Comparison of Two Respirator User Training Methods:

Video and One-On-One Training

BY

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THESIS

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LIST OF ABBREVIATIONS

FF	Fit Factor
FFP	Filtering Facepiece
FFR	Filtering Facepiece Respirator
GM	Geometric Mean
HFR	Half Facepiece Respirator
N95	A disposable filtering facepiece respirator that can filter 95% of airborne particles.
OSHA	Occupational Safety and Health Administration

SUMMARY

Lung disease is one of the leading causes of occupation-related illness (Blanc et al., 2019; Sirajuddin & Kanne, 2009). To protect themselves, millions of workers rely on respiratory devices (Syamlal et al., 2006; Wizner et al., 2016). However, for these devices to be protective, workers must be trained to consistently don and doff a mask correctly. Currently, there are only a few documented training strategies employed and their effectiveness for respiratory protection has largely been unchallenged. Therefore, this study aims to compare the efficacy of two popular training strategies: one-on-one training and video training.

Twenty subjects were recruited for this study and stratified into two groups based on the type of training they received. One group received training by a pre-recorded video, and the second group received one-on-one training by the lead investigator. All participants underwent unassisted quantitative fit tests before and after training, to assess their ability to achieve respiratory protection. Those that were trained by video had statistically insignificant improvements in fit test results after training ($P = 0.07$). In contrast, those trained in person by a professional were able to significantly improve their pass rates post-training ($P = 0.01$). These findings are consistent with the literature, suggesting that in-person strategies can better serve to enhance the learning experience.

I. INTRODUCTION

A. Literature on adult learning

Andragogy, the theory of adult learning, identifies that adults are self-directed, goal-oriented, practical, self-motivated to learn and have an array of past experiences (Tough et al., 1985). Combined, these unique characteristics culminate in an understanding that adults learn best through learner-centric tactics rather than traditional teacher-focused methods (Tough et al., 1985). As proposed by Knowles these assumptions constitute the four core principles of adult learning. Principle 1, adults need to be actively involved in the learning process (Knowles, 1984); Principle 2, the learner's prior experience should be respected and built upon (Knowles, 1984); Principle 3, adults are motivated to learn by the need to solve problems (Knowles, 1984); and Principle 4, adults need to know why they are learning (Knowles et al., 1998). When applied to the educational curriculum, these principles can maximize a learner's experience (Collins, 2004).

Similarly, the practical education of respiratory training may also be enhanced by the inclusion of these assumptions (Bryan et al. 2009). When adults enter a workforce they are bringing with them a diverse amount of knowledge and experience. Employers can utilize this as an opportunity to involve workers in the training process (Bryan et al., 2009). Addressing principle 1, workers can be surveyed for prior respiratory training experience, and employers can use their input to create a more focused training program. This involvement also addresses principle 2 by acknowledging the learners' experience and building on what they already know (Bryan et al., 2009; Knowles, 1984).

Workers want their training material to be applicable and relevant to their workplace needs (Zack et al., 2016). In respiratory training, this can be effectively addressed by implementing principle 3 into instruction. Since adults are motivated to learn by their need to solve problems, employers should first identify what the problems are (Collins, 2004). However, it is important to note that the problem identified should be specifically relevant to the worker (Bryan et al., 2009; Collins, 2004; Knowles, 1984). In respiratory training, one major issue is improperly fitted respirators. Therefore, workers need to understand how training can prepare them to avoid this.

Respiratory protection training is mandatory across all industries and occupations that require workers to use a respirator (Occupational Safety and Health Administration, 1994). However, its obligatory nature does not ensure that an employee will learn how to properly don respiratory protection. To engage workers, they need to know why they are learning. Employers can facilitate engagement by conveying the relevancy of the material (Campbell, 1999; Knowles et al., 1998). Training instruction can meet principle 4 by explicitly informing workers how failure to learn the material can affect their wellbeing (e.g. if your respirator does not create a seal, you are not protected).

B. Literature on respirator training methods

Lung disease is one of the leading causes of occupation-related illness worldwide (Blanc et al., 2019; Sirajuddin & Kanne, 2009). While engineering controls are ideal for reducing respiratory hazards, millions of workers still rely on routine or occasional use of respiratory devices (Syamlal et al., 2006; Wizner et al., 2016). However, respirators can only protect if the model selected is appropriate for the task and is fitted adequately. To control for these variables, workplaces requiring the use of respirators must implement a respiratory protection program that follows OSHAs respiratory protection standard, 29 CFR 1910.134 (Occupational Safety and Health Administration, 1994).

A core component of a respiratory protection program is devoted to teaching workers how to don and doff a respirator. Previous literature has evaluated the following methods to train workers: pre-recorded videos, printed documents (e.g. brochures and posters), in-person directives (e.g. classroom lectures and one-on-one instruction), and computer-based courses (simulations, lectures, and quizzes) (Harber et al. 2013; Hannum et al.,1996). To verify that each respirator user is achieving the expected level of protection, OSHA training programs also require annual OSHA-approved fit tests (Occupational Safety and Health Administration, 1994). Although these methods are frequently used, literature comparing their efficacy is limited.

One study interested in the effects of respirator training on the ability of healthcare workers to pass a fit test, found two variations of in-person training methodologies to be equally effective to one another (Hannum et al., 1996). The study recruited 179 hospital employees and stratified them into three groups according to the type of training they were to receive. Group A received one-on-one instruction by the hospital's industrial hygienist, group B received classroom instruction by infection control nurses, and group C received no training. Fit test passing rates assessed the overall effectiveness of different training strategies. Group A had a 94% pass rate (49 of 52), which was nearly equivalent to the 91% pass rate (58 of 64) for group B. In contrast, Group C subjects were only able to achieve a 79% pass rate (50 of 63). Authors conclude that high pass rates support the importance of training, although specific methods applied (in-person vs. classroom training) may not be. They add that fit testing as part of training, may have enhancing effects; as demonstrated by the slightly higher pass rate of group A (Hannum et al., 1996). While fit testing procedures are described thoroughly in the study, it is unclear what fit testing as part of training truly entails.

Similar publications propose video training to be an effective alternative when direct training from an occupational health professional is unavailable. In a randomized trial study comparing the effectiveness of video, print, and computer-based training programs, researchers used quantitative fit testing to measure the efficacy of training among 226 subjects. Two - commonly used respirators, Filtering Facepiece Respirator (FFR) and dual-cartridge Half Mask Filtering Respirator were assigned at random along with one of the three training strategies (six possible combinations). Video-based training had the lowest fail rates (6 of 37 and 3 of 33 for FFP and HFR respirators, respectively). The other training strategies resulted in significantly higher failure rates. Print, for example, yielded 13 of 39 subjects and 9 of 35 for N95 and HFR respirators, respectively. Computer-based programs had 10 of 41 and 15 of 41 for N95 and HFR respirators, respectively (Harber et al., 2013).

While the studies discussed above focus on training methods, a common and integral component of them all is fit testing. Fit testing determines by either quantitative or qualitative means whether the seal between the respirator face-piece and the user's face is satisfactory. Studies evaluating the role of fit testing in respiratory protection are conflicting. A commentary geared towards clarifying the purpose of a fit test, describes fit testing to be an important aid in reinforcing training (Clayton, & Vaughan., 2005). However, another study by Lee and others find fit testing to have limited benefit, especially among infrequent respirator users (2008).

In "Respirator-Fit Testing: Does It Ensure the Protection of Healthcare Workers Against Respirable Particles Carrying Pathogens?" authors wanted to know if fit testing could predict short and long-term fit adequacy among healthcare workers (Lee et al., 2008). In the absence of any training or assistance, 28 of 58 of health care workers were able to pass a standard qualitative fit test protocol. After fit testing, workers were retested 3 and 14 months later.

Researchers found insignificant improvements in pass rates, 20 of 43 (P = .99) at 3 months and 28 of 43 (P = .08) at 14 months. Results suggest that fit testing is not useful for predicting long-term effective respirator use and protection. Moreover, most of the participants regularly used respirators, which likely contributed to the high passing rates. Investigators conclude that infrequent users may alternatively benefit from additional training experience rather fit testing (Lee et al., 2008).

Anecdotally, research on respiratory protection training programs often describes respirator training to occur at the same time as fit testing (Brosseau et al., 2015). This may lead to inadequate worker preparation since the focus of training can be shifted towards passing a fit test rather than learning to recognize proper fit. To address this dilemma, and investigate the importance of respiratory training methodologies, this study aims to integrate unassisted fit tests for the quantitative comparison of two popular training strategies, video, and one-on-one instruction. The objectives of this study were to:

1. Determine if training on donning and doffing improves respirator fit.
2. Investigate the impact of training on fit-testing
3. Analyze whether one method is more effective than the other at teaching users how to correctly use a respirator.

II. METHODS

A. Instruments

UIC IRB protocol number (20190714-124850-1). All fit tests were performed within a 6’ x 6’ x 8’ plastic test chamber (Figure 1A). Within the enclosure, a generic humidifier and a salt generator (Model 8026, TSI Inc., Shoreview, MN) was used to create a high ambient particle concentration (approximately 1500 particles/cm^3). Meanwhile, a low- speed fan mixed the air for a homogeneous concentration of particles throughout. Additionally, to quantify fit test outcomes a PortaCount® Pro Respirator Fit Tester (Model 8038, TSI Inc., Shoreview, MN) equipped with FitPro+ Fit Test Software was used to calculate overall fit factors (FF). (Figure 1B).

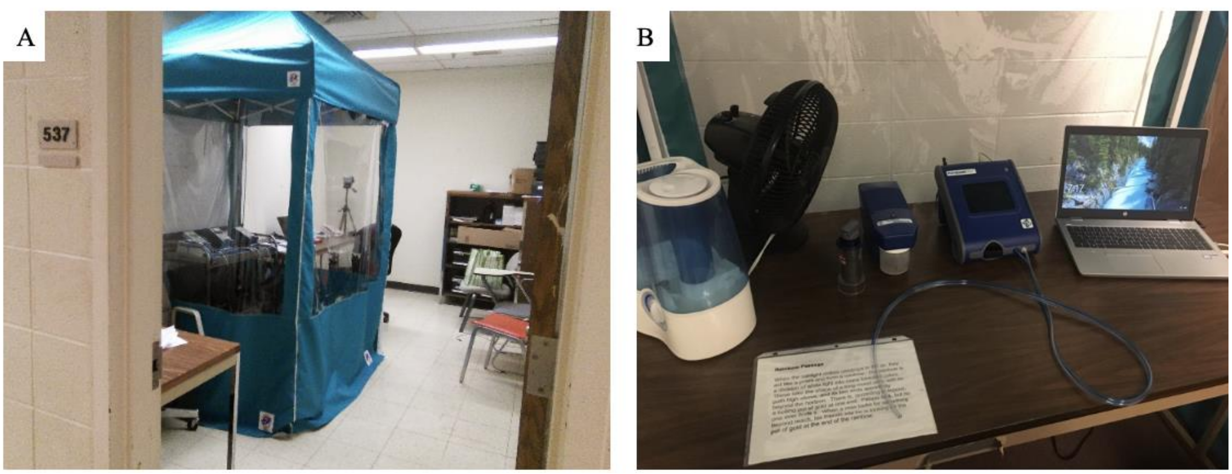

Figure 1. Fit testing equipment. Pictured from left to right: testing chamber, humidifier, fan, TSI salt generator (Model 8026), TSI PortaCount® Pro Respirator Fit Tester (Model 8038).

B. Respirator Model

For the purpose of this study, NIOSH approved N95 3M-VFlex flat-fold single-use particulate respirators (Model 1804 and 1804s) were used throughout experimental procedures (Figure 2A). The two sizes available for this respirator (small and regular) were purchased to accommodate a broad range of facial proportions. Mask sizes were determined by measuring the subjects menton sellion length and bizygomatic breadth (Figure 2B). Additionally, for quantitative analysis, all respirators were probed using a TSI probing kit (TSI8025, Figure 2C).

A protocol developed for respirators manufactured in two unique sizes suggests that subjects in NIOSH panel cell sizes 1-5 be tested with a small/medium face piece and a medium/large facepiece for those in panel cell sizes 5-10 (Zhuang et al., 2017). The respirator model used in this study comes in size small and regular, where regular is designed to fit medium-large faces. To accommodate this, subjects in panel cell sizes 1-3 were given a size small respirator and subjects in panel size 4-10 were given regular-sized respirators (Figure 3).

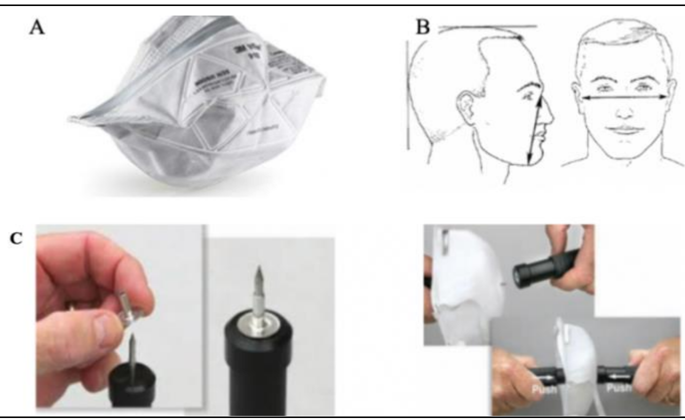

Figure 2. Research equipment. Top (left to right): 3M-VFlex respirator, menton sellion length and bizygomatic width. Bottom: Visuals for probing an N95 using a TSI-8025 probing kit.

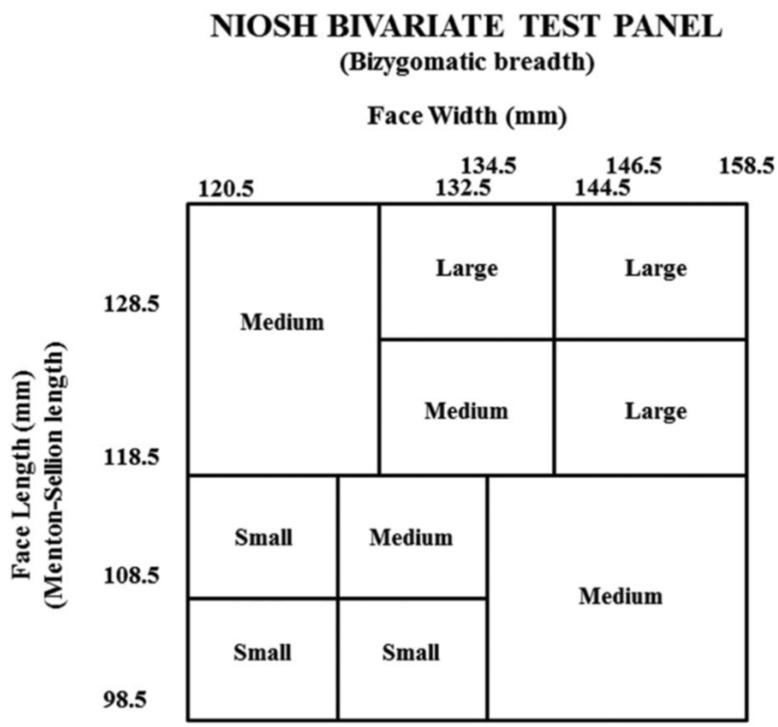

Figure 3. NIOSH-NPPTL Bivariate Test Panel.

C. <u>Subject enrollment</u>

The study was advertised using posted signs and handouts throughout various northside Chicago communities. Recruiting emails were also sent to the students of the University of Illinois in Chicago. When subjects contacted investigators, they were asked screening questions (Figure 4). Similar questions were asked again at the time of the scheduled meeting to re-assess the participants' eligibility. Subjects were excluded if they reported having respiratory or health conditions that would make wearing a respirator difficult, experienced claustrophobia, had facial impediments (e.g. piercings), were not willing to be clean-shaven, were less than 18 years of age or older than 65, and were not willing to refrain from smoking and eating 60 minutes before the session.

Contact with all recruited individuals was managed in Microsoft Excel. The logged information included recruit names, date of contact, email addresses, responses to eligibility questions, and whether or not they participated and completed the study. This file was protected from unauthorized users via passwords. Upon participation, subjects' names were reentered in another file as assigned ID numbers. Anthropometric facial dimensions, mask size, training method administered, and fittest scores were also logged in this second data file.

Date: ________________Interviewer Name: _________________ Subject ID: ___________

1. Are you between the ages of 18 and 65?	Yes ☐ No ☐
2. Would you agree that you are in generally good health at this time?	Yes ☐ No ☐
3. Do you have any pre-existing respiratory or other health conditions that might make it difficult for you to wear a respirator?	Yes ☐ No ☐
4. Do you experience claustrophobia or a fear of being in enclosed or narrow places?	Yes ☐ No ☐
5. Take a few minutes to review the task list for the tests you will be performing today. Are you able to perform all the tasks on the list? ~ 60 seconds each. a. In a normal standing position, without talking, you will be asked to breathe normally. b. In a normal standing position, you will be asked to breathe slowly and deeply, taking caution so as not to hyperventilate. c. Standing in place, you will be asked to slowly turn your head from side to side between the extreme positions on each side. Your head shall be held at each extreme momentarily so you can inhale at each side. d. Standing in place, you will be asked to slowly move your head up and down. e. You will be asked to talk out loud slowly and loud enough so as to be heard clearly by the test conductor. You can read from a prepared text such as the Rainbow Passage, count backward from 100, or recite a memorized poem or song. f. Grimace. You shall grimace by smiling or frowning. g. You will be asked to bend at the waist as if you were to touch your toe	Yes ☐ No ☐
6. If you are a smoker, have you smoked within the last 60 min?	Yes ☐ No ☐
7. Have you eaten within the last 60 min?	Yes ☐ No ☐
8. Do you have any facial hair, bandages, jewelry or other impediments to a facial seal?	Yes ☐ No ☐

Figure 4. Eligibility questionnaire.

D. <u>Video training methods</u>

The Respiratory Safety video used in this study was created by the U.S. Department of Labor for educational purposes (2009). It runs for a total of 9 minutes (only 5 of which were deemed relevant to respirator donning and used for this study) and provides a general description of OSHAs respiratory protection standard, 29 CFR 1910.134. It also includes a brief guide on donning and doffing for several respirator types, fit testing, and user seal checks. The video is narrated and features a model performing donning, doffing, and user seal check tasks with an N95 respirator. Due to the nature of video training, no assistance, dialogue, or modifications in mask placement, is provided at any point during the experimental procedure. The timestamp and featured content are as follows:

> (0:00 - 0:48) “When you must wear a respirator to protect yourself against airborne contaminants in your workplace it is very important to follow proper procedures for putting it on and taking it off. The process of putting on and taking off your respirator is also referred to as donning and doffing. Manufacturers provide instructions on how to do this on every respirator they produce.”
>
> (0:49 - 1:40) “Manufacturers also provide instructions on how to properly conduct a user seal check, which is a way to verify that the respirator has been properly positioned on your face to ensure a proper seal. Sometimes workers confuse the term user seal check with the term fit test which is different. A user seal check is not a substitute for a fit test. A fit test is a more involved process that uses a test agent or instruments to verify the respirators fit. A fit test must be performed *before* you wear a respirator for the first time and at least annually thereafter. A user seal check must be performed each time you put on a respirator to check that it has been donned correctly. Remember always follow the respirator manufacturer's instructions for the specific respirator model that you are using.”
>
> (1:41 – 3:12) “Here are some general instructions for properly donning and doffing and properly conducting a user seal check for the most common types of respirators. Let’s begin with instructions for a disposable filtering facepiece respirator, which is often referred to as an N95 or a dust mask. Remove the respirator from its packaging and inspect it for tears or damage. Make sure to look at the straps. If you find any damage to the respirator replace it. Open the folds fully. Then, using one hand place the respirator on your face with the nose piece at your fingertips allowing the headbands to hang freely. The nose piece should span and cover the bridge of your nose and the respirator should

> cup your chin. Place the top strap over your head, resting high at the back of your head. Take the bottom strap over your head and position it around your neck and below your ears. Be sure not to crisscross the straps and make sure that your mouth and nose are covered by the respirator. Press down firmly on the metal nose piece by pushing inward and moving your fingertips down along both sides of the nose piece."
>
> (3:13 – 4:40) "Conduct a user seal check: For a positive seal check, cover the surface of the respirator with your hands so that air is prevented from passing through the mask, then exhale deeply. If the face piece bulges slightly you have passed the seal check. For a negative pressure seal check, cover the surface of the respirator with your hands so that air is prevented from passing through the mask and take a deep breath to see if the face piece collapses slightly. If so, you passed the seal check. During either test if air leaks out between your face and the respirators then the respirator may not fit your face properly. One way that you can identify leakage is if you feel air blowing through the seal onto your face or eyes. If you feel this, readjust the fit of your respirator and check the seal again. If you cannot achieve a proper seal you are not protected and should not enter a hazardous area. When you're finished wearing the respirator carefully remove it without touching the exterior."

E. In person training methods

The one-on-one training curriculum was created by transcribing the Respirator Safety video verbatim (U.S. Department of Labor, 2009). Analogousness was maintained by providing visual demonstrations of mask donning, doffing, and seal checks. While the facilitator read out the transcribed script, a respirator was used to carry out each step. Subjects were encouraged to follow along during instruction but where not provided any physical assistance or modifications in mask placement at any point during the experimental procedure. Additionally, the script incorporates pauses where the facilitator checked in with the trainee to answer any questions and encourage dialogue. The script is as follows:

> When you must wear a respirator to protect yourself against airborne contaminants in your workplace it is very important to follow proper procedures for putting it on and taking it off. The process of putting on and taking off your respirator is also referred to as donning and doffing. Manufacturers provide instructions on how to do this on every respirator they produce. *Pause for questions/dialogue.*

Manufacturers also provide instructions on how to properly conduct a user seal check, which is a way to verify that the respirator has been properly positioned on your face to ensure a proper seal. *Pause for questions/dialogue.*

Sometimes workers confuse the term user seal check with the term fit test which is different. A user seal check is not a substitute for a fit test. A fit test is a more involved process that uses a test agent or instruments to verify the respirators fit. A fit test must be performed *before* you wear a respirator for the first time and at least annually thereafter. *Pause for questions/dialogue.*

A user seal check must be performed each time you put on a respirator to check that it has been donned correctly. Remember always follow the respirator manufacturer's instructions for the specific respirator model that you are using. *Pause for questions/dialogue.*

I am going to give you some general instructions for properly donning and doffing and properly conducting a user seal check for a disposable filtering facepiece respirator, which is often referred to as an N95. *Pause for questions/dialogue.*

General instructions for respirator donning and doffing:

Hand subject mask and use another mask to demonstrate instruction. Remove the respirator from its packaging and inspect it for tears or damage. Make sure to look at the straps. If you find any damage to the respirator replace it.

Open the folds fully. Then, using one hand place the respirator on your face with the nose piece at your fingertips allowing the headbands to hang freely. The nose piece should span and cover the bridge of your nose and the respirator should cup your chin.
Place the top strap over your head, resting high at the back of your head. Take the bottom strap over your head and position it around your neck and below your ears. Be sure not to crisscross the straps and make sure that your mouth and nose are covered by the respirator.

Press down firmly on the metal nose piece by pushing inward and moving your fingertips down along both sides of the nose piece.
Conduct a user seal check: For a positive seal check, cover the surface of the respirator with your hands so that air is prevented from passing through the mask, then exhale deeply. If the face piece bulges slightly you have passed the seal check.
For a negative pressure seal check, cover the surface of the respirator with your hands so that air is prevented from passing through the mask and take a deep breath to see if the face piece collapses slightly. If so, you passed the seal check

During either test, if air leaks out between your face and the respirators then the respirator may not fit your face properly. One way that you can identify leakage is if you feel air blowing through the seal onto your face or eyes. If you feel this, readjust the fit of your respirator and check the seal again. If you cannot achieve a proper seal you are not protected and should not enter a hazardous area. When you're finished wearing the respirator carefully remove it without touching the exterior. *Allow time for questions/dialogue*.

F. <u>Respirator fit testing and fit factors</u>

A standard OSHA fit testing protocol includes eight exercises. Each is performed for 60 seconds while the subject is connected to the PortaCount® Pro Respirator Fit Tester. The exercises are normal breathing, deep breathing, moving head side to side, moving the head up and down, talking, grimacing, bending over, and normal breathing again. When a subject completes an exercise, FitPro+ ™ Fit Test Software computes a FF.

For each exercise, PortaCount® software calculates a FF by taking the average ambient particle concentration before and after the given exercise and then dividing it by the average concentration of particles within the respirator (TSI, 2015, p. 85). For the purpose of this study, analysis was conducted utilizing the overall FF. An overall FF is based on the individual FF of each exercise (TSI, 2015, p. 86). The actual formulas are:

$$FF = \frac{\mathrm{CB} + \mathrm{CA}}{2\mathrm{CR}}$$

FF = Fit Factor
CB = Ambient particle concentration in the ambient before the exercise
CA = Ambient particle concentration in the ambient after the exercise
CR = Particle concentration within the respirator

$$\text{Overall FF} = \frac{\mathrm{N}}{\frac{1}{\mathrm{FF1}} + \frac{1}{\mathrm{FF2}} + \frac{1}{\mathrm{FF3}} + \cdots \frac{1}{\mathrm{FFn}}}$$

N = Number of exercises
FFx = Fit factor for the individual exercise.

G. Data analysis

PortaCount® Pro Respirator Fit Tester data was logged into an excel sheet for every test subject prior and post their respective training session. Since fit testing data is non-normally distributed, overall fit factors were log-transformed. Using R statistical software, objectives were addressed as follows:

Objective 1. Determine if training on donning improves respirator fit. Using a Students T-test, overall FFs were combined for both methods before receiving training and compared to those achieved after training. Statistical significance was considered if the difference resulted in a P-value < 0.05.

- H_0: Respirator fit will not significantly improve after any training.
- H_a: Respirator fit will significantly improve after any training.

Objective 2. Investigate and compare the impact of two training methods (video and one-on-one) on respirator fit. For each training method, a Students T-test compared overall FF achieved before training to those achieved after training. Statistical significance was considered if the difference resulted in a P-value < 0.05.

- H_0 : Respirator fit will not significantly improve after video training.
- H_a : Respirator fit will significantly improve after video training.
- H_0 : Respirator fit will not significantly improve after one-on-one training.
- H_a : Respirator fit will significantly improve after one-on-one training.

Objective 3. Analyze whether one method is more effective than the other at teaching users how to correctly don a respirator. Qualitatively compare users ability to perform key donning tasks before and after the two types of training (Table III).

III. RESULTS

A. Participant characteristics

A total of 20 people participated in and completed the study. 5 of 20 subjects reported having prior respiratory training experience. The experience reported by 3 of the 5 subjects had occurred over 2 years prior and they indicated not using respirators since then. The other 2 subjects did report frequent use of various respirators but disclosed that they have difficulty donning due to small facial proportions. (Table I).

The majority of participating subjects identified as females (75%). For facial size distribution, 50% of subjects fell within the NIOSH Bivariate Fit Test Panel cells 4-10 (Table I) and were given a mask size regular (Figure 5). The other 50% of subjects fell within the NIOSH Bivariate Fit Test Panel cells 1-3 and were assigned a respirator size small. The median measurement for face width and face length were 134 cm and 113.5 cm, respectively. (Table I).

Table I. DEMOGRAPHIC CHARACTERISTICS

	Video group (n=10)	In-person group (n=10)	Total (n= 20)
Gender			
Female	7 (70)	8 (80)	15 (75)
Male	3 (30)	2 (20)	5(25)
Prior knowledge/training			
Yes	3 (30)	2 (20)	5 (25)
No	7 (70)	8 (80)	15 (75)
Anthropometric measurements			
Face width (mm)	133.5	134.5	135
Face length (mm)	113.5	113.6	113.5
Mask size			
Regular	5 (50)	5 (50)	10 (50)
Small	5 (50)	5 (50)	10 (50)

Categorical variables are presented as numbers (%). Continuous variables as medians.

B. NIOSH panel

All participants had their bizygomatic breadth (face width) and menton sellion length (face length) measured. Following the NIOSH bivariate test panel; four subjects fell in cell 1, three in cell 2, two in cell 3, two in cell 4, two in cell 5, two in cell 6, and four in cell 7. Subjects falling within cells 1, 2, and 3 were assigned a respirator size small. All other subjects were given a respirator size regular. No subjects fell within the extremes of 8, 9, and 10. (Figure 5).

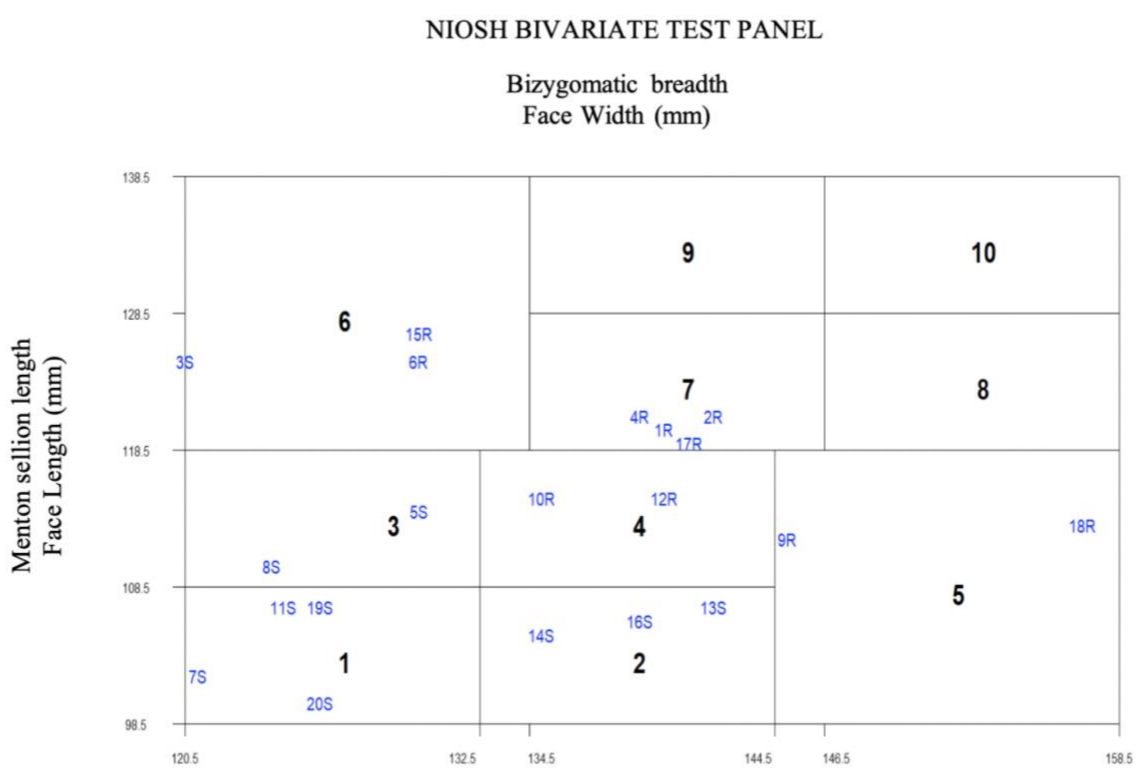

Figure 5. Distribution of participants according to the NIOSH Bivariate Test Panel. Subject number and mask size are shown in blue. R= regular and S= small.

C. Fit factors during experimental procedure (objective 1 and 2)

Subjects underwent fit testing before receiving training instruction. The initial fit tests were unassisted and served as a baseline marker for any improvements made post-training. The geometric mean (GM) for overall fit factors (FF) before video training was 16.94. After training this insignificantly improved to a GM= 55.70 (P = 0.07). In contrast, overall FFs significantly increased for subjects after in-person training from an initial GM= 6.88 to GM= 94.63 (P = 0 .01). (Table II). Overall, the impact of training was significant. When FFs for both groups were combined before training, the GM= 10.84. This increased after training to GM= 72.80 (P = .0006). (Table II).

Table II. GEOMETRIC MEAN (GM) OF FIT FACTORS BEFORE AND AFTER TRAINING

	Video		**In-person**		**Combined**	
	Before	After	Before	After	Before	After
Fit factors (GM)	16.94	55.70	6.88	94.63	10.84	72.80
P-value	0.07		.01***		.0006***	

D. Donning practices (objective 3)

Dialogue interjections for subjects undergoing one-on-one instruction led to an increase in training duration. The interactions between the subject and the facilitator were strictly verbal.

During the exchange, participants commonly asked for further clarification on donning steps and looked for assurance that they were following along correctly. No assistance or interchange ensued outside of training. Subjects in both groups had to put on their mask and undergo fit testing unassisted.

Before training, seven subjects in the video group and four in the one-on-one group successfully placed the respirator in the correct position over nose mouth and chin. Incorrect positioning included placing the mask too low on the nasal bridge, upside down, or not covering the chin and nose. For nose piece adjustment, the same number of subjects successfully performed the task by firmly pressing down on the metal strip so that it lay flush against the skin. Subjects that performed this incorrectly only pinched the metal piece at the nose bridge (causing a small opening at the site) or failed to adjust the nose piece altogether.

Correct strap placement occurred among four subjects in the video group and three in the one-on-one group. The errors observed were failure to separate the straps and placing them too low on the crown of the head. Low strap placement resulted in folded ears and gaps below the temples.

For user seal checks, subjects in both groups had difficulty performing this task. One video trained participant and two from the in-person group performed negative and positive user seal checks after slipping on their masks. All other subjects omitted user seal checks from their donning procedures. (Table III).

Table III. COMPARISON OF DONNING A PRACTICES BEFORE AND AFTER TRAINING

Task	Before Performed action correctly (%)	After Performed action correctly (%)
	Video	
Mask placement	7 of 10 (70%)	9 of 10 (90%)
Nose piece adjustment	7 of 10 (70%)	9 of 10 (90%)
Strap placement	4 of 10 (40%)	8 of 10 (80%)
Seal check	1 of 10 (10%)	6 of 10 (60%)
	In-person	
Mask placement	4 of 10 (40%)	10 of 10 (100%)
Nose piece adjustment	5 of 10 (50%)	10 of 10 (100%)
Strap placement	3 of 10 (30%)	10 of 10 (100%)
Seal check	2 of 10 (20%)	6 of 10 (60%)

IV. DISCUSSION

A. Quantitative results

Studies suggest that employees who don a respirator without the assistance of a trained professional, are more likely to have an improperly fitted respirator and, therefore, be less protected (Hannum et al., 1996). In these cases, pre-recorded videos have been more effective than other indirect methods such as print and computer-based programs at teaching users how to correctly wear a respirator (Harber et al., 2013). The present study supports this finding by showing a significant increase in respiratory protection when subjects were individually trained by a professional. After training, subjects in this group were able to better performed key donning tasks (Table III) and fit factors, as determined by PortaCount® software, support their improvements as statistically significant (P = .01, Table II). In contrast, subjects that underwent video training had marginal improvements. Although preliminary analysis for the video group revealed a strong understanding of donning practices (i.e. knew to place the mask over mouth and nose, adjust nose piece, etc.), few were able to achieve respiratory protection (P= .07), Table II).

Additionally, the results of this study support the overall effectiveness of training, regardless of the method employed. When overall FFs were combined for both methods before training and compared to those achieved after training, there was a statistically significant increase in respiratory protection achieved. (P = .0006, Table II). Hannum et. al had similar findings when they compared the effects of one-on-one training by a profession and classroom instruction by a professional against a group that received no formal training (1996). They found both methods of training, one-on-one, and classroom instruction, produced nearly equivalent pass rates of 94% and 91%, respectively (Harber et al.,1996).

B. Training observations

Previous training experience can be a confounding factor when examining the impact of training methods on a user's ability to pass a fit test. (Hannum et al.,1996). While some participants in this study (3 of 10 for video and 2 of 10 for in-person) reported having prior respiratory training experience, the overall prevalence of incorrect donning suggests that their particular exposure has little influence. The previous experience reported by 3 of the 5 subjects had occurred over two years prior. Since, they have rarely used any form of a respirator. Failure to fortify training via frequent or occasional respirator use (at least 5 days per year) nullifies the impact of previous experience (Harber et al., 2013). Additionally, Harber and others find there is no association between previous experience and fit factors achieved after current training (Harber et al., 2013). Moreover, the other two subjects did report frequent use of various respirators but also disclosed that they have difficulty donning due to small facial proportions.

Observations revealed the most reoccurring issue for participants before and after training was strap placement and user seal checks (Table III). Subjects that had trouble with strap placement after training were observed to don the respirator out of order. Both training methods instruct users to first place the mask over face, then secure top strap, follow with bottom strap, and then press down on the nose piece. Despite this, subjects used the straps to hold the mask upright and then adjusted the nose piece. Afterward, they would attempt to readjust the straps but had difficulty, since distinguishing crossed straps after mask placement is not easy. Previous research also found that subjects had trouble with these same two elements of respirator donning, but was not able to attribute it to the specific order the tasks were performed (Brosseau, 2010).

For user seal checks, the only error observed for both groups was a failure to remember to conduct one. It is unclear why this occurred since both training methods provided instruction on user seal check procedures. Moreover, training stressed the importance of seal check procedures for ensuring that adequate respirator-to-face seal has been achieved after donning.

C. Training methods for meeting andragogy principles

An integral part of adult education is understanding how individuals learn and building on the unique experiences that influence their understanding (Campbell, 1999; Chen et al., 2015). Research in public health practice finds that learning may also be enhanced when curriculum integrates principles of adult learning (Bryan et al., 2009). Based on adult learning theories, the four core andragogic principles are (1) Adults need to be actively involved in the learning process (Knowles, 1984), (2) Past experience should be respected and built upon (Knowles, 1984), (3) Adults are motivated to learn by the need to solve problems (Knowles 1984), and (4) Adults need to know why they are learning (Knowles et al., 1998).

To aid motivation and involve learners in their training experience, subjects in both groups were given masks and encouraged to follow along during instruction. This training enhancement directly addressed andragogy principles 1, 3, and 4. Subjects were explicitly told the purpose of their training prior to experimental procedures and the masks given reiterated that point. Encouraging subjects to follow along during donning is a useful strategy for active involvement. Subjects here have the choice of becoming part of the educational process and in turn may be motivated to continue learning (Bryan et al., 2009; Zack et al., 2016).

However, it is unclear if enhancements were enough to motivate video learners as most subjects in the group interacted minimally with their respirator during instruction (i.e. only inspecting it for tears and holding it to face). Subjects may have had control over their level of participation, but they did not have a choice in the training method they received. This lack of choice can inhibit motivation and in the case of video training, exacerbate the rigidness of their learning environment (Bryan et al. 2009; Knowles 1984). In contrast the script created for in-person training allowed subjects to have control over how much they wanted to interact with the facilitator. As a result more subjects trained by a professional were observed to emulate donning.

Principle 2, building on previous experience, was the most difficult point to address. Since the video is intended for a general audience there is no opportunity to customize the content for an experienced subject. By design, the script for one-on-one training was analogous to that of the video and consistent for every subject. The only opportunity to build on previous experience was through dialogue. If subjects had questions beyond the understanding of an inexperienced user the facilitator was available during training to answer them. The majority of participants had no prior respiratory training experience. Those that did had either been trained 2 years prior, or had no questions regarding their current understanding of donning procedures.

Overall, remote methods of training, such as the respiratory safety video used in this study, are beneficial because they increase access to learning (Campbell, 1999). The fixed nature of a pre-recorded video makes it difficult to address all the needs of the individual learner. Here, subjects are restricted to a self-guided experience with no further opportunity for dialogue or to have their questions answered. Subjects are responsible for self-motivating and extracting the necessary information from the training. In our study, this distance learning approach demonstrated that subjects improved after training but not significantly. This is problematic since video training is particularly useful in emergency training scenarios where professional assistance is limited or not feasible (Harber et al., 2013).

Studies evaluating training experiences found that workers most desire a hands-on approach that is relevant to their specific job needs (Zack et al., 2016). In-person training strategies are beneficial for this because they allow an exchange of information to occur between the facilitator and learner (Campbell, 1999). This study found that discussions encouraged active participation and motivated subjects to ask questions. Training was an average of 9-minutes (almost double the video) and resulted in a significant increase in respiratory fit.

D. Limitations

This study is limited by the small and convenient sample of subjects. Majority of individuals are university students who are not actively employed in positions that require respirator use. It is also important to note, that subjects were unable to swap their designated respirator size for another. This can impact respirator fit, despite improvements seen in donning practices after training and may explain the low fit factors observed after training.

Due to the dialogue incorporated with in-person training, total training time varied and was not controlled for in this study. The recorded time for 3 of 10 subjects in the one-on-one group was 9 minutes, 10 minutes, 9 minutes (average 9.3 minutes). Furthermore, the N95 model used in the pre-recorded video differs from the one used in the study. Though donning instruction is the same, this difference can impact a user's willingness to learn or understand the material.

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VITA

NAME Karen Segura

EDUCATION

Master of Science- Public Health — University of Illinois at Chicago
Concentration: Environmental and Occupational Health Science — Spring 2020
B.S. in Biology — Northeastern Illinois University
Spring 2018

SCHOLARSHIPS & AWARDS

The National Institute for Occupational Safety and Health at Illinois ERC Industrial Hygiene Traineeship — University of Illinois at Chicago, August 2, 2018-Present

American Industrial Hygiene Conference & Exposition Best in show poster award — AIHce, Atlanta Georgia, June 25, 2020

President of American Society of Safety Professionals- Student Section — University of Illinois at Chicago, February 8, 2019-Spring2020

McNair Scholarship — Northeastern Illinois University, 2015-Present

TRIO Engagement Scholarship — Northeastern Illinois University, Spring 2017

WORK EXPERIENCE

Program Assistant
Northeastern Illinois University, Department of McNair Scholars Program
Fall 2016- Spring 2018
Guided incoming McNair students through IRB training. Managed and organized student and program data. Coordinated public events such as: annual student and faculty symposiums. Produced annual student and faculty symposium handbooks. Assisted in the editing of program newsletters, program poster boards, informational booths, and student research projects.

RESEARCH EXPERIENCE

University of Illinois at Chicago
Department of Public Health (Industrial Hygiene)
June 2019- June 2020
Primary Investigator: Dr. Margaret Sietsema
Analyzing the efficacy of respirator training methods among habitual and occasional users.

University of Illinois at Chicago
Department of Public Health (Industrial Hygiene)
June 2018- January 2020
Primary Investigator: Dr. Margaret Sietsema
Developing a mobile application aimed to improve respirator fit testing.

University of Illinois at Chicago
Department of Public Health (Environmental and Occupational Health)
June 2019-Ongoing
Primary Investigator: Dr. Susan Buchanan
Investigating impact of air quality in newly renovated housing complexes in Chicago and Chicago-land area.

Northeastern Illinois University
Department of Biology (Evolutionary Biology/ Ecology)
2016- May 2018
Primary Investigator: Dr. Jennifer Slate
Examining freshwater sponges in the Chicago river and Volo Bog to assess their potential as bioindicators.

Northern Illinois University/ Yucatan Peninsula, Mexico
Department of Public Health
June-August 2017
Primary Investigator: Dr. Tomoyuki Shibata
Investigated the adverse health effects of cenote (sinkhole) water quality in the Yucatan Peninsula of Mexico.

Northeastern Illinois University
Department of Biology (Evolutionary Biology)
Fall 2014-2015
Primary Investigator: Dr. Aaron Howard
Quantified the influence of flower color of the common milkweed plant (*Asclepias syriaca*) on pollinator behavior.

TEACHING EXPERIENCE

Teaching Assistant for Aquatic Biology (BIO 352)
Northeastern Illinois University, Department of Biology
Fall 2016
Assisted in the design of class syllabus, quizzes, and exams. Led class in research discussion and provided students with guidance during laboratory activities. Assisted in training students on various techniques and activities during field work.

FEATURED ARTICLES

Segura, K., Slate J. 2018. Volo Bog: Home to Ancient Animals. *The Bog Log*. Available at https://www.friendsofvolobog.org/history

Segura, K., Vujanovic, M., Slate J. 2017. Fresh Water Sponges in Volo Bog and The Chicago River: Potential as Bioindicators. *Illinois Riverwatcher,* (38), 6. Available at http://www.ngrrec.org/RiverWatch/resources/
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ORAL PRESENTATIONS

Segura, K., Vujanovic, M., Slate J. 2017. Fresh Water Sponges in Volo Bog and The Chicago River: Potential as Bioindicators. McNair National Conference. College Park, Maryland.

POSTER PRESENTATIONS

Segura, K., Sietsema, M. 2020. Comparison of Two Respirator User Training Methods: Video and One-on-One Training. American Industrial Hygiene Conference & Exposition(AIHce). Atlanta, Georgia.

Segura, K., Quintanar-Alfaro, A., Cerda-García, C., Tomoyuki, S. 2017. Recreational Water Illness in Cenotes of The Riviera Maya: The Potential Impact of Cenote Water Quality on Public Health. Annual Biomedical Research Conference for Minority Students (ABRCMS). Phoenix, Arizona.

Segura, K., Quintanar-Alfaro, A., Cerda-García, C., Tomoyuki, S. 2017. Recreational Water Illness in Cenotes of The Riviera Maya: The Potential Impact of Cenote Water Quality on Public Health. Ronald E. McNair National Conference. Schaumburg, Illinois.

Segura, K., Quintanar-Alfaro, A., Cerda-García, C., Tomoyuki, S. 2017. Recreational Water Illness in Cenotes of The Riviera Maya: The Potential Impact of Cenote Water Quality on Public Health. Northeastern Illinois University Student Research and Creative Activities Symposium. Chicago, Illinois.

Segura, K., Quintanar-Alfaro, A., Cerda-García, C., Tomoyuki, S. 2017. Recreational Water Illness in Cenotes of The Riviera Maya: The Potential Impact of Cenote Water Quality on Public Health. Northern Illinois University Summer Student Research Symposium. DeKalb, Illinois.

Segura, K., Vujanovic, M., Slate J. 2016. Fresh Water Sponges in Volo Bog and The Chicago River: Potential as Bioindicators. Annual Biomedical Research Conference for Minority Students. Tampa, Florida.

Segura, K., Vujanovic, M., Slate J. 2016. Fresh Water Sponges in Volo Bog and The Chicago River: Potential as Bioindicators. Wild Things Conference. Chicago, Illinois.

Segura, K., Vujanovic, M., Slate J. 2016. Fresh Water Sponges in Volo Bog and The Chicago River: Potential as Bioindicators. Northeastern Illinois University Student Research and Creative Activities Symposium. Chicago, Illinois.

Segura, K., Howard. A 2016. The Influence of *Asclepias syriaca* (Common Milkweed) Flower Pigmentation on Floral-Visitor Behavior and Pollination. Chicago River Student Congress. Chicago, Illinois.

Segura, K., Howard. A 2016. The Influence of *Asclepias syriaca* (Common Milkweed) Flower Pigmentation on Floral-Visitor Behavior and Pollination. Chicago Area Undergraduate Research Symposium (CAURS). Chicago, Illinois.

Segura, K., Howard. A 2015. The Influence of *Asclepias syriaca* (Common Milkweed) Flower Pigmentation on Floral-Visitor Behavior and Pollination. Conference for the Society for Advancement of Chicanos and Native Americans in Science (SACNAS). Washington, District of Columbia.

Segura, K., Howard. A 2015. The Influence of Asclepias syriaca (Common Milkweed) Flower Pigmentation on Floral-Visitor Behavior and Pollination. Northeastern Illinois University Student Research and Creative Activities Symposium. Chicago, Illinois.

VOLUNTEER AND OTHER EXPERIENCE

Green Petition — University of Illinois at Chicago, Fall 2019
Drafted and promoted petition for a sustainable food vendor at UIC. We are asking UIC to contract with a food vendor that aligns with UIC's zero waste climate commitment.

Academic Decathlon — Northeastern Illinois University, Spring 2018
Lead mock interviews for high school students in annual academic competition. Event is organized by the non-profit United States Academic Decathlon Association.

Green Fee Committee Proposal — Northeastern Illinois University, Spring 2017
Constructed a proposal that was approved by the Green Fee Committee to fund environmentally friendly microwaves. Microwaves are free for use in the cafeteria.

Field Trip Leader — Thomas J. Waters Elementary, 2011-Present
Lead field trips of 15 students from K-7th grade. Teach basic ecology concepts, with a focus on environmental issues. Encourage students to be environmentally conscious and develop green habits.

Regional Science Fair Judge — Northeastern Illinois University, Spring 2017
Judged posters and provided feedback for high school student research presenters.

Chicago Herpetological Society Reptiles Fest Volunteer — Northeastern Illinois University, Spring 2017
Exhibited various reptiles, and educated families on how to care and handle exotic pets.

High School Youth Mentorship — Northeastern Illinois University, Fall 2015-2017
Led integrative workshops on aquatic parasites. Led talks on the importance of research and higher education.

Bird Collision Project — Northeastern Illinois University, Fall 2015-2016
Monitored bird collisions on campus with the intent to raise awareness and propose solutions to stop further collisions.

Restoration Volunteer — North Park Village Nature Center, Fall 2015-2016
Removed invasive plant species from nature preserve and cleaned litter.

Chicago River Student Congress Workshop Leader — Taft High School, Spring 2015-2017
Designed creative and interactive activities to engage high school students during a 30-minute workshop. Led a workshop on freshwater sponges for young adults. Presented a poster discussion on sponges and the advantages of research.