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Developing a Scalable STEM Career Development Program for Elementary School-Aged Students

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ABSTRACT: This article describes an approach to designing a scalable career development curriculum for elementary school students using minimal-cost and readily available resources. Content experts, veterinary medical students, university staff, teachers, community partners, evaluation experts, and a children's book illustrator developed a library of low-cost, culturally responsive, fun, and educationally engaging lessons to expose elementary school-aged students to scientific knowledge and careers in veterinary medicine. The home team piloted and evaluated the approach at a local community center. Teams in eight other states were provided materials to pilot and assess the program. Seven of those teams successfully piloted the program and provided evidence of child engagement. Although models, props, and other costly supplies enhance delivery of Science Technology Engineering and Math lessons, our experience with the delivery of this curriculum was proof of concept that a low-cost curricular model is one strategy to facilitate scaling and sustainability of an engaging veterinary science curriculum.

INTRODUCTION

In 2013, the NIH Physician-Scientist Workforce Working Group analyzed the demographic composition and size of the clinician-scientist workforce and recommended that the NIH intensify its efforts to increase diversity (Ginsburg et al., 2014). Current efforts to broaden participation in Science Technology Engineering and Math (STEM) fields typically target high school- and college-age students. Unfortunately, history and national trends suggest that these efforts alone will not result in rapid or significant change in the racial or ethnic diversity of STEM professionals, because such disparities are already evident in high school students, and become accentuated in the undergraduate population (Garrison, 2013; National Science Foundation, 2013). Research supports a focus on elementary school students as this developmental time is a critical opportunity to increase exposure to STEM careers. Young children form career impressions from adults in their lives and from books that they read. As early as elementary school, children are considering occupational choices and developing career aspirations (Magnuson and Starr, 2000; Amass et al., 2013). Indeed, Trice (1991) reported that 41% of career aspirations that adults made before 12 years of age matched their current occupations. Even if children are not selecting a specific career at this young age, they may narrow their focus to careers that seem more familiar and welcoming, and avoid careers for which they lack exposure.

Considering that inadequate science instruction is amplified in schools in low income areas (Bell et al., 2009), this leaves many children, especially those who are socioeconomically disadvantaged, with limited opportunities for science learning at a time when interest in STEM careers is forming. University engagement with community partners provides opportunities to address the gap in STEM educational programs, and promote interest in STEM careers; yet, sustaining such partnerships and programs is challenging.

To expose underserved children to the veterinary profession, Purdue University College of Veterinary Medicine (PVM) established formal partnerships with elementary schools and teachers to develop and deliver an in-classroom STEM program. The program, *Fat Dogs and Coughing Horses: Animal Contributions towards a Healthier Citizenry*, was supported by a National Institutes of Health (NIH), Science and Education Partnership Award (SEPA), with the ultimate goal of diversifying the veterinary profession. Veterinarians, elementary school teachers, and program evaluators worked together to iteratively develop the curriculum.

The program was premised on social cognitive career theory (Lent and Brown, 2013) to create learning experiences that help children feel motivated, capable, and enabled to pursue STEM careers. Specifically, the program aimed to increase youth perceptions of self-efficacy, perceptions of ability in a STEM curriculum, and expectations for positive outcomes for engaging in the program to foster intentions to pursue STEM-related careers. Social cognitive theory positions personal mastery experiences, verbal persuasion, and vicarious learning experiences as mechanisms of this growth. Therefore, key elements of the program were helping children experience success even with difficult content, encouraging children to share their knowledge and personal experiences, and having consistent and quality social interactions with role models (i.e., veterinary medicine professionals).

Elementary school teachers delivered the curriculum in their classrooms with the intention that veterinarians would visit the classrooms to serve as role models. From 2009-2014, thousands of dollars were invested in each participating classroom to purchase books, scientific models, and other resources needed to deliver the curriculum. We found that classroom curricula based on health conditions shared by people and their animals are an effective means of engaging elementary school students in STEM activities and enhancing their interests in STEM careers (San Miguel et al., 2013; Shin et al., 2015). The curriculum increased positive attitudes toward science, enhanced student perceptions of the relevance of science, and increased student aspirations for careers in science (San Miguel et al., 2013; Shin et al., 2015). Although these indicators demonstrate program success, time constraints limited STEM role model classroom visits to once or twice a year, and the development and cost of classroom materials was expensive. In the end, the replication and sustainability of this program was limited due to the high level of teacher training and external funding required to deliver such a resource-intensive curriculum.

These drawbacks and challenges are not unique to this STEM outreach program. Eilam et al. (2016) use the Theory of Legitimacy to examine high and low performing university engagement structures. Sustainable programs were characterized as those delivered within a framework of institutional, government, and community support, bolstered by mutual interests, with freedom for innovation and delivery outside of a formal classroom experience (Eilam et al., 2016; Greany et al., 2014). In contrast, low performing programs were described as those dependent on support and delivery by individual faculty members or staff, volunteering their time in addition to their regular job responsibilities; highly dependent on external funding; and having limited reach due to limited resources (Eilam et al., 2016). Challenges in implementing, sustaining, and scaling STEM curricula are increased further due to their resource-intensive nature (Committee on Integrated STEM Education, 2014; McGinnis, 2017) and the need for individuals delivering the curriculum to be competent and confident in the subject matter (Committee on Integrated STEM Education, 2014; Falk and Dierking, 2010; McGinnis, 2017). Programs and relationships tend to end when funding ceases or people spearheading the initiative leave (Greany et al., 2014).

This article describes our response to the sustainability challenges encountered by our team. To facilitate scalability and sustainable adoption by others, we present an approach to creating a minimal-cost, yet engaging curricula, to inspire elementary school students to explore careers in the veterinary profession.

Scalable Program Foundation. Development of a second program, *This is How We "Role"*® supported by the National Institute of General Medical Sciences (NIGMS) SEPA program, was initiated. The new program was based on the strengths of the *Fat Dogs and Coughing Horses* program, namely its theoretical grounding in social cognitive career theory, animal-based curriculum, and existing collaborations. The overall goal remained to provide culturally responsive, educational programs to elementary school students diverse in gender, race, and ethnicity. The added aim was to provide a solution to common STEM program sustainability challenges. Consequentially, the *This is How We "Role"* program would be less resource intensive to promote replication by others. Overall, the new program would be successful if *it resulted in an engaging STEM curriculum that was easily adopted and disseminated by faculty and veterinary students at veterinary colleges across the U.S., in partnership with non-profit community entities, with limited financial resources*.

The Curriculum Development Team. Our team consisted of original team members, namely veterinarians who served as content experts; elementary school teachers who ensured that educational materials were age-appropriate and consistent with Next Generation Science Standards; and evaluation experts who developed tools for, and led, formative assessment. Other critical team members included a program manager, an administrative assistant, veterinary medical students, and community center staff who provided invaluable feedback and access to our target population. A children's book illustrator was added to the team to make program materials visually engaging. All members participated in the developmental process for activities associated with the curriculum.

Proposed Curriculum. The aim was to develop a curriculum consisting of low-cost, fun, and educationally engaging lessons that could be flexibly delivered in a wide range of educational settings (e.g., in school or after school programs) by veterinary role models. The curriculum would be designed to meet the needs of children from diverse backgrounds, abilities, stage of development, and interests. Although the curriculum would expose children to scientific knowledge, activities would be designed to seem less like school (e.g., no grading or didactic instruction) and more informal and fun (e.g., demonstrations and games). Ultimately, the curriculum would provide positive learning experiences for children from diverse economic, cultural, and racial backgrounds to foster STEM career pursuits.

METHODS

Reducing Physical and Human Resource Cost. We established criteria for lesson development and delivery that would increase the probability that the curriculum would be sustainable and scalable in low-resource environments: a) One should only need a copy machine, common supplies found in a classroom or community center (crayons, colored pencils, scissors, glue sticks), and little additional time for prep; and, b) Role models from diverse backgrounds and life experiences with veterinary experience should deliver the curriculum.

Developing Engaging Lessons. We established criteria for developing an engaging curriculum: a) Lessons from the *Fat Dogs and Coughing Horses* program would be converted to minimal-resource lessons while maintaining child interest; and, all program activities would facilitate learning and opportunities for positive social interactions between role models and children. A shortened version of the Engagement in Science Learning Activities Scale (Chung et al., 2016) was used to assess engagement. The scale was previously validated with middle school students participating in science related activities. To accommodate our youngest students, the scale was shortened to three points (1 = *No!*, 2 = *I don't know*, 3 = *Yes!*), and we reduced the scale to four items that represented behavioral, cognitive and affective dimensions of engagement:

1. During this activity, I felt happy.
2. During this activity, I felt bored.
3. During this activity, I was focused on things we were learning most of the time.
4. During this activity, time went by quickly.

Children completed the short paper and pencil survey after every lesson. To accommodate the diversity of ages and reading abilities, role models were available to read the survey aloud. Children were reminded that their participation was voluntary, they could quit at any time, and there were no right or wrong answers. Children usually took less than 5 minutes to complete the survey. Descriptive statistics including the mean, standard deviation and ranges were calculated in SPSS version 25 (IBM, 2017).

Piloting the Program. Purdue University's Institutional Review Board (IRB) granted a Category 1 exemption (Protocol # 1602017294) for this research. Before program implementation, faculty veterinarians and veterinary medical student role models were required to complete an online *This is How We "Role"* certification, including training for engaging with children in an age-appropriate and culturally responsive manner. Role models also completed training mandated by Purdue University before working with minors.

Lessons were delivered during afterschool and summer programs for children under 12 years of age, 90% of whom were from low income families at a local community center, through a longstanding and valued collaboration. The center's mission is to provide a gathering place, celebrate cultural differences, and provide social services that improve the quality of life for local families.

At the end of each lesson, children completed the Engagement in Science Learning Activities Scale. Participating veterinary faculty, students, support staff, and community center staff completed a Lesson Fidelity Sheet, providing opinions on, and explaining why, aspects of the lesson went well or did not go well. They were also asked to list challenges in delivery such as materials, content, child interest, time, etc. and provide suggestions for improvement. Lessons were revised based on the feedback from the pilot implementation.

Replicating and Scaling the Program. To replicate and scale the program, we established a model for implementation at other U.S. veterinary colleges. A call for proposals was initiated where colleges described role model teams consisting of at least one veterinarian and 6 veterinary medical students. Colleges also had to demonstrate a relationship with a community partner (school or community center, or other not-for-profit group). Priority for selection was given to colleges with a) role model teams representing diversity in the profession; and, b) community partners who were delivering programs aimed at educationally disadvantaged children in underserved communities.

As required by Purdue University, amendments to Purdue University's IRB Protocol #1602017294 were submitted and approved as external sites became part of the program. Additionally, before data collection at external sites, all individuals administering surveys or collecting data were required to complete their institution's requirements for Non

Key Personnel Collaborative Institutional Training Initiative certification in Social Behavioral Research and follow to any other IRB requirements a their institution.

Selected colleges received a starter supply package (including scissors, crayons, colored pencils, and glue sticks) and free online training to certify role models in age-appropriate and culturally responsive curriculum delivery. After role model certification, any additional requirements of their home institution, and IRB requirements were met, colleges received curricular materials which included a step-by-step guide to deliver the curriculum, minimal resource lesson plans with learning objectives, Next Generation Science Standards met by each lesson, scripts, activity sheets, and supply checklists. Colleges were provided funds to support assessment costs upon receipt of assessment materials by researchers at Purdue University.

RESULTS

Lesson Conversion Process Example. The process of converting a resource intensive lesson to a minimal resource lesson is exemplified through the development of a lesson on orthopedic surgery. The purpose of the lesson was to review what veterinary surgeons do and learn about the diagnosis and repair of fractured bones. Specific learning objectives were:

- Students will learn about careers in veterinary surgery.
- Students will be able to identify different types of bones.
- Students will be able to identify different types of bone fractures.
- Students will be able to explain methods for fracture repair.
- Students will interpret radiographs of fractured bones before and after repair.

The original, resource-intensive lesson involved presenting radiographs of fractured bones and repair techniques. For the activity, children pretended to scrub in and dress for surgery, and then used a screwdriver, screws, and a replica bone plate, to repair a broken plastic replica of a tibia. Resources required for each student were a surgical gown ($4), children's gloves ($5), surgical mask ($0.12), bouffant cap ($0.07), shoe covers ($0.66), a surgical scrub brush ($1.90), screw driver ($3), replica bone plate ($1), screws ($0.80), screw anchors ($0.80) and a plastic human tibia model ($26) for a supply cost of $43.35 for each child. Preparation included cutting the plastic tibias to replicate a simple fracture, pre-drilling screw holes in the tibia to match the plate holes, and inserting screw anchors in the holes.

Development of a minimal-resource activity began with the content expert, a veterinary surgeon. The surgeon reviewed foundational surgical and orthopedic principles and selected concepts that were most relatable to daily life and that we could explain at a level appropriate for young children. Activities introduced formal scientific language and offered definitions when needed, instead of oversimplifying the content for youth. For example, word "fracture" was introduced as the term for broken bone and the word "radiograph" as the scientific term for a picture of bones to replace the colloquial term "x-ray." Activity development focused on creating a novel and age appropriate activity that would encourage problem solving, creativity, exploration, and fun. Since fractures were relatable to any child who had ever had a broken bone or knew of someone who had, the surgeon reviewed hospital case logs and selected radiographs that represented the most commonly fractured bones in the body of both people and their animals. Considering the cost limitations and the desire to encourage the aspirations of fulfilling the veterinary role, the activity had the children assume the role of a "veterinarian."

The surgeon introduced key concepts, including bones, fractures, types of fractures, and various fracture repair methods, using examples from hospital cases. The suggested activity mirrored the steps of the veterinary surgeon. The child would ask for the patient's name and create a history, the story of how the patient was injured. The child would then "take" a radiograph by cutting out drawings of fractured bones from templates and paste them onto black sheets of paper. Finally, the child would select a method to repair the fracture, cut out the equipment needed from templates (e.g., printed drawings of surgical implants), and paste it over the bones.

Activities prepared by the veterinary surgeon were further refined based on time limitations for each lesson and educational level of children. We selected two cases of broken femurs, the largest leg bone. We sent the concept and radiographs to the artist to bring the activity to life. For each case, we made a handout with actual images of radiographs of a fractured femur, before and after surgical repair. The first sheet asked the children to "Examine these radiographs of a fractured femur (top leg bone) before and after bone surgery" and explained how the veterinary surgeon repaired the fracture, (i.e. "The veterinary surgeon repaired the femur with plates, screws, and a pin"). Then, we gave children a second sheet, illustrated by the artist that had drawings and names of different types of fractures (i.e. simple, multiple, displaced), drawings of the pieces of the fractured femur, and drawings of the equipment used to repair the femur. We gave children scissors ($2.30), glue sticks ($0.70), and a sheet of black construction paper ($0.05). However, most programs already have scissors and glue sticks available. Instructions were to cut out the broken bone and equipment needed to repair the fracture. Then, create a radiograph of the repaired fracture by pasting the cut-outs on the black construction paper.

The resulting minimal-resource lesson met Next Generation Science Standards and cost approximately $3 per child. Considering that some materials could be reused for future activities (i.e., scissors and glue sticks), this activity clearly met our sustainability criteria. Observationally, the activity appeared to successfully engage the children. Our participants envisioned themselves as the surgeon, really thought about their fractures, and the accuracy of their repair-some even replicated 3D repairs! Eighteen children completed the Engagement in Science Learning Activities Scale with a mean score of 2.6 (*Range* =1-3, *SD* = 0.53).

Curriculum.

Minimal resources. In total, 49 lessons meeting the minimal-resource criteria were developed. Six additional lessons not meeting all of the criteria were developed. These lessons involved children's books, a card game, and additional supplies beyond a photocopier. The children's books were provided at no cost to partners and were made available online (www.WeRoleLikeThis.org). The card game is being supplied to partners but is not scalable for minimal cost at this time. A surgery lesson requiring rope or yarn for knot-tying will be distributed but did not meet the resource criteria.

Lesson elements. For the lessons that met our criteria, all used a variety of games and activities to avoid redundancy, maintain student engagement, and meet the needs of students in informal learning contexts. Each lesson considered a number of essential elements closely tied to the program purpose including: 1) developmental flexibility, 3) supporting perceptions of competence and 4) fun, and 5) integrating physical activity.

Developmental flexibility. In the program, role models would interact with children that ranged in age from 5-12. Therefore, activities were designed to enable success for children across all ages. For example, younger children could work with role models to discriminate among items (select items a swine veterinarian would use, select items that kittens need to stay healthy, select foods that come from cattle, find household hazards), while older children could work independently, discriminate among items, and describe their function. Younger children could draw examples of veterinarians in different careers, while older children would write about various veterinary careers, animal behaviors, new medical instruments they envisioned, or develop public service announcements regarding health hazards for people and their animals.

Supporting perceptions of competence. Many activities utilized the structure of common games. For example, maze activities illustrate concepts of regulatory veterinary medicine where children identify health risks that animals encounter during movement through the maze. Children recreate the skeletons of humans and dogs using puzzles. Color by Number activities illustrate vision differences among and within animal species, and help children interpret color changing diagnostic assays. This approach allowed children to focus on learning the content without the additional demands of new rules and processes. Doing so creates opportunities for participants to feel confident trying activities while building competence with new material.

Fun. In an informal after school learning environment, children have already spent a long day at school and, when designing the program, administrators wanted to couch learning in a fun and lighthearted environment. Therefore, the curriculum focused on engagement, effort, and social interactions. For example, children completed crafts centered around program content such as making medical instruments and supplies, or making animal puppets to supplement lessons. Time spent using standard teaching methods that required students to sit still and listen was minimized, and kids were encouraged to ask questions, share their experiences, and get involved whenever possible.

Physical activity. All program activities started with physical activity to help children prepare to engage in program activities. Role models led brain/body activities that challenged coordination and set the stage for fun. These activities were selected from the Brain Gym warm-up (Brown, 2012). Physical activities were also used to teach about healthy eating, exercise, and anatomy.

Opportunities for role model interaction. Each role model was provided a portion of the lesson to deliver (i.e., a script) and were encouraged to make their delivery age appropriate, and insert their own perspectives, interpretations, and personality when speaking with children. During activities, role models were urged to sit down with children, help them with activities, and get to know them. As the age range of children and therefore ability to complete activities varied, role models met children where they were and helped them complete activities to the best of their ability. Role models asked and answered questions, and talked to children about their educational pursuits, life goals, and daily lives. Role models shared their content expertise in many activities, especially in advanced areas. For example, children and role models worked together to learn about anatomical terms for body parts, body part function, and comparative anatomy using text matching and pasting internal organs in the proper locations on animal drawings.

Pilot Program Delivery. Lessons were piloted by PVM faculty, staff, and students, with 54 veterinary student role models participating. At the start of each lesson, faculty led a series of physical activity-based brain exercises to get the students moving and ready for their learning (Brown, 2012). Then role models introduced themselves and answered a question that allowed them to share a bit about themselves and their educational experiences (e.g., What subjects were challenging for you in grade school and how did you overcome those challenges?). Role models then presented the lesson content, guided by a script, and assisted children with activities. On average each lesson lasted for 60 minutes. The program was delivered, weekly for 8 weeks during the school year and for 10 weeks during the summer break.

The most common challenges revealed were the need to clarify instructions, shorten activities, include versions of activities that better accommodate different educational and skill levels, and offer completed examples of crafts or activity sheets. Lastly, although most activities went well, at times the preparation time was too extensive to be easily scaled.

Replicating and Scaling the Program. National implementation of *This is How We "Role"* programming through U.S. Veterinary colleges and their community partners began in 2017. The data presented in this manuscript is limited to institutions that met all IRB requirements. Role model teams at each college delivered a first set of six lessons over a period of two to three months with no more than two lessons delivered each week. Some partners (n = 4) also delivered a second set of six lessons Preliminary results from eight partner veterinary medical educational institutions in Alabama, Colorado, Georgia, Kansas, North Carolina, Massachusetts, Oregon, and Tennessee, who have together certified 148 role models qualified for inclusion in this manuscript.

Lesson Fidelity. Teams shared, through Lesson Fidelity Sheets, feedback on the lessons as delivered at their site, including aspects of each lesson they felt went well or were challenging, and reasons for their opinions. One site reported that they did not deliver the lessons as provided. Instead they, created their own activities based on the lesson titles.

Other partner teams reported that children were excited about the topics, eager to learn, and loved opportunities to ask questions and share their knowledge. Movement during brain exercises and Simon Says, boosted energy and excitement. During small group discussions on career exploration, children immediately began sharing animal stories and were excited about the variety of veterinary careers. Children especially enjoyed activities involving drawing, coloring or crafts because of their active and creative nature. Children also liked the interactive nature of designing research experiments, and tracing animal movements using the maze. Activities where children drew a new pet, designed a fish tank, and invented new medical instruments or new animals were popular. Activities that involved thinking while covering familiar topics, such as bone puzzles where children assembled human and dog skeletons, were specifically cited as effective. Children liked the challenge of the math problems where they became owners of a pet supply store and decided the price of items. One site mentioned how children liked developing competitive pricing after comparing their store's items to classmates. Other enjoyable activities that were mentioned included reading, matching, word unscrambles, and word searches.

Areas for improvement that were cited were similar to pilot feedback, finding some unclear instructions, certain activities to be too difficult for their audience, or not having enough time to complete all activities. One site reported students were worried about getting the wrong answers. One site did not prepare the skeleton puzzle activity in advance, as recommended, and found that cutting out all of the bones during the lesson was quite time consuming. Most sites commented that additional props, models, or bones would improve the lessons and supplemented some lessons with these items. One site said that if one child did not want to participate in brain exercises then the others followed. One role model at one site did not do brain exercises.

Lesson Engagement. Post-lesson surveys were administered across seven universities for 12 different lessons in the Fall and Spring of 2018 and Spring of 2019. Engagement data from the site that did not follow the standard lesson implementation protocol were not included in the engagement data analysis.

At each site, the number of children who completed the surveys varied (N = 5 - 39) and, across all the sites, there were 33 – 125 children who completed each survey. See Table 1 for the total number of children who completed the survey for each lesson and the number of sites that implemented each lesson. The performance of the engagement scale was below ideal thresholds (α = .63), however, as there were only four items representing the three dimensions of the scale and the analysis was only descriptive, all administered items were kept. See Table 1 for the summary results of the descriptive analysis. For each lesson, responses spanned the entire scale range and average engagement was above the midpoint of the scale (M = 1.97, *Range* = 1.83 – 2.66). Although, engagement varied by lesson the mean scores indicate generally neutral to desirable perceptions of engagement where children feel like the activities elicit positive emotions, maintain their concentration, and keep them from being distracted by other unrelated tasks. See Tables 2 and 3 for the descriptive analysis by site for the first and second sets of six lessons, respectively. Overall, children reported more positive perceptions of engagement for the first set of 6 lessons (M = 2.59, *Range* = 2.51 – 2.66) when compared to the second set of 6 lessons (M = 1.97, *Range* = 1.83 – 2.53). However, mean engagement scores for the second set of 6 lessons are more susceptible to an individual underperforming site due to the small sample size. Thus, these descriptive differences will not be interpreted further as they require more data to appropriately inform program improvement.

Table 1. *Descriptive statistics and student participation across lessons and sites.*

Lesson	*M*	*SD*	Range	Number of participants range	Number of participants total	Number of participating sites
Careers in Veterinary Medicine	2.64	.46	1 – 3	10 – 31	125	7
Fish Veterinarians	2.53	.51	1 - 3	8 - 30	108	7
Puppy and Kitten Care Costs	2.66	.44	1 - 3	8 - 26	98	6
Poultry Veterinarians	2.63	.43	1.5 - 3	6 - 26	89	6
Bone Games	2.56	.47	1 - 3	8 - 30	113	7
Donkey's Need Dentists, Too!	2.51	.62	1 - 3	6 - 30	103	7
Snakes, Turtles, and Tortoises	1.83	.79	1 - 3	7 - 39	75	4
Muscles!	1.89	.81	1 - 3	7 - 37	69	4
Let's Do Research!	1.85	.74	1 - 3	5 - 40	70	4
Government Veterinarians	1.83	.74	1 - 3	5 - 39	69	4
Take a Look Inside! (Comparative Anatomy)	1.90	.78	1 - 3	6 - 34	65	4
Elephants Need Eye Doctors, Too!	2.53	.60	1 - 3	5 - 20	33	3

DISCUSSION

The strategy described addresses many of the challenges faced by high impact STEM programs, including: 1) developing a framework of institutional and community support; 2) providing trained educators and role models for young children; and 3) the cost of purchasing engaging STEM resources. The resulting minimal-resource and engaging STEM career development program for elementary school-aged students was scaled and replicated as intended at seven other institutions, meeting our definition of a successful outcome.

Although the *This is How We "Role"* program relied on fewer resources than the *Fat Dogs and Coughing Horses* Program, children reported relatively strong and positive perceptions of engagement across all lessons. It seems that even when the primary mode of program delivery is restricted to simple and cost effective activities such as coloring, cut and paste, and activity sheets, children report that the curriculum maintains their engagement. Positive perceptions of the three dimensions of engagement (i.e., cognitive, affective and behavioral engagement) set the stage for student learning, attraction to activities and motivation for continued participation in current activities (Fredricks et al., 2004). Therefore, programs that are low cost can still lay the groundwork for a long-term interest in careers in veterinary medicine and science and other positive academic outcomes if they are able to support an engaging learning environment.

Recommendations and examples from our curriculum to maintain engagement while reducing costs include:

- Providing opportunities for developing scientific thinking skills by having children compare and evaluate evidence-based explanations (Biggers et al., 2014). The *How We "Role"* curriculum afforded children many opportunities to engage in evidence-based explanations. Children learned about and compared anatomic differences and wellbeing need differences among people and other species of animals, followed by discussions of possible reasons for similarities and differences.
- Providing opportunities for children to be creative when building science skills, such as developing hypotheses, solving problems, and synthesizing factual material (Newton, 2012). Our curriculum includes a research lesson which offers a standard approach to developing hypotheses and synthesizing factual material. Other lessons invoke creativity when children design instruments to solve medical challenges such as inventing an instrument that a veterinary ophthalmologist could use to examine the eyes of a tiger.
- Providing the appropriate level of challenge such that children are not deterred (Brunsell and Fleming, 2014). We created developmentally flexible lessons and activities to accomplish this goal.
- Employing a joyful learning approach by providing hands-on activities related to real life that involve choice, creativity, and autonomy (Brunsell and Fleming, 2014). Our curriculum illustrates that the joyful learning approach need not be resource intensive. Choice was reflected in the children's options of selecting from a variety of species (human, dog, cat, goat, cow, pig, horse, rat) to perform a paper dissection, or choose which pet (puppy or kitten) to study wellness needs. Children creatively built their own fish tank, designed research projects, and used their imagination to design novel medical instruments. Such activities build on personal interests and let children identify as veterinary scientists (Brunsell and Fleming, 2014).

Table 2. *First Set of 6 Lessons: Descriptive statistics and student participation across lessons and sites.*

Lesson	Site	*M*	*SD*	*Range*	Number of participants
Careers in Veterinary Medicine	Site 1	2.66	.53	1.25-3	11
	Site 2	2.58	.33	2-3	13
	Site 3	2.82	.20	2.5-3	25
	Site 4	2.56	.47	1.25-3	31
	Site 5	2.23	.80	1-3	13
	Site 6	2.88	.20	2.5-3	22
	Site 7	2.47	.29	1.75-2.75	10
	Total (N=7)	**2.64**	**.46**	**1 - 3**	**125**
Fish Veterinarians	Site 1	2.82	.23	2.5-3	11
	Site 2	2.38	.73	1.25-3	10
	Site 3	2.74	.34	1.75-3	26
	Site 4	2.45	.48	1.25-3	30
	Site 5	2.05	.71	1-3	13
	Site 6	2.78	.28	2.25-3	8
	Site 7	2.45	.42	1.5-3	10
	Total (N=7)	**2.53**	**.51**	**1 - 3**	**108**
Puppy and Kitten Care Costs	Site 1	2.62	.35	1.75-3	15
	Site 2	2.74	.28	2-3	18
	Site 3	2.81	.29	1.75-3	26
	Site 5	2.03	.86	1-3	8
	Site 6	2.87	.17	2.5-3	21
	Site 7	2.28	.45	1.5-2.75	10
	Total (N=6)	**2.66**	**.44**	**1 - 3**	**98**
Poultry Veterinarians	Site 1	2.69	.35	2-3	9
	Site 2	2.68	.30	2-3	14
	Site 3	2.70	.42	1.5-3	26
	Site 5	2.10	.47	1.5-2.5	6
	Site 6	2.85	.13	2.75-3	22
	Site 7	2.23	.57	1.5-3	12
	Total (N=6)	**2.63**	**.43**	**1.5 - 3**	**89**
Bone Games	Site 1	2.65	.42	1.75-3	12
	Site 2	2.55	.55	1-3	15
	Site 3	2.73	.34	1.5-3	30
	Site 4	2.46	.54	1-3	19
	Site 5	2.16	.72	1.5-3	8
	Site 6	2.63	.29	2-3	20
	Site 7	2.39	.52	1.5-3	9
	Total (N=7)	**2.56**	**.47**	**1 - 3**	**113**
Donkey's Need Dentists, Too!	Site 1	2.69	.44	2-3	8
	Site 2	2.35	.53	1-3	17
	Site 3	2.69	.39	1.5-3	30
	Site 4	2.56	.58	1-3	17
	Site 5	1.83	.41	1.5-2.5	6
	Site 6	2.65	.32	2-3	15
	Site 7	2.23	.64	1-3	10
	Total (N=7)	**2.51**	**.62**	**1 - 3**	**103**

Table 3. *Second Set of 6 Lessons: Descriptive statistics and student participation across lessons and sites.*

Lessons (7-12)	Site	*M*	*SD*	*Range*	Number of participants
Snakes, Turtles, and Tortoises	Site 1	2.59	.42	1.75-3	8
	Site 3	2.82	.29	1.75-3	26
	Site 5	1.38	.34	1-2	6
	Site 6	2.77	.22	2.5-3	22
	Total (N=4)	**1.83**	**.79**	**1 - 3**	**75**
Muscles!	Site 1	2.82	.19	2.5-3	7
	Site 3	1.22	.30	1-2	37
	Site 5	1.75	.50	1.25-2.25	3
	Site 6	2.76	.26	2.25-3	22
	Total (N=4)	**1.89**	**.81**	**1 - 3**	**69**
Let's Do Research!	Site 1	2.8	.21	2.5-3	5
	Site 3	1.30	.34	1-2.25	40
	Site 5	2.0	.35	1.5-2.5	5
	Site 6	2.68	.24	2.25-3	20
	Total (N=4)	**1.85**	**.74**	**1 - 3**	**70**
Government Veterinarians	Site 1	2.85	.22	2.5-3	5
	Site 3	1.31	.37	1-2.25	39
	Site 5	2.06	.71	1-3	13
	Site 6	2.71	.25	2-3	18
	Total (N=4)	**1.83**	**.74**	**1 - 3**	**69**
Take a Look Inside! (Comparative Anatomy)	Site 1	2.54	.37	2.25-3	6
	Site 3	1.32	.49	1-2.75	34
	Site 5	1.89	.40	1.5-2.5	7
	Site 6	2.8	.20	2.5-3	18
	Total (N=4)	**1.90**	**.78**	**1 - 3**	**65**
Elephants Need Eye Doctors, Too!	Site 1	2.45	.27	2-2.75	5
	Site 5	1.84	.67	1-2.5	8
	Site 6	2.83	.37	1.75-3	20
	Total (N=3)	**2.53**	**.60**	**1 - 3**	**33**

- Incorporating physical activity for health benefits and to improve cognitive function (Tomporowski et al., 2008). In the context of the *This is How We "Role"* goals, physical activity provides a resource-free, easily scalable activity to prepare children for lessons and to reinforce learning objectives. Exercises for the curriculum were selected to provide options for children of various physical abilities.

Developing a high impact curriculum using minimal resources required substantial creativity. The human capital resources vital to successfully creating and delivering the curriculum could not be minimized. Assembling a collegial, diverse, cohesive, interdisciplinary team of experts who worked together to share perspectives, explore possibilities, and build on each other's ideas, was crucial to achieving the creativity required for fulfilling our project goals.

Moreover, the people power required to deliver the curriculum in a meaningful manner was substantial. We recommend no more than 4 children per role model for an optimal experience. Falk and Dierking (2010) found that without formal science education training, elementary school teachers were not equipped to engage students in STEM programming. However, having veterinary professionals and veterinary medical student role models deliver the curriculum enhances scalability because the program is not limited to a formal classroom setting, nor is it dependent on providing professional development opportunities to enable elementary school teachers to gain sufficient content knowledge of veterinary medicine to deliver the program. Veterinary student and veterinarian role models offer the additional advantage of providing real-life examples to children of people who look like them, live or attend school in their community, who are advancing their education or are professionals in the veterinary field. However, such role models generally do not have formal training in teaching, communicating in an age-appropriate manner, or cultural responsiveness. To address these deficits, all role models were required to participate in professional development modules before interacting with children. Alper (1994) observed that the teaching skills of scientists improved after delivering presentations to elementary school students. Anecdotally, we find that our role models further develop their communication and teaching skills through engaging with children.

Currently, 19/30 veterinary colleges have established *This is How We "Role"* chapters in the U.S. through institutional and community partnerships. Expansion of the program includes opportunities for practicing veterinarians, not associated with universities, to deliver, but not assess, the curriculum in their communities. Workshops at national veterinary meetings have been offered as well as online training to facilitate this effort. The curriculum is provided on a flash drive to veterinarians who have completed their certification.

Veterinary college teams continue to utilize the Lesson Fidelity Sheets. Data regarding student enjoyment, content knowledge, and self-efficacy is also being collected. We expect to continuously improve the curriculum in response to measurable program results; while meeting specific needs of individual children and their communities. Current areas of focus are to create clearer instructions, develop more activities to address a wider range of cognitive abilities, and shorten lesson times. We will also explore the systematic differences in engagement across lessons (e.g., subject matter, stage of development of lesson with respect to continuous improvement from feedback, time of year lesson was delivered) and site (e.g., role models, children, role model to child ratio, group dynamics) to determine systematic lesson and site level mechanisms that can inform overall program improvement.

As the program scales, better insights into improvement that consider context in terms of program location (school, community center) and specific community needs can be developed. Detailed results on impact of program is forthcoming as data collection is ongoing.

In summary, although models, props, and other costly supplies can enhance delivery of STEM lessons, the minimalist strategy described in this manuscript was proof of concept that a low-cost curricular model can be feasible, scalable, and engaging. Through this accessible design, the development of career interest in STEM fields using a tested outreach program is now within reach for more veterinary professionals and young people by reducing common burdens that limit the delivery and sustainability of these programs.

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ABBREVIATIONS

IRB: Institutional Review Board. NIGMS: National Institute of General Medical Sciences. NIH: National Institutes of Health. PVM: Purdue University College of Veterinary Medicine. SEPA: Science and Education Partnership Award. STEM: Science, Technology, Engineering, and Math.

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