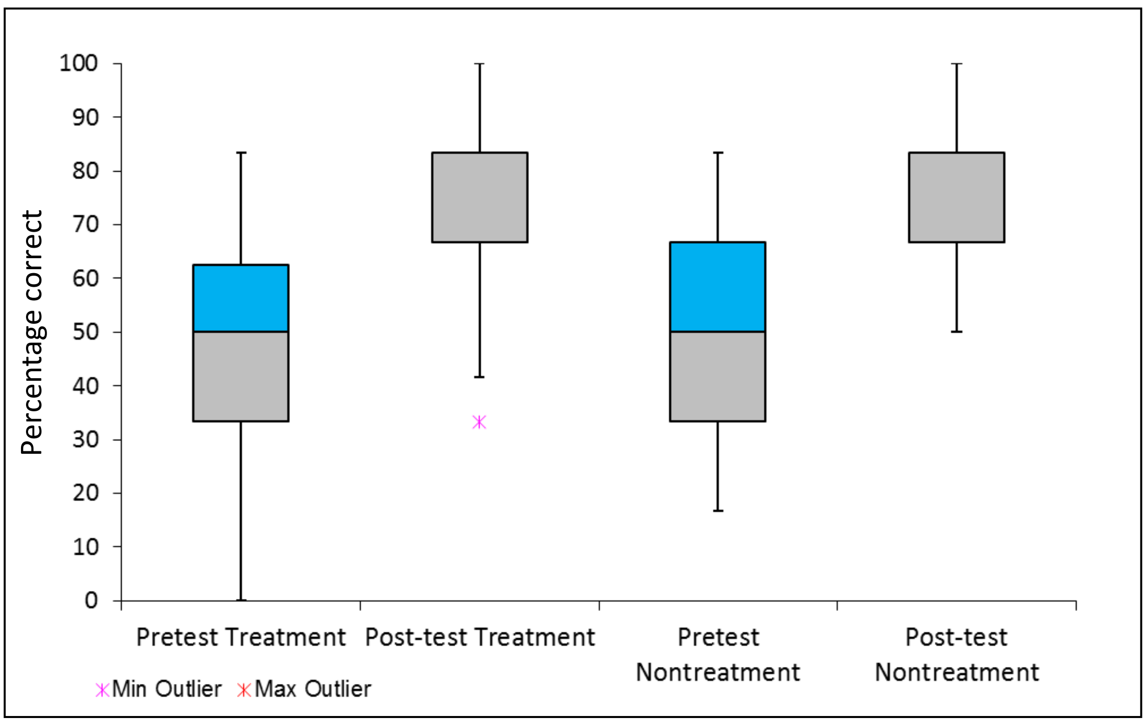


*Figure 9*. Box and whisker plot for the aggregate percentage correct on content tests. Boxes represent the second (gray) and third quartiles (blue) with whiskers representing the first and fourth quartiles.

To account for differences in content between the treatment units, a comparison of each content test for treatment and non-treatment groups revealed similarities in scores (Figure 10). For the content test on the skeletal and muscular systems, the average score began at 37.50% for the treatment group (Group A) and 39.39% for the non-treatment group (Group B). Post-test scores raised to 73.68% for the treatment group (percent increase of 36.18%) and 75.00% for the non-treatment group (percent increase of 35.61%). On the immune and integumentary systems content test, the average score increased 19.44% from 58.33% and 77.78% for the treatment group (Group B) and 22.19% for the non-treatment group (Group A) from 55.88% to 78.07%.

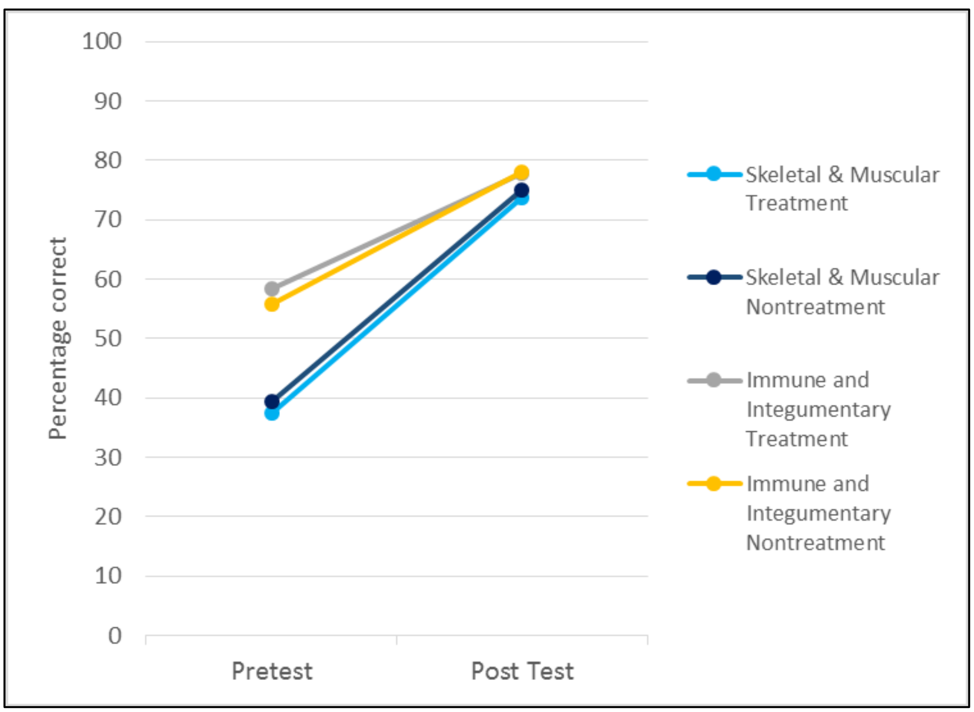


*Figure 10.* Student scores on the content tests separated by unit of study and treatment.

During interviews, 10 of 12 students found Skyping with scientists make science class more relevant. One student said that “talking helps me get it more.” Another student indicated that the Skype session “helps to explain in different ways.” Students liked the immediacy of Skype sessions with one student saying that she “likes getting answers to questions right away.”

Students responded to prompts at the beginning of each class during both treatment and non-treatment units. These formative assessments were identical for both groups. One question per unit was selected for analysis. The skeletal and muscular system prompt was “Name on moveable joint and give an example in the human body.” Student responses were scored based on a correct answer for the joint type and example. The immune and integumentary system prompt involved a description of the lines of defense in the immune system. The prompt stated, “How do the primary and secondary defenses of the immune systems differ.” Journal responses were compared for treatment and non-treatment groups (Figure 11). Of the students receiving treatment of Skype sessions with female scientists during the skeletal and muscular system, 75.00% responded to the journal prompt correctly (N=20) while 62.50% of students not receiving treatment responded correctly (N=8). For the immune system prompt, 80.00% of students participating in Skype sessions listed correct responses (N=10) compared with 61.10% of students not participating in Skype conversations submitted correct responses (N=18).

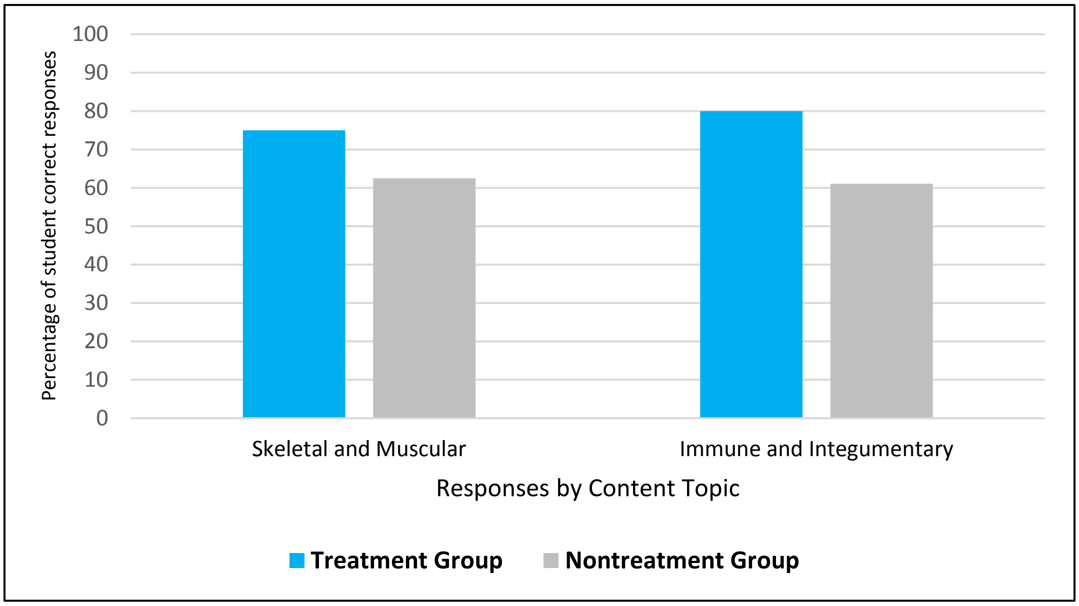


*Figure 11.* Student responses on journal prompt separated by unit of study and treatment.

Teacher Preparation, Planning Time, and Attitudes

The impact of classroom-scientist partnerships and virtual field trips (VFTs) on teacher preparation, planning time, and attitudes was assessed through teacher journaling, student interviews, and observation by my co-teacher paired with a questionnaire. I journaled during each Skype session with the science professional recording my observations including student questions, scientist responses, and student engagement.

I recorded details about each Skype session including time and duration of conversation, scheduling sessions, connection and technology issues, student engagement, and the nature of student questions,. Skype sessions ranged from 10 to 20 minutes, with an average duration of 12.33 minutes for group A (N=6) and 9.67 minutes for group B (N=3). The short nature of these conversations allowed me to fit in the sessions without losing significant instructional time. In fact, I could schedule the same lessons and activities for both the treatment and non-treatment groups regardless of the timing of the scheduled Skype session. The portable nature of the Skype app on smart phones and the brevity of the session made the conversations with the scientists simple. I communicated with the scientists via email and text to schedule sessions and touch base in the event of connection problems. Technological difficulties occurred during four of the nine Skype sessions. These problems were minor, often involving broken responses due to slow connections.

I devised a system to categorize student engagement based on the number of student initiated questions. Highly engaged conversations consisted of five or more student initiated questions, moderately engaged conversations were measured by three or four questions, and unengaged conversations consisted of two or less questions. Five Skype sessions conversations included high levels of student engagement including all three Skype sessions for Group B and two of the six Skype sessions for Group A. Of the remaining Skype conversations for Group A, one session was categorized as moderately engaged with three to five student initiated questions and three sessions were measured as unengaged.

The nature of student inquiries addressed a variety of topics including questions regarding content material, the science professional's working conditions, and education and career choices. During the collaboration with the equine veterinarian, students in Group A (class 2) asked her about the number of bones in a horse's foot, types of animals under veterinary care, and her experience with unusual cases. Students partnered with the physical therapist in Group A (class 1) inquired about the difference between a sprain and a strain, the benefits of physical therapy, and the types of patients she treats. Questions posed to the immunologist from Group B varied greatly and included why she chose to study science, types of immune system disorders, requests for description of her lab work, and questions about her college and high school experiences with regard to science.

During student interviews, five of the 12 students preferred Skype sessions over other activities like watching videos or playing science games. One student said that she wished the sessions could be longer in length while another said that she would prefer the sessions to be in person. Students indicated that the sessions were awkward and would be improved by preparing questions in advance.

My co-teacher observed the third Skype session with Group B. When questioned about student engagement, she responded that "students were involved, engaged, and had many questions for their scientist." She observed students making direct connections to their study of human body systems during the Skype conversation. My colleague suggested that the Skype sessions could be improved by student research regarding the science professions prior to the session. Additionally, she recommended students preparing questions in advance to improve the content and flow of the conversation.

## INTERPRETATION AND CONCLUSION

The Skype sessions proved to be a valuable experience with marked improvement in student perceptions about scientists and student attitudes toward science. Student perceptions of scientists changed as a result of the Skype sessions with female scientists as students drew fewer stereotypical indicators on the draw-a-scientist test (DAST). The increase in young, female depictions following the conversation with female science professionals indicates that students can see young women like themselves as scientists. Throughout this study, I have noted that student perceptions of scientists are integrally connected to their attitudes toward careers in science. Young women who perceive science and engineering as male-dominated fields where older men work in isolation will be unlikely to identify with a future career in science. When taking the attitude survey, several students asked if doctors and veterinarians were considered scientists after the Skype session. I found this both surprising and reassuring that student perceptions of medicine shifted as a result of the scientist-classroom partnership.

The interpersonal connection between the students and the scientist was powerful. Students in Group B would pull their desks together to crowd around the projector during each Skype with their scientist and I observed them developing a rapport with their scientist very quickly. This group Skyped with the immunologist during the unit on the immune and integumentary systems. The connection between the scientist’s career and the content was direct and the immunologist made a point to use terms that my students were learning in class. Additionally, she was the youngest participant and my students seemed to more easily identify with her than Group A did with their scientists, all middle-aged.

While Skype sessions alone did not influence content knowledge in a meaningful way, the conversations certainly enhanced the learning environment. Students used vocabulary terms during conversations and were able to hear about the application of scientific knowledge in the real world. The sessions provided context and relevance for their classroom learning. I argue that the relevance of content relates directly to student perceptions of scientists and attitudes towards science careers. Why would students want to pursue a career that they do not perceive as relevant?

Developing the classroom-scientist partnership was an overwhelmingly worthwhile endeavor. I found the experience to be fulfilling and gratifying as a teacher and the work required to manage the Skype sessions was outweighed by the benefits to my students. My co-teacher observed the work required to plan and implement the scientist-classroom partnership. Her feedback supports my evaluation of the Skype sessions as worth the time required to plan and implement the program.

## VALUE

I found the Skype sessions as invaluable tools to connect students with real-world science. Because I used personal acquaintances in the study, the participants were eager to connect with my students. I highly recommend using this approach when beginning to build a scientist-classroom partnership. The relationship between the teacher and scientist is key to the partnership's success as it sets the foundation for the relationship that develops between the students and the scientist. Rapport between the students and their scientist enhances the relevance of the interaction and deepens the learning experience.

As a teacher, I often find myself needing to take a step back and allow students to take control of their learning. I found this to be also true of the scientist-classroom partnership. Noticeably absent from the partnership is the *teacher*. While the teacher is an integral part in the planning and execution of the partnership, she serves as a facilitator in the conversation. I found that when I drove the interaction between the students and scientist, the students tended to pull back and ask fewer questions. Using the teacher-as-facilitator model can allow the students to build the relationship with the scientist without teacher interference and deepen the relevance of the experience. This model transcends the scientist-classroom partnership as I consider student-centered learning as an integral component of the middle school science instruction.

Through this experience I have realized the power of the scientist-classroom partnership as a professional development opportunity allowing teachers to reconnect with science in the “real world.” It allows teachers to expand their professional network by developing new relationships and connections. I am also struck by the potential for the scientist-classroom partnership to provide opportunities for other underrepresented groups to connect with scientists with whom they can identify. These partnerships provide an avenue for all students to relate to science as a human endeavor.

Questions that remain involve the best practices for implementing a scientist-classroom partnership. Student and co-teacher feedback indicated that student initiated research and pre-conversation planning of questions improve the productivity and meaningfulness of the Skype sessions. A research component might be added to increase student understanding about careers in science and engineering. Also, I want to know if grouping fewer students with a scientist might be a possibility as several students expressed a desire to Skype in smaller groups. While this might be more difficult to plan and coordinate, expanding the number of scientists partnered with a class thereby decreasing the student-scientist ratio is worth exploring.

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# APPENDICES

# APPENDIX A

## MODIFIED DRAW A SCIENTIST TEST CHECKLIST (DAST-C)

Draw a Scientist

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

Draw what you imagine when you hear the word *scientist.* Use the rectangle below for your drawing.

Draw a Scientist Test Checklist

*Adapted from the DAST-C (Finson, Beaver, & Cramond, 1995)

| Indicators | Present (notes) |
|---|---|
| Lab coat | |
| Eyeglasses or goggles | |
| Facial hair<br>(beard, mustache, sideburns) | |
| Unkempt appearance | |
| Caucasian | |
| Male gender | |
| Middle aged or senior citizen | |
| Working indoors | |
| Working alone | |
| Indicators of danger<br>(radiation symbol, biohazard, weaponry) | |
| Mythic stereotypes<br>(Frankenstein, Einstein) | |
| Symbols of research<br>(scientific instruments, laboratory equipment) | |
| Symbols of knowledge<br>(books, filing cabinet, lab journal, pens/pencils) | |
| Symbols of technology<br>(computer, phone, tablet, TV) | |
| Science captions<br>(“eureka,” formulas, equations) | |
| Indications of privacy and danger<br>(top secret, keep out, do not enter) | |

# APPENDIX B

# MODIFIED TEST ON SCIENCE RELATED ATTITUDES

Science Attitude Survey
*Adapted from the TOSRA (Frasier, 1982)

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

Student Directions:

1. This survey contains statements about science. There are no “right” or “wrong” answers. Instead, please mark what you think about these statements. Your participation is completely voluntary.
2. For each statement, mark how you feel about the statement by responding strongly agree, agree, disagree, or strongly disagree.
3. Submit your responses using the Google Form link provided by your teacher.

| **Statement** | **SA** | **A** | **D** | **SD** |
|---|---|---|---|---|
| 1. Scientists usually like to go to their laboratories when they have the day off. | 1 | 2 | 4 | 5 |
| 2. I would dislike being a scientist after I leave school. | 1 | 2 | 4 | 5 |
| 3. Scientists are about as fit and healthy as other people. | 5 | 4 | 2 | 1 |
| 4. When I leave school, I would like to work with people who make discoveries in science. | 5 | 4 | 2 | 1 |
| 5. Scientists do not have enough time to spend with their families. | 1 | 2 | 4 | 5 |
| 6. I would dislike a job in a science laboratory after I leave school | 1 | 2 | 4 | 5 |
| 7. Scientists like sports as much as other people do. | 5 | 4 | 2 | 1 |
| 8. Working in a science laboratory would be an interesting way to earn a living. | 5 | 4 | 2 | 1 |
| 9. Scientists are less friendly than other people. | 1 | 2 | 4 | 5 |
| 10. A career in science would be dull and boring. | 1 | 2 | 4 | 5 |
| 11. Scientists can have a normal family life. | 5 | 4 | 2 | 1 |
| 12. I would like to teach science when I leave school. | 5 | 4 | 2 | 1 |

| | | | | |
|---|---|---|---|---|
| 13. Scientists do not care about their working conditions. | 1 | 2 | 4 | 5 |
| 14. A job as a scientist would be boring. | 1 | 2 | 4 | 5 |
| 15. Scientists are just as interested in art and music as other people are. | 5 | 4 | 2 | 1 |
| 16. A job as a scientist would be interesting. | 5 | 4 | 2 | 1 |
| 17. Few scientists are happily married. | 1 | 2 | 4 | 5 |
| 18. I would dislike becoming a scientist because it needs too much education. | 1 | 2 | 4 | 5 |
| 19. If you met a scientist, she would probably look like anyone else you might meet. | 5 | 4 | 2 | 1 |
| 20. I would like to be a scientist when I leave school. | 5 | 4 | 2 | 1 |

# APPENDIX C

# CONTENT TESTS

Skeletal and Muscular System Content Test

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

______ 1. Identify one function of the skeletal system.
A. Control voluntary movement
B. Move food through the stomach and intestines.
C. Maintain a steady body temperature.
D. Provide shape and support for the body.

______ 2. Which type of muscle tires quickly during exercise?
A. smooth muscle
B. skeletal muscle
C. cardiac muscle
D. involuntary muscle

______ 3. Much of a newborn baby's skeleton is made of
A. hard bone.
B. soft bone.
C. cartilage.
D. ligaments.

______ 4. The spaces in bones are filled with soft connective tissue called
A. blood.
B. calcium.
C. cartilage.
D. marrow.

______ 5. What kind of motion is possible with a hinge joint?
A. rotating.
B. sliding.
C. backwards and forwards.
D. side to side.

______ 6. Why do muscles work in opposing pairs?
A. Muscles can only shorten, pulling on bones.
B. Muscles can only lengthen, pushing on bones.
C. Muscles wrap around the ones and contract at the same time.
D. Muscles pull and push at the same time.

Immune and Integumentary Content Test

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

______ 1. Identify one function of the integumentary system.
A. Regulate body temperature.
B. Move food through the stomach and intestines.
C. Reproduction of offspring.
D. Provide shape and support for the body.

______ 2. What is the outer layer of the skin?
A. dermis
B. follicles
C. epidermis
D. melanin

______ 3. What can you do to keep your skin healthy?
A. keep your skin clean
B. limit time in the sun
C. eat a healthy diet
D. all of the choices

______ 4. What is body's ability to destroy pathogens before they cause disease?
A. immunity
B. vaccine
C. inflammation
D. defense

______ 5. Antibiotics are used to treat disease caused by
A. viruses.
B. bacteria.
C. both viruses and bacteria.
D. none of the choices

______ 6. Identify one of the body's first line of defense.
A. white blood cells
B. red blood cells
C. the stomach
D. the skin

# APPENDIX D

# STUDENT JOURNAL PROMPTS

# Student Journal Prompts

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

Skeletal and Muscular Systems Unit

1. What do you already know about the skeletal system and what do you want to know?
2. What are the functions of the skeletal system?
3. Why do babies have more bones than adults?
4. What do you think mineralization means? How does this word relate to our bones?
5. Name one type of moveable joint and give an example in the human body.
6. What makes muscle tissue unique?
7. Name the three types of muscle tissue and give an example of each.
8. What can you do to build healthy bones and muscles?
9. Describe a disease of the bones or muscles.

Immune and Integumentary Systems Unit

1. What do you already know about the skin and immune system and what do you want to know?
2. Have you ever gotten sick from a cold or the flu? How did you feel? What caused this disease?
3. List the five functions of the integumentary system.
4. How does the skin regulate body temperature?
5. What happens to the skin during a sunburn?
6. How do the primary and secondary defenses of the immune system differ?
7. What are antibiotics? Think about a time you or a family member had to take antibiotics.
8. How do vaccines prevent disease?
9. Describe a disease of the immune system.

# APPENDIX E

# STUDENT INTERVIEW QUESTIONS

Student Interview Questions

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

1. Do you prefer skyping with the scientist over other activities like watching *BrainPop* videos or playing science games on the internet?
2. How did interacting with the female scientist (mention name specifically) impact your learning?
3. Tell me why you think Skyping with the scientist was helpful/not helpful to you.
4. What was it like for you to hear the scientist (mention name specifically) use the vocabulary terms (give examples) that we use in class?
5. Did the Skype session make science class more relevant to you?
6. How did Skyping with the female scientist change your feelings about science?
7. Are you interested in studying science after high school?
8. How could I make the experience with the scientist and virtual field trip better?

# APPENDIX F

## CO-TEACHER OBSERVATION QUESTIONNAIRE

Co-teacher Observation Questionnaire

1. Were expectations and objectives clearly communicated to the students?
2. Describe the level of student engagement that you observed.
3. Did you observe students making connections to the content during the Skype? If so, please describe.
4. Were the objectives revisited at the end of the lesson?
5. What went well in the lesson?
6. How could the lesson be improved?
7. From your observations over the course of the unit, how could the Skype with the scientist be improved?
8. Because we share a classroom, you have observed the development and implementation of the treatment. Do you think that the planning and time commitment was worth the student outcomes?