Shadow Puppet Plays in Elementary Science Methods Class Help Preservice Teachers Learn about Minority Scientists

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Abstract

This practical article describes an arts-integrated project with engineering design and science concepts from the Next Generation Science Standards, art principles from the National Arts Standards, as well as ideas under the theme of "Culture" from the National Council for the Social Studies Standards. Preservice teachers in an undergraduate science methods class researched the background, life, and accomplishments of a minority scientist by reading books and articles about the person. They created a script to present the experiences and contributions of the scientist to other preservice teachers and, eventually, elementary students. Shadow puppets were constructed out of cardboard to portray different aspects of the scientist's setting and work communicated by the script. The preservice teachers performed the shadow puppet shows for their peers, receiving feedback. Examples of the puppet show scripts and models of puppets are included in this article.

Key Words

Arts-integration, shadow puppets, science methods, preservice teachers, minority scientists, culture, STEM education, STEAM education

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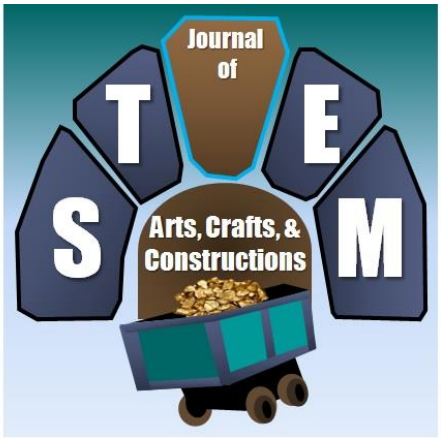

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Introduction

This article describes an arts-integrated science project conducted with preservice elementary teachers in a science methods course. Preservice teachers worked in small groups, chose a minority scientist, read information about the chosen scientist from books provided by the course instructor, and researched additional information in other library books or online resources. They created paper stick puppets and a script to present to the class a short shadow puppet play about the scientist's life and contributions to science.

Project Rationale

Most preservice teachers are White, middle class students who will be teaching an increasingly diverse population of students (Deruy, 2013; Maxwell, 2014). Becoming culturally competent to teach minority students and having background knowledge of successful minority scientists to inspire future students is essential. Many students face the intersection of multiple points of oppression (Garbato, 2009) including racial or ethnic discrimination, poverty, gender or sexual orientation bias, religious discrimination, or disability that combine to magnify the oppression. Grant and Zwier (2011) recognized seven constituents of pedagogy that are culturally responsive to these intersectional identities of students: 1) teachers' views

of student assets; 2) knowledge of various components of culture; 3) experience in students' community; 4) challenging, relevant content; 5) multiple modes of expression; 6) differentiation; and 7) critical consciousness and engagement. In accordance with Grant and Zwier's ideas, this project was designed to help preservice teachers recognize the legacy of scientific achievement of minority populations, to learn how culture impacts student vocational choices, and to become familiar with different community experiences that reinforce specific career paths through biography. The project provided the stimulating activity of researching the life of a scientist and expressing the most essential components through a short puppet play script and hand-made shadow stick puppets. Preservice teachers translated adult texts into material appropriate for elementary students, while teaching positive ways to overcome setbacks and recognizing societal obstacles that need to be addressed and eliminated.

Arts Integration

Arts integration involves students in creatively constructing and demonstrating meaning that supports learning objectives of the integrated subject through an art form (Silverstein & Layne, 2013). Effective arts integration moves beyond a single activity to transform learning into student-centered projects in which students draw upon prior knowledge, connect to previous experiences, demonstrate their learning, and reflect upon the process and products. The strongest benefit of effective art integration occurs when both of the integrated subject areas are reinforced and extended (Silverstein & Layne, 2013). For this to happen, teachers must engage in very purposeful planning in which they define the big ideas that should be taught and learned by students from both integrated subject areas (McDonald, 2010). Arts-integrated projects tend to be more motivating and student-centered because they allow students freedom in selecting tasks and making choices that assist them in understanding content, while placing responsibility on them for fulfilling the project requirements (Lynch, 2007). Communication through the arts allows students to expand their repertoire of communication by challenging them to transform their knowledge into pictures, gestures, or sounds (Lynch, 2007). The array of choices provided by the arts allows students multiple correct ways of expressing their feelings and knowledge, and of seeing the perspectives of others (Davis, 2009). A benefit of these multiple perspectives is the opportunity to express cultural ideas and empathy, reflect personal values, and to think critically and creatively as one problem-solves, comprehends, and composes (Colley, 2012; Cornett, 2011). Arts-integrated projects can help students to recognize how form and content are connected, can open the door to explorations of new, exciting media, and provide a sense of purpose and direction within a project (Colley, 2012). Finally, the surprises found in art such as unexpected discoveries related to new media or accidental alterations of products should be viewed as rewards to be taken to advantage. Students may exercise their imaginations and problem-solving skills to incorporate "mistakes" into the body of work, turning disaster into satisfaction (Eisner, 2009).

Background

Scholars agree that shadow theater originated somewhere in Asia but the exact time or place of origin is not known (Chen, 2003). Nomadic tribes of central Asia who used fires and tents (therefore, having access to a lighted screen) carried leather cut-outs of animals and characters with them for shadow scene performances. Some expertly-cut leather silhouettes of animals were found in burial grounds on a trade route between China and Russia in Outer Mongolia; others are known from three or four centuries BCE from the Scythians (Iranian-Eurasian nomads) (Baird, 1973). A Chinese myth (Currell, 2015) from 121 BCE relays the story of a grieving emperor who mourned the loss of his favorite mistress. Nothing consoled him until a court artist created a shadow figure in her likeness and, using her voice and gestures, brought her to life on a silk screen illuminated from behind.

Shadow puppet plays were used at an early time in India with some evidence of their existence as play scripts and descriptions in the Mahabharata literature from 400 BCE to 400 CE (Stache-Rosen, 1976). This leather puppetry was introduced to Java and Indonesia when kings from South India conquered these islands in the sixth century (Murty, 1976). Shadow plays may have been introduced to China by Buddhist monks during the great period of Buddhist expansion from the sixth through ninth centuries CE, but also may have followed with Hindu teachings (Chen, 2003). The rich

multicultural art traditions of shadow puppets in Asian countries may be an interesting connection to explore as extensions to this project.

Shadow puppetry has been used by many authors to support literacy skill development and content area reading (e. g., second graders in Peck & Virkler, 2006), to further social studies understandings of the cultures and arts of different groups of people (e.g., for preservice teachers in Hsieh & Davenport, 2013), and to explore gender issues (e.g., Orenstein, 2015). Shadow puppets have been used by elementary students to explore properties of materials in light (McCubbins, Thomas, & Vetere, 2014), as a science demonstration of solar energy for high school students (Osnes & Hunt, 2014), and as a medium for exploring the lives of scientists by primary students (e.g. Rule & Webb, 2014). This article describes how shadow puppets were used by preservice teachers to explore the lives and contributions of minority scientists while also conducting inquiry into the properties of various papers and materials in a beam of light. Shadow puppets are particularly useful for these purposes because they are inexpensive and easily constructed with common materials, allow ample experimentation with different constituents, and provide a means for exploring shadow properties.

Shadow puppet shows are especially effective in holding the audience's attention because of the mysterious surroundings of a darkened room and the charm of interesting student-made puppets. This magical atmosphere alludes to the possible origins of shadow puppets in shamanism. The animal silhouettes used by nomadic tribes were likely used by shamans to tell stories or to interact with the shadowy spirits around them (Chen, 2003). Additionally, historians have suggested that the performance of Balinese shadow theatre (Wayang) represents the peak of development of shamanism in that culture (Rubin & Sedana, 2007).

National Standards Addressed

This shadow puppet play project fulfilled many of the promises of effective arts integration by addressing both science, social studies, and arts standards.

Next Generation Science Standards. Two of the Next Generation Science Standards (NGSS Lead States, 2013) that pertain to asking questions and defining problems to research are addressed by the shadow puppet play project as students learn about the work of successful minority scientists. For example, Engineering Design Standard K-2-ETS1-1 states "Ask questions, make observations, and gather information about a situation people want to change to define a simple problem that can be solved through the development of a new or improved object or tool." This standard is supported by learning about the work of Fred Begay, Navajo/Ute nuclear physicist, who was interested in producing affordable heat energy from the sun without damaging the environment. Another Navajo scientist, Willard Denetclaw, who grew up on a farm working with cattle and sheep, asked why some animals were born unhealthy, bringing him into the field of biology and eventually to studying rare human diseases. He engaged in research work concerning Duchenne Muscular Dystrophy in which he investigated dynamic changes in cells. This work supports the Next Generation Science Standard 3-5-ETS1-1, which states "Define a simple design problem reflecting a need or a want that includes specified criteria for success and constraints on materials, time, or cost."

Another Next Generation Science Standard addressed by the activities in this project is the first grade standard, 1-PS4-3: Plan and conduct an investigation to determine the effect of placing objects made with different materials in the path of a beam of light. This project was initiated after preservice teachers had participated in lessons related to properties of light and shadow, continuing the investigation into the behavior of transparent, translucent, opaque, and perforated materials in a shadow theater. The second grade standard, 2-PS1-2: Analyze data obtained from testing different materials to determine which materials have the properties that are best suited for an intended purpose, can be applied to the project as preservice teachers experimented with different materials to create effective shadow puppets. The engineering design standard for grades kindergarten through second grade can also be applied: K-2-ETS1-1: Ask questions, make observations, and gather information about a situation people want to change to define a simple problem that can be solved through the development of a new or improved object or tool. This standard is implemented as preservice teachers seek to design shadow

puppets that present visual information in an optimal way to an audience. Engineering design standards for grades 3 through 5 can also be applied to this project: 3-5-ETS1-1: Define a simple design problem reflecting a need or a want that includes specified criteria for success and constraints on materials, time, or cost. Preservice teachers were given the problem of designing a shadow puppet play within two weeks to portray the life and major accomplishments of a minority scientist.

Social Studies Standards. The National Council for the Social Studies (2010) has identified ten important themes of social studies. Several of these themes are addressed by the shadow puppet plays project. One social studies theme that is well-supported is "Culture." Examining the lives and social contexts of minority scientists helps students to understand how cultural circumstances change over time. For example, Cupeno Native American Marigold Linton was the first of her people on the Morongo Reservation to attend and graduate from college. She was also the first woman to be hired as a full time professor at the University of Utah. An example of how people create and adapt to culture is Willard Denetclaw's reluctance to dissect a cat in anatomy class because it conflicted with his cultural beliefs. His discussions with the tribe's medicine man allowed him to deviate from accepted behaviors when necessary to reach a worthy goal. Another aspect of culture that is advanced by studying the lives of minority scientists and making shadow puppet plays is the awareness, through reflection, of similarities and differences among cultural groups. For example, Daniel Hale Williams, an African-American surgeon, began by following in his father's career of being a barber. During the mid to late 1800's many people depended on their barbers for medical advice. He eventually became an apprentice to a doctor and attended medical school, becoming the first successful open heart surgeon. Students will find similarities and differences between their current views of these professions and the paths people pursue to become medical doctors.

Another social studies theme addressed by this project is "Individual Development and Identity." Personal identity is shaped by culture, groups, institutional influences, and life experiences. This concept is reinforced by learning how these factors help a minority scientist to choose a science career and how they assisted in success. For example, Granville T. Woods had little schooling, but learned science and engineering through his machine shop job and the many other early positions he held. Working with trains stimulated him to invent railway telegraphy devices for communication on trains. Similarly, Willard Denetclaw's farm upbringing caused him to develop an interest in animals and disease.

National Core Arts Standards. Many of the National Core Arts Standards (National Coalition for Core Arts Standards, 2014) can be applied to the shadow puppet play project. During the conceptualization and creation phase of the project, students engage in generating and conceptualizing artistic ideas and work (Anchor Standard #1), organizing and developing these artistic ideas and work (Anchor Standard #2) and then refining it (Anchor Standard #3). Performance of the puppet play to peers supports additional standards. Anchor Standard #6 states "Convey meaning through the presentation of artistic work." This occurs as students decide the order and motion of puppet images to illustrate and bring to life the play scripts. Responding to the artwork of others occurs as peers tell the strengths of the production and make suggestions for improvement or expansion (Anchor Standard #9: "Apply criteria to evaluate artistic work"). Another standard supported by this project is Anchor Standard #10 "Synthesize and relate knowledge and personal experiences to make art." Explanations of choices and personal connections made by the presenters assists peers in understanding the presentation.

Method

This project was easy to implement and exciting for preservice teachers who enjoyed the drama and creative expression through puppets.

Materials and Equipment

This project requires a shadow theater, a bright light such as a gooseneck lamp with a clamp attachment that can be fastened to the shadow theater, a darkened room, and stick puppets that portray characters, objects, and scenery.

The shadow theater used in our class had a simple three-piece, easily stored construction with the front and the two triangular side supports cut from plywood. See Figure 1. The front piece had the shadow scene area cut out and long slots on each side to receive the two tabs of each triangular side support. Each triangular side support tab was then inserted into its slot and held in place by a pin put through a hole in the triangular support that prevented it from pulling backwards out of the slot. A piece of plain pink bulletin board paper was glued over the scene area on the back side of the front to provide a smooth screen for the shadow puppets to rest against and float across during the play. A similar shadow theater could be made from a large cardboard box instead of plywood. A gooseneck lamp was clamped onto the top of the theater and angled so as to shine upon the screen from the back; shadow puppets will rest against the back of the screen with the light coming from behind them.

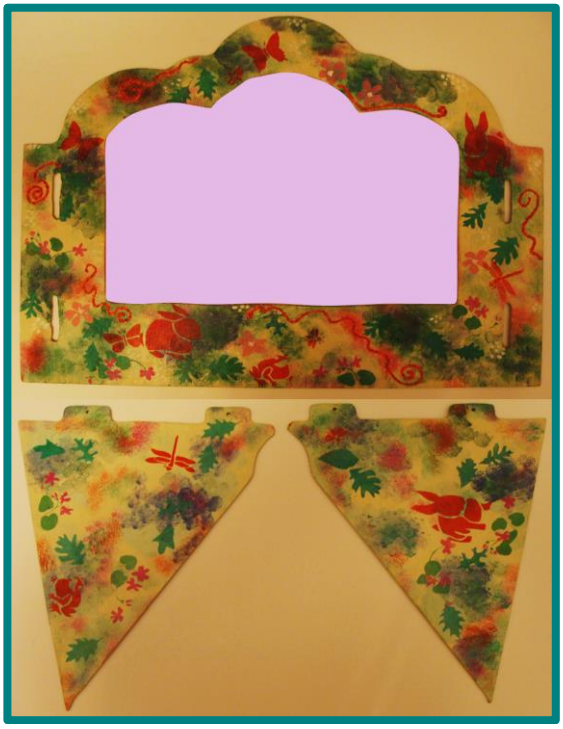

Figure 1. Shadow Theater Pieces

The shadow puppets were simple stick puppets made from recycled file folders, cardboard, craft foam sheet, and cardstock paper. The sticks were made by cutting a rectangle approximately 28 by 6 centimeters in dimension (approximately 11 by 2.5 inches) and folding it along the longest dimension three times, creasing it sharply, unfolding, then smearing it with white craft glue, and refolding it to make the stick. Pressing these sticks under heavy books allowed them to dry straight and flat. Each puppet image was made by sketching or tracing a figure, head, object, or scenery item onto cardboard or cardstock and cutting along the outline. Internal features were shown by cutting out with scissors narrow lines or areas, such as eyes, that will appear light against the dark silhouetted shape. Perforating an area to be cut out with a hole punch is often an effective way of starting the cutting. Color can be added by covering cutout areas with colored tissue paper, cellophane, or transparent colored plastic, or by using colored craft sheet foam to make the puppet, which will retain a colored silhouette. These materials allow experimentation with opaque, translucent and transparent materials, thereby practicing science concepts related to properties of materials in light. Experimentation with different materials is recommended and part of the fun of designing the stick puppets. The silhouette is then securely glued to the stick. Making a two-part puppet with a paper fastener connecting the parts can allow exciting action. Hand-drawn puppets are much more charming than traced ones, but students who have not had the opportunity to develop drawing skills and confidence tend to prefer tracing. See Figure 2 for two example shadow puppets depicting Marigold Linton made by tracing photographs of her and cutting out light-colored parts or outlines with scissors.

Figure 2. Two Shadow Puppets Featuring Marigold Linton Alone and with a Colleague

Class Procedures

The first day of the science methods course, students completed the Draw-A-Scientist Test without any instruction other than to draw a scientist. Later in the course, the professor asked students to read an article about the Draw-A-Scientist Test (Finson, 2002) and to examine drawings of scientists made by class members. Stereotyped characteristics or features that appeared in several drawings such as male, old age, facial hair, wild hairdo, lab coat, eyeglasses, laboratory glassware, high-tech equipment, and exclamations such as "Eureka," among others, were noted as students viewed their scanned drawings electronically projected on a screen. A discussion ensued as to how to bring awareness of more diverse successful scientists to elementary students.

The professor introduced the strategy of teaching about diverse scientists' lives and contributions to science through shadow puppet plays and explained the assignment. Students formed small groups of three to four students and chose one of the scientists from a list. The professor provided a short trade book about that scientist and asked students to research additional information to create a short five-minute play about the scientist's life and achievements. The play script would be turned in and would need to relay the cultural identity of the scientist and how different events shaped his or her life. Each student was required to contribute a minimum of two stick puppets or props to the play. Students were provided a rubric that would be used to score their work and time during class to organize the project. The rubric is shown in Table 1. The professor passed around several stick puppets she had made and demonstrated how to make a stick puppet of a house in just a couple of minutes. Connections were made to a previous lesson on light and shadows that the class recently had experienced.

Table 1. *Rubric Used for Scoring Minority Scientist Shadow Puppet Play Projects*

Criteria Question	Yes, entirely = 4 Points	Mostly = 3 Points	Somewhat = 2 Points	A little = 1 Point	No = 0 Points
1. Creation of Shadow Puppets. Did each person in the group create at least two recognizable, neat, sturdily-made shadow puppets that represented the intended concepts from the play?					
2. Efficacy of Play Script. Was the play script well-written, clever, and interesting?					
3. Scientist's Culture. Did the puppet play script effectively explain how the person's culture affected his or her career path to science?					
4. Scientist's Contributions. Did the puppet play script effectively present one or more contributions that the scientist made to science or the science community?					
5. Resources. Did the group note at least two other resources of information about the scientist in addition to the book provided?					
6. Material Properties in Light. After the puppet play presentation, did a group member correctly explain opacity, translucency or other light properties utilized by or discovered during the puppet work?					
7. Participation. Did all members contribute to the script, puppets, and presentation of the play?					

Results and Discussion

Preservice Teacher Products

Five example puppet play scripts with photographs of the shadow puppets are shown in the appendix. Students were able to present the lives and major contributions of these scientists with attention to their culture and life circumstances in a lively and fascinating manner. The puppet plays were especially exciting because of the seldom-encountered darkened and cozy atmosphere created during the shadow performances. The preservice teachers had the freedom to make choices concerning which facts and events to include, along with what images to use during the play, thereby making the project student-centered and motivating (Lynch, 2007). They drew upon their background knowledge and researched information to explain the work of the scientists at an elementary level. Science, art, and social studies concepts were addressed through project work, strengthening the learning in all subject areas (Silverstein & Layne, 2013). The professor carefully planned the project to address the science, social studies, and arts standards integrated into the project (McDonald, 2010). Students used many different approaches and materials in creating their stick puppets. They expressed abstract ideas with interesting symbols and portrayed the perspectives of others (Davis, 2009). The use of drama deepened the students' understanding of the minority scientists as they researched and created the script, then constructed the necessary puppets for their shadow puppet play. Taking on the role of a minority scientist facilitated the learning of new facts about their scientist and encouraged preservice teachers in creatively sharing that information. They were able to role-play what it must have been like to be that scientist. After the plays, many preservice teachers remarked how they enjoyed learning about the culture and lives of the scientists, and how they felt empathy for the hardships and obstacles they overcame (Cornett, 2011).

Application of Standards

Next Generation Science Standards. Engineering Design Standard K-2-ETS1-1 and 3-5-ETS1-1 were supported by preservice teacher work in researching the life and work of the scientists to create play scripts. Preservice teachers also determined the effects of placing different materials in the path of a beam of light as they experimented with different craft materials to find those best for the desired properties of their shadow puppets (1-PS4-3 and 2PS1-2). Requiring more than an oral report on experiments with materials might facilitate stronger learning outcomes for these standards in the future. Such a written report might contain the results of testing various papers and other materials for use in shadow puppets. If the professor required each person to incorporate a new material not provided in class (something other than cardstock, file folder cardboard, or cardboard from frozen food packaging), such as tinsel, yarn, oiled paper, tissue paper, or colored plastic, into one of the shadow puppets, perhaps more experimentation and creative products would result, better supporting the engineering standards (K-2-ETS1-1 and 3-5-ETS1-1).

Social Studies Standards. Preservice teachers noted several cultural factors that influenced the career paths of the minority scientists, supporting the social studies theme of "culture." They expressed great interest in class in understanding cultural barriers to science careers. Preservice teachers noted some possible barriers for K-12 students in low-socioeconomic rural schools in the area, along with African American and immigrant students attending low socio-economic urban schools. One barrier for many students is that their parents did not attend college and so do not know how to coach them in developing the skills and dispositions to become college-bound. Another barrier is the lack of visible role models for many African American students in the schools and community of people who have succeeded in science careers.

National Core Arts Standards. The completed projects provided evidence of many of the National Core Arts Standards being addressed. Shadow play presentations were organized, well-rehearsed, and quite clever in their storylines indicating that Anchor Standards 1, 2, and 3 had been supported by the work. Play script stories were coherent and conveyed important information about the lives and contributions of scientists (Anchor Standards 6 and 10). Other groups were asked to provide strengths and suggestions for improvement or expansion of the work of the presenting group. Preservice teachers listened attentively and provided

good insights and suggestions, supporting Anchor Standard 9. Some suggestions included moving the puppets more during the presentation to better hold the audience's attention and keeping the puppets flat against the screen so that they remain in focus. Some students advised that more details of the scientist's life be given during the presentation and that future presentations might be enhanced with sound effects or background music.

Challenges and Suggestions

One of the challenges of this project is locating good informational texts on minority scientists. Over several years, the professor teaching the science methods course was able to gather enough books for eight groups in each of two sections of science methods courses. It is important to provide a resource to each group so that they can immediately get started. There are some good websites providing information, as noted in the list of references in the appendix.

Another challenge is the concern some preservice teachers have that they are "not creative" enough to produce a shadow puppet play. There is evidence to suggest that recent American college graduates lack creativity and innovation skills because the education system that produced them emphasized quick determination of the one right answer (Land, 2013). Arts integration can assist students in developing more divergent thinking skills, combining aesthetic and analytic modes of thinking (Bequette & Bequette, 2012). Creativity seems to be a self-fulfilling prophecy in which those who believe they are creative take risks, put themselves in new situations, try new approaches, and generate new ideas (von Oech, 2008). Encouraging students, appreciating their artistic attempts as unique or interesting, and providing tips such as the possibility of tracing some images helps. Another useful strategy is to think out loud the considerations one makes while demonstrating the making of a shadow puppet.

Conclusion

Overall, the project was motivating (based on observations of student enthusiasm) and resulted in the desired standards being supported through student learning. The preservice teachers were able to participate in a project idea that encouraged creativity as well as science inquiry, and could be easily implemented in their own classrooms in the future. In fact, several preservice teachers later approached the professor, asking to see the shadow puppet theatre again and to take photographs of it so that they could construct their own. Through this project, preservice teachers were able to see firsthand how the arts can be integrated with science to bring deeper understanding to both areas.

The professor implemented this project for several semesters while teaching the course, allowing it to evolve as she discovered books describing the lives and accomplishments of additional minority scientists. This wide array of scientists from different minorities broadened the preservice teachers' awareness of many different minority scientists and encouraged the preservice teachers to expose their own future students to a wide range of scientist role models. Several preservice teachers who were student-teaching the semester after science methods class told the professor how they had incorporated readings about minority scientists and puppet plays into their lessons with elementary students. Preservice teachers had experienced the benefits of arts integration as they worked with their team to create, collaborate, communicate, and think critically; they wanted a similar experience for their students.

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Appendix

Minority Scientist Shadow Puppets and Scripts

Fred Begay

Navajo/Ute Native American

Nuclear Physicist

Written by Audreanna Bednarz, Gabrielle Doud, Megan Olsen, and Jennica Ruppert.

Information supporting this script was taken from American Physical Society (2015), Kurzweil, (2013), Meyer and Cline (2005-2015), and St. John (1996).

Puppet Characters: Reporter, Fred Begay, School building, Hunter, Family, Fox, Sun, Mushroom cloud (Atom bomb explosion). See Figures 1 and 2.
There are other images that could be used to support this story.

(Enter Reporter and Fred Puppets)

Reporter: Hi Fred, thanks for letting me meet with you today.

Fred: No problem. What do you want to know?

Figure 1. Shadow Puppets used in the Fred Begay Shadow Puppet Show

Reporter: Tell me about yourself.

Fred: *(Family puppet)* Well, I was born in 1932. My father, mother and four siblings lived in Towaoc, Colorado.

Reporter: What did you do in your free time as a child?

Fred: *(As the following section is spoken put up the hunter and the fax puppet.)*

I was a skillful hunter, my parents called me Clever Fox. When I wasn't hunting I went to school.

Reporter: Clever Fox, that sounds like you were very smart. What was your school like?

Fred: At nine years old, I walked by the river for 15 miles to school. *(School building)* The school I attended was a school for Indian children, it was run by the government and White people.

Reporter: Sounds like you had to walk a long way to school. What did you do when you were done with school?

Fred: I joined the US Army and did rescue missions during the Korean War. When I returned home, I started college at the University of New Mexico. *(School building)*

Reporter: Well thank you for serving our country. How was your college experience?

Fred: I attended the University of New Mexico. I graduated with honors. I earned my bachelor's degree in physics and math in 1961. I went on to obtain my master's in 1963, and eventually my doctorate in physics in 1971.

Reporter: Sounds like you were very busy in college. What did you do after you left the University of New Mexico?

Fred: I went to work for Los Alamos National Laboratory where the first atom bomb was made in 1945. *(Mushroom Cloud Puppet)* I, myself, worked on joining atoms to produce heat.

Reporter: Why did you take on this type of project?

Fred: I wanted to learn more about the heat coming from the sun. *(Sun Puppet)* I was trying to find a way to produce an affordable heat source without harming the environment. I wanted to try to copy the way the sun works. I thought this could help bring heat and electricity to reservation homes.

Reporter: That is fascinating. Have you done much to share your love of science with other Native people?

Fred: Yes, I was one of the founders of the Society for the Advancement of Hispanic/Chicano and Native American Scientists (SACNAS).

Reporter: Thank you for all your work, your sharing your science vision with others, and for meeting with me today.

Fred: You're welcome, thank you for letting me take up some of your time.

Figure 2. Fred Begay Shadow Puppets

Meet the Scientist:

Dr. Willard F. Denetclaw, Jr. Navajo Native American Biologist and Zoologist

Written by Raine Allen, Emily George, and Francis Lapointe.

Information supporting this script was taken from Denetclaw (2002, 2015), Lapahie (2001), and St. John (1996).

Puppet Characters: Maryam, Dr. Denetclaw, Cow, Mouse, State of California, School building, and Medicine man. See Figures 3 and 4. There are many other images that are related in this story. Try having your students create shadow puppets to go with the other images in the story.

Maryam: Welcome everyone to this session of "Meet the Scientist." I am your host, Maryam Bishop. Today's guest scientist is Dr. Wilfred Denetclaw. Dr. Denetclaw is a Navajo scientist who grew up in the four corners region of the Navajo Nation. Dr. Denetclaw, welcome to "Meet the Scientist."

Dr. Denetclaw: Thank you I am glad to be here, sharing my story with you and your audience.

Maryam: Would you please share with us your occupation and where you are currently working?

Dr. Denetclaw: I am currently a Zoologist and Cell Biologist working at the University of California in San Francisco.

Maryam: Tell us a little bit about your background growing up in the Southwestern part of the United States.

Dr. Denetclaw: I was born in 1959 near the four corners at the Navajo Nation. I grew up on a farm, where I spent much of my time working with cattle and sheep. *(Cow and Sheep Puppets)*

Maryam: Was this the beginning of your interest in diseases?

Dr. Denetclaw: Yes, I noticed that when animals were born they varied in strength and health. I wanted to know why the animals were born unhealthy and what was causing this condition?

Maryam: How did you become interested in studying biology?

Dr. Denetclaw: I had spent my early life raising and caring for animals. I thought I would like to have a job working with animals.

Figure 3. Shadow Puppets for Dr. Willard F. Denetclaw, Jr. Shadow Puppet Play

Maryam: Were there any challenges for you as you worked to become a biologist?

Dr. Denetclaw: I began studying biology at Fort Lewis College in Colorado. One day in class, I was asked to dissect a cat in anatomy class, which is strongly against the beliefs of my people.

Maryam: What did you do?

Dr. Denetclaw: I was unsure what to do, so I visited my village and talked to a medicine man. The medicine man told me I was like a modern scout, and that my actions were in good faith as I was searching to make my family and tribe's lives better through research on diseases.

Maryam: That must have made you feel good about your career choice.

Dr. Denetclaw: I returned to Colorado to continue my education and completed my degree in Biology. *(Mouse Puppet)*

Maryam: Where did you go next on your educational journey?

Dr. Denetclaw: I continued my education at the University of California at Berkeley, where I completed a Ph.D. in 1991 in Zoology. *(State of California Puppet)*

Maryam: Tell us about your current research.

Dr. Denetclaw: I am working at the University of California on diseases without a cure. *(Mouse Puppet)*

Maryam: Why diseases without a cure?

Dr. Denetclaw: A few years ago a young Navajo man was taken to a hospital and died of an unknown disease. Along with other scientists, I worked hard to find a cause and a cure. We struggled trying to find where this unknown disease had come from or to discover where there was a common link between the victims of this disease.

Maryam: That sounds like a real medical mystery. Are you working on any other medical mysteries?

Dr. Denetclaw: In addition to working with this unknown disease. I am also doing research on Duchenne Muscular Dystrophy. Duchenne Muscular Dystrophy effects mostly boys.

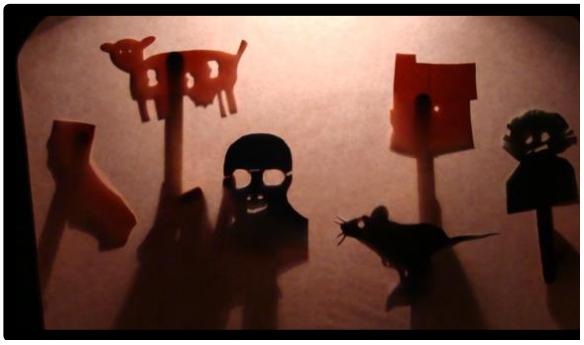

Figure 4. Shadow Puppets for Dr. Willard F. Denetclaw, Jr. Shadow Puppet Play

Maryam: What have you learned so far while researching Duchenne Muscular Dystrophy?

Dr. Denetclaw: I am investigating the dynamic changes in cells. These changes can be interpreted as signal mechanisms that will help identify skeletal myogenesis in the early stages.

Maryam: Your work is very important. How has your Navajo culture influenced your life as a scientist?

Dr. Denetclaw: Throughout my life, I have stayed true to my Native roots while also continuing my passion for cell biology. I believe what the Medicine Man told me, I am like a modern scout in an unfamiliar world. There is so much left to be learned in my field, and it is rewarding to be a part of this field of study.

Maryam: Thank you for your continued contributions to the study of biology and zoology.

Dr. Denetclaw: It is my hope that others of the Navajo Nation will feel able to pursue their dreams of becoming scientists. I sometimes tell young Native scientists, "Don't let other people tell you what is culturally right, you know, important. You should think about it yourself".

Maryam: Those are indeed words to live by. Thank you Dr. Denetclaw for joining us today on "Meet the Scientist."

Dr. Denetclaw: You are welcome it was a joy to be here with you.

Maryam: Join us next week when our guest scientist will be Dr. Marigold Litton a cognitive psychologist from the University of Texas.

Marigold Linton

Cupeno Native American

Cognitive Psychologist

Written By: Jordan Garlich, Sara Reierson, and Alyssa Stevenson.

Information supporting this script was taken from Linton (2012), SACNAS (2005-2012), and Westberg, (2007).

Puppet Characters: Reporter with microphone, Marigold for puppets, Brain, State of California Number One, College, Book. There are many other images that are related in this story. See Figures 5 and 6. Try having your students create shadow puppets to go with the other images in the story.

(*Reporter, Microphone and Marigold puppets are on the screen until the end of the script.)*

Reporter: We are here today with Marigold Linton to talk about her success in the field of science. Marigold, we are glad you could be with us today.

Marigold: Glad to be here!

Reporter: Let's start with a little bit about your heritage, if that is all right with you?

(California puppet)

Marigold: That sounds great! I was born in 1936 in Southern California. My father was a Native American from the Cupeno tribe and my mother was not. I am the great-granddaughter of Antonio Garra, war chief of the Cupeno. I was raised in poverty. I overcame a lot of obstacles to get to college. Luckily, I have always done well in school so college wasn't out of my grasp.

Figure 5. Marigold Linton Shadow Puppets

Reporter: It is said that you broke an impenetrable racial barrier in education. What can you tell us about that?

Marigold: Well, I was the first Indian from the Morongo Reservation in California to continue on to college to study cognitive psychology. I attended the University of California, Riverside. *(College Puppet)* I was the only Native American at the University of California, Riverside. I went on to graduate school at the University of Iowa. I received my Ph.D. from the University of California, Los Angeles. I was just one of 14 Native Americans to earn a Ph.D. at that time. After that I became a professor at San Diego State University. I left San Diego State University to become a professor at the University of Utah. I was actually the first woman to be hired as a full time professor at the University of Utah.

Reporter: That is definitely a lot of time in college! Was your family supportive of you attending college?

Marigold: Actually no. They repeatedly told me that I would flunk out before the first semester ended so I shouldn't bother going. Most of the people on my reservation couldn't even tell me what college was.

Reporter: It must have taken a lot of courage to go when you had many negative influences. What was it like when you first attended?

Marigold: Everything was traumatic. I couldn't figure out how to catch the bus and on campus I was afraid to make a fool of myself, so I never talked. When called on in class, I would start crying and run out of the room.

Reporter: You sure went a long time for all that struggling.

Marigold: Slowly but surely, I learned the ways of the world I hadn't grown up in. I started dating, working part-time, and winning increasingly larger scholarships.

Reporter: What a huge accomplishment! Can you tell us about some of your other accomplishments?

Marigold: Of course. I have two published works. *(Book puppet)*

Memory Observed: Remembering in Natural Contexts and *Autobiographical Memory*. I am one of the founding members of the Society for the Advancement of Hispanic/Chicano and Native American Scientists (SACNAS) and the National Indian Education Association (NIEA). I have also served as the director for mathematics and science initiatives as a part of the University of Texas system as well as serving on a number of various boards. *(Brain puppet)*

I have done large amounts of research in my field including the development of a consortium to support biomedical research opportunities for Native American students. My research regarding long-term memory has been internationally recognized as well and I have several honors and awards named after me.

Reporter: I've also read that you, along with Lance Armstrong, are examples of something. What are people saying about the two of you?

Marigold: That we are examples of the courage needed to fulfill your dreams. Even though our dreams were different, we both reached them. I am honored to be an example of that for people around the world.

Figure 6. Marigold Linton Shadow Puppets

Reporter: That is something to be very proud of. Thank you for sharing all your life's accomplishments with us here today!

Marigold: You are welcome! I am glad I was able to be here.

Daniel Hale Williams

African-American

Doctor and Surgeon

Written by Ashley Ehrig, Jenna Deutmeyer, Dani Hale, and Bridget Spree

Information supporting this script was taken from Bellis (2015b), Bio. (2015), Dunbar (2006-2015), (Ruffin (2007), The Black Inventor On-line Museum (1998-2011), Haber, (1970) and WGBH Educational Foundation, (2003).

Puppet Characters: Frank, and Dr. Dan. See Figures 7 and 8. There are many other images that are related in this story. Try having your students create shadow puppets to go with the other images in the story.

Frank: Welcome everyone to this session of "Meet the Scientist." I am your host, L. Frank Bishop. Today's guest scientist is Dr. Daniel Hale Williams. Dr. Williams, welcome to "Meet the Scientist."

Dr. Dan: Thank you, Frank. Please call me Dr. Dan. *(Dr. Dan Shadow Puppet)*

Frank: Dr. Dan, tell us a little about yourself.

Dr. Dan: I was born in 1856 in Hollidaysburg, Pennsylvania. My heritage was a mixture of African-American, Caucasian, and Indian. I was the 5th child born out of 7. *(State of Pennsylvania Shadow Puppet)*

Frank: What types of jobs did you have along the way to becoming a doctor?

Dr. Dan: My father, a barber, died when I was ten years old. (Scissors Shadow Puppet) Following in my father's footsteps, I opened up my own barber shop when I was seventeen.

Frank: How did you get from being a barber to being a doctor?

Dr. Dan: During my time, barbers were looked upon as substitute doctors. We had to know about the human body and many of the ailments that people would suffer. We were also sometimes midwives.

Frank: That is fascinating! How long did you work as a barber?

Dr. Frank: I worked in my own barber shop until, in a chance meeting at the age of 22, I met a doctor who took me under his wing. I became his apprentice. I enrolled in medical school and graduated in 1883. *(Graduation Cap w/ Tassel Shadow Puppet)*

Frank: Were there many opportunities for you to work in a hospital?

Dr. Dan: No, at that time there were not any opportunities for me to work in an established hospital. I began my medical career by doing surgery in my patients' homes. In 1891, I made medical history when I opened the first interracial hospital in the U.S. that was also a training facility for nurses. *(Hospital Symbol Shadow Puppet)*

Frank: What was the name and location of the hospital?

Dr. Dan: Provident Hospital in Chicago, Illinois.

Frank: What other contributions have you made to medicine?

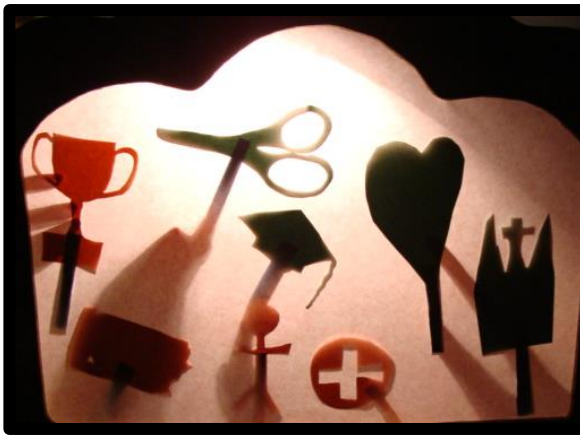

Figure 7. Shadow Puppets for Daniel Hale Williams Shadow Puppet Story

Dr. Dan: In the summer of 1893, I entered the chest cavity of a stabbing victim. Fifty-one days later, the patient was released from the hospital. I was the first surgeon to sew up a human heart. *(Heart Shadow Puppet)*

Frank: Was Provident the only hospital in which you worked?

Dr. Dan: No, from 1894 until 1898 I was the Director of the Freedmen's Hospital in Washington, D.C.

Frank: Were the people working at the hospital welcoming to you and your methods?

Dr. Dan: There is always an adjustment period when the administration changes. I found that the doctors and nurses were very open to making the positive changes needed to improve medical care.

Frank: How did your life change after you left The Freedmen's Hospital?

Dr. Dan: Not long after I left in 1898, I married Alice Johnson. My friend, Paul Laurence Dunbar (2006-2015), wrote us a poem for our wedding. *(Church Shadow Puppet)*

> *Diagnosis, cease your squalling.*
> *Check that scalpel's senseless bawling.*
> *Put that ugly knife away.*
> *Doctor Dan doth wed today.*
>
> *Tis no time for things unsightly,*
> *Life's the day and life goes lightly*
> *Science lays aside her sway.*
> *Love rules Dr. Dan today*.
> (Stanzas 2 and 3)

My wife and I returned to Chicago and to Provident hospital where I worked until I retired in 1920. I had taught, lectured at many colleges, and helped to establish more hospitals where Black and White doctors and patients could learn from each other. I received many awards and honorary degrees during my medical career. *(Trophy Shadow Puppet)* Once I retired I moved to a country cottage and died at the age of 75 in 1931.

Frank: You had a truly amazing career Dr. Dan. Thank you for joining us on this episode of "Meet the Scientist."

Dr. Dan: Thank you for having on your show.

Figure 8. Shadow Puppets for Daniel Hale Williams Shadow Puppet Story

Granville T. Woods, African-American Inventor and Electrician

Written by Lara Henry, Josh Inman, and Marie Untermahrer.

Information supporting this script was taken from Brown (1995-2000), Bellis (2015a), Butler (2007), Head and Kassel (2002), Hudson (1995), Scholastic Inc. (2015), and Ohio History Central (n.d.).

Puppet Characters:
Granville, Mr. \Smith, Conductor John, Telephone, Train, Rollercoaster, Gears, Fire, RIP. Sledge hammer, Books, and Telegraph. See Figures 9 and 10. There are many other images that are related in this story. Try having your students create shadow puppets to go with the other images in the story.

(Granville Puppet, stays up throughout the script)

Narrator 1: This is a story about Granville T. Woods, an African American man who used his creative mind to invent many useful things. He was born on April 23, 1856 in Columbus, Ohio where his love for the railroad began.

Narrator 2: Granville T. Woods received little schooling as a young man. At the age of ten, he decided to pursue a job based on his interests.

Granville: I'm going to work in a machine shop. *(Gears puppet)*

Narrator 1: Granville held many jobs before beginning his began inventing. He invented eight creative resources that helped him get the name "The Black Edison."

Narrator2: The steam boiler furnace was his first invention which helped heat homes and other buildings. *(Fire puppet)* This advancement improved winter living for people around the world.

Narrator 1: One of his little known inventions was a telephone transmitter to help workers on trains communicate with each other. A person could now send a message by speaking near telegraph keys.

Narrator 2: One of the most important inventions made by Granville was the railway telegraphy. *(Telegraph puppet)* This allowed engineers, conductors, and station operators to communicate with one another.

Granville: Conductor John, how is the new communication system working?

Conductor John: Oh it is absolutely wonderful! Just a few days ago it saved us from causing an accident. Looks like our train problems are over, thanks to you!

Narrator 2: This invention is what opened the door for the invention of the telephone. The American Bell Telephone Company thought Granville's idea was so great they decided to buy the rights to his invention, granting them exclusive access to the speaking telegraph.

Figure 9. Shadow Puppets for Granville T. Woods Shadow Puppet Show

Granville: Hello, can you hear me? It's Granville. *(Telephone puppet)* I sure am glad I invented this telephone transmitter otherwise I wouldn't be able to talk to you while you are on the train Mr. Smith.

Mr. Smith: Yes, especially since there is a great distance between us. I was wondering, what will you invent next?

Granville: I'm not for sure but I bet it will be something great!

Narrator 2: And it was, Granville created an amusement apparatus. *(Rollercoaster puppet)* His amusement apparatus opened the way for the creation of many new rides for amusement parks. The amusement apparatus allowed motorized cars to run on a track like railroad cars.

Granville: I'm changing the world with my inventions. Now, families can enjoy amusement parks even more. Loretta, we should join our friends and family this next week at the amusement park. What do you think?

Loretta: I think that sounds wonderful! Although it wouldn't be a bad idea to continue working on your next brilliant idea.

Granville: My dear wife, I think you're right. Maybe I should spend some more time putting the finishing touches on the incubator. I just don't know how I can get it warm enough to hatch the chicken eggs.

Narrator 1: Granville, did spend some time working on the incubator. Today, you can find incubators that can hatch over 100,000 baby chicks at once. Even inventions that have already been made can be rethought to create something even bigger and better.

Narrator 2: As Granville worked on his inventions he kept returning to one of his conversations with Conductor John.

Conductor John: Your inventions have improved train safety and all of the train workers are grateful to you for your work. *(Train puppet)*

Granville: Gee, thanks. I try to do my best for the better of everyone.

Conductor John: And you do Granville. I'm sure you have some new safety feature for trains up your sleeve

Narrator 1: With safety in mind, Granville later on introduced the third rail to the railroad. This rail ran alongside of the tracks, providing power to the train along with an overhead electrical system.

Narrator 2: Many cities made transportation advancements after this invention, which eliminated a great number of steam engines trains. *(Train puppet)*

Narrator 1: Things were not always easy for Granville. Some of his inventions were challenged by other inventors.

Edison Company: Hello, are you Granville T. Edison?

Granville: Why yes, I am. What can I do for you?

Edison Company: I am sorry to let you know, but it seems as if you have been given credit for the third rail when in fact Thomas Edison was the one who generated this idea. Would you not agree?

Narrator 2: Granville proved that it was his idea behind his invention of the third rail. Thomas Edison offered Granville a job to make up for the mistake that had occurred, but Granville graciously declined.

Granville: I am sorry Mr. Edison, but I must turn down your offer. I apologize.

Narrator 1: As time went on, Granville continued to use his creativity to make the world a better place. He passed away in 1910 at the age of fifty-three. His headstone can be found in Elmhurst, Queens NY.

Narrator 2: One Ohio governor even recognized Granville as the "Greatest Electrician in the World."

Narrator 1: Based on what Granville did for us, I can't see why everyone wouldn't agree.

Figure 10. Granville T. Woods Puppets

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