THE OHIO STATE UNIVERSITY

Evaluation of a Training in Science Education Outreach Course Summary

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Executive Summary

As interest in Science, Technology, Engineering, and Mathematics (STEM) education grows (Olson & Riordan, 2012), the need for professionals to clearly communicate sophisticated concepts associated with these areas also increases (Fischoff & Scheufele, 2013). This evaluation focuses on a 3 credit university course "Training in Science Education Outreach" which utilizes a novel course structure. The course's main aim is to teach graduate and undergraduate students how to speak to the public about science, focusing specifically on language science. The structure of the course is non-traditional in that a portion of the required course hours must be completed at the Center of Science and Industry (COSI) in the form of hands-on science demonstrations for visitors. Students performed interactive science demonstrations covering a range of language topics from the physiology of the larynx (producing speech) to the Stroop task, a task demonstrating how reading is automatic for a literate person. Demonstrations lasted around 5 minutes, or longer depending on visitor interest. Other course activities include guest speakers, lectures, and discussion. Fifteen undergraduate and graduate students from the fall 2014 course participated as well as 71 groups of COSI visitors. Groups ranged from one to thirteen people.

The course had three goals: 1) increase students' knowledge about language and their confidence in engaging in scientific discussions, 2) train the students to present a successful science demonstration, 3) improve COSI visitors' experience as a result of interacting with a student. The corresponding evaluation goals to measure the effectiveness of this novel course model were: 1) To what extent was there an increase in students' knowledge of language for and confidence in discussing science with the public? 2) What was the quality of the students' science demonstrations, as evidenced by accuracy, engagement, and appropriateness? 3) In what ways, if any, did the demonstrations improve the COSI visitors' overall experience? Data from a combination of student questionnaires, student observations, and interviews with COSI visitors revealed a positive impact from the course on all three goals. Specifically, taking the course significantly improved students' views of their ability to communicate effectively with the public and observation scores found that 80% of the students in the course could successfully perform a science demonstration by the end of the course. Students that failed to meet this criteria either presented inaccurate information, provided too little information, was not sufficiently engaging, or some combination of the three. Average student interest in science outreach increased by 15% from the beginning to the end of the course. In addition 92% of students reported increased language knowledge, although overall scores on a test of language myths did not show much improvement. Visitors provided an accurate piece of information from the demonstration 76% of the time, indicating that they learned something new from the 5-minute interaction. Finally, 98% of COSI visitors interviewed after experiencing a science demonstration said the demonstration improved their visit to COSI. This multi-faceted evaluation of a unique course model suggests that, overall, the course was effective at teaching students skills in interacting with the public, generally improving their confidence as (language) science communicators, and enriching COSI visitors' experiences.

1. Introduction

An increasing interest in Science, Technology, Engineering, and Math (STEM) education (Olson & Riordan, 2012) calls for professionals to spend time clearly communicating sophisticated concepts to the public. Scientists recognize the value of discussing science and providing outreach to the public (Fischhoff & Scheufele, 2013). Moreover, there is evidence that experience teaching science to others benefits the teachers as well as the learners (Dandavino, Snell, & Wiseman, 2007). Those who spend time working with the public will increase not only public knowledge and interest, but also their own communication skills and understanding of teaching and learning. Beyond communicating sophisticated STEM concepts, it is important for the future of STEM areas to convey an excitement for learning to the public (Feder, Shouse, Lewenstein, & Bell, 2009). Integrating these factors suggests that science education outreach serves not only to educate citizens, but also to encourage an interest in learning. Even if someone is not interested in the specific topic of discussion, he or she may become motivated to search for more information and experiences on a topic of their interest. An ideal forum for this type of public outreach is at science museums, which provide many opportunities for scientists and researchers to share information with the public in an informal learning environment.

This evaluation focuses on a university course "Training in Science Education Outreach" with a non-traditional course structure: a portion of the required course hours are completed at the Center of Science and Industry (COSI) in the form of hands-on science demonstrations for visitors. The course aims to teach students how to speak to the public about science, focusing specifically on language science. The overarching goal of this evaluation was to assess the extent to which taking this course impacted the students and the COSI visitors with whom they interacted. The broad skills taught in this course aim to go beyond specific language topics to encompass generalizable strategies for discussing complex topics with the public in informal settings. If this course is determined to be a good model for teaching future educators and scientists how to interact with the public, it could be extended to STEM domains beyond the content area of this course, language science.

2. Program Description

The "Training in Science Education Outreach" undergraduate and graduate course at The Ohio State University is open to undergraduate and graduate students. The course is cross-listed in Psychology, Linguistics, and Teaching and Learning departments and aims to teach students how to speak to the public about science, specifically about language science. The course instruction rotates among three professors: Dr. Laura Wagner, Dr. Kathryn Campbell-Kibler, and Dr. Leslie C. Moore.

The course has a non-traditional structure in that a portion of the required course hours were completed at the Language Sciences Research Lab (the so-called "Language Pod") within the Life exhibit of the Center of Science and Industry (COSI). During this portion of the course students engage in informal science demonstrations for visitors as well as recruit participants for research studies. The science demonstrations covered a range of language topics from the physiology of the ear and larynx to the Stroop task, a task demonstrating the difficulty of a literate

person to inhibit reading. Demonstrations were typically set up on mobile carts outside of the Life exhibit at COSI to attract visitors moving between exhibits and lasted around five minutes. Students were trained on multiple demonstrations, and were allowed to choose which to present each day. The target age group of the demonstrations varied, but most were generally appropriate and adaptable for preschool-aged children through adults. The first three weeks of the course involved training on how to interact with the public as well as learning about specific language science topics, which provided foundational knowledge for the students to present science demonstrations to COSI visitors. Additionally, students learned about COSI's mission, policies, and specifically about the COSI Labs in Life exhibits. Not only did students experience working with the non-profit science museum, they also learned how a research lab works. After the first three weeks, students were required to work at COSI an average of three hours per week over the remaining 11 weeks of the semester; in-class sessions were reduced during this time period to allow students added time and flexibility to schedule and work their COSI hours at their own convenience. Students received formal training in how to conduct demonstrations during class sessions, and received both formal and informal feedback about their demonstrations from peers, a trained course assistant, and the instructor over the semester. The instructor evaluated each student presenting a science demonstration at COSI at least once during the final weeks of the course, which accounted for 20% of their final grade in the course.

Students were required to attend 3-hour-long class sessions a total of 9 times over the semester. Attendance in class and at COSI accounted for 25% of the students' grades. The more traditional classroom time included lectures, class discussions, and guest speakers. The classroom topics included basic language science background material that was largely tied to the content of the museum demonstrations. The primary readings for this portion of the course were drawn from a non-technical book about language, Crystal's *How Language Works.* Special attention was paid to discussions about common language misconceptions and one of the students' writing assignments focused on discussing a myth from the edited volume *Language Myths* by Bauer and Trudgill. Language misconceptions were not central to the demonstrations, but their inclusion helped to establish the expectation that students were responsible for providing scientifically accurate information while at COSI. Finally, a large portion of classroom time was spent reading and discussing informal science education principles and practices. Students read several current journal articles and book chapters and one of their writing assignments required them to compare and contrast the demonstrations used in class with respect to the informal science concepts they had learned.

Students completed three assignments directly related to communicating language science with the public. First, students were required to post multiple times to a discussion board concerning the demonstrations. This board served as a repository for student questions as well as "tips from the field" as students offered each other advice. The board discussions were monitored and augmented by the instructor as needed. Second, the students created a set of slides that could be played in a rotation on a TV display within the Language Pod. The slides provided short facts about language and provided an alternative way to educate visitors. The third assignment was the course final project in which students created a set of guidelines for a potential new language

demonstration, modeling their work off of existing guidelines already in use. The final guidelines accounted for 10% of the students' final grade.

The effectiveness of this class model was evaluated focusing on three primary goals: 1) To what extent was there an increase in students' knowledge of language for and confidence in discussing science with the public? 2) What was the quality of the students' science demonstrations, as evidenced by accuracy, engagement, and appropriateness? 3) In what ways, if any, did the demonstrations improve the COSI visitors' overall experience? Data to assess these goals were collected in the fall of 2014 with Dr. Wagner as the course instructor.

3. Methodology

3.1. Participants

All 15 undergraduate and graduate students at The Ohio State University enrolled in the course consented and participated in the evaluation study, as well as 71 groups of COSI visitors. Dr. Johanson recruited student participants within the first two weeks of the fall 2014 semester, but was not involved with the course beyond the evaluation activities. Participation was voluntary and not associated with course grades. The student participants were on average 23.55 years old (range: 19 - 42 years, with 4 responses missing). Eleven women and 4 men participated in the study. Participants were predominantly White (n = 14), one student selected Hispanic/Latino, and one selected Asian/Pacific Islander (participants could select more than one ethnic category). Twenty percent of the participants were sophomores, 53% were juniors, 13% were seniors, and 13% were graduate students. Most participants were either Psychology (n = 4), Speech and Hearing (n = 4), or Neuroscience (n = 3) majors. Other majors included Agriculture and Extension Education, Environmental Education, Linguistics, and English.

COSI visitors were recruited at COSI immediately after they participated in a language demonstration during the final four weeks of the fall 2014 course using a continual-ask sampling method. Fifteen randomly selected one-hour time intervals were selected for recruitment during this four-week period, in an attempt to capture a representative sample of COSI visitors. Only four groups of visitors declined to participate. Group size ranged from one to thirteen people. On average groups had three people. One adult visitor in the group reported the ages of everyone in their groups including themselves, because groups often consisted of one adult and several children (see Table 1). However, the group could consist of multiple adults. These data revealed the substantial spread in age of COSI visitors. Additionally, the gender of the adult participant in the group was obtained, but not the gender for all members of the group. Nearly twice as many females than males participated and the relation of the adult to rest of the group was most frequently parent-child.

Adult visitors were approached to participate immediately after experiencing a science demonstration by a participating student. Visitors answered questions about the demonstration experience, their interest in language and research, and their demographic information. Details of the visitors' interviews are described below.

Table 1. COSI visitor demographics

Number of People in Age Group		Number
	Birth - 4 years	30
	5 - 10 years	56
	11 - 18 years	25
	19 - 40 years	60
	40 - 60 years	35
	60+	5
Sex		
	Male	24
	Female	40
	No Response	7
Relation		
	Parent	45
	Teacher	1
	Sibling	4
	Other	13
	No Response	8

Note. The demographic information was asked at the end of the survey and in some cases participants did not complete the entire survey or missed a question. Eight groups chose not to provide age information and other non-responses are noted in the table.

3.2. *Measures*

Three types of data were collected: 1) Pre- and post-test student questionnaires, 2) Student demonstration observations at the end of the course, and 3) COSI visitor interviews. See Appendices A-C for full questionnaires and interview questions. The pre-test questionnaire was emailed to the students through Qualtrics within the first week of the course. The post-test questionnaire was emailed in the final week of the course. Questionnaires included questions about demographic information, beliefs in language myths, ratings of interest and confidence in science outreach, and future plans. Language myth statements included both correct and incorrect language science information; many of the statements were common misconceptions the public holds about language. These questionnaires assess evaluation Goal 1: the extent to which there is an increase in students' knowledge of language and confidence discussing science with the public.

Student demonstrations were observed by Dr. Johanson and COSI staff member John Osborn in the final four weeks of the course. The two independent observers rated the 15 participating students during a science demonstration with a COSI visiting group. All 15 students were observed at least twice: 6 were observed twice and 9 were observed 3 times. The students were rated in three domains: their ability to provide accurate information, their ability to be engaging, and their ability to explain the material at an appropriate level. For each domain, students could receive a score of 1 (poor), 2 (expected), or 3 (exceptional). One of the goals of the course is for students to perform science demonstrations with COSI visitors by conveying the expected

amount of accurate information, being engaging, and speaking at an appropriate level for the group. See Table 2 below for descriptions of demonstrations at each rating level. Scores were averaged across raters to create an Accuracy score, Engagement score, and Explained at the Appropriate Level score. These three scores were then averaged to create an overall Success score. A student would be deemed successful if they received a score of 2 or higher. The demonstrations were designed to assess Goal 2: What was the quality of the students' science demonstrations, as evidenced by accuracy, engagement, and appropriateness?

Table 2. Rating rubric for student observations

	Poor (1 point)	Expected (2 points)	Exceptional (3 points)
Accurate	Information contains significant factual errors and/or omissions.	All information presented was accurate. No serious or misleading omissions.	All information presented was accurate. Discussion overall gave a comprehensive picture of the topic.
Engaging	Presentation was awkward and/or distant. Presenter seemed to have trouble reading visitor social cues.	Presentation was comfortable, with a relatively smooth flow of information. Presenter showed awareness of visitor social cues.	Presentation was lively, funny and interesting. Presenter showed awareness of visitor social cues and offered extended information to visitors who indicated deeper interest.
Explained at an Appropriate Level	Presenter sometimes assumed concepts not likely to be available to visitors based on their ages. Technical words or jargon were used.	Presenter assumed only concepts likely to be available to visitors based on their ages. Technical words or jargon were avoided.	Presenter assumed only concepts likely to be available to visitors based on their ages, and followed visitor cues as to whether to introduce more complex concepts. Technical words or jargon were avoided or were introduced and defined where appropriate for the audience.

All participating COSI visitors were interviewed by Dr. Johanson during the final four weeks of the course. The interview for COSI visitors included three open-ended questions, prompting visitors to describe what they learned from the demonstration, how interested they were, and whether the demonstration enhanced their visit. COSI visitors were also asked to indicate their level of agreement with 12 statements relating to their interest in the demonstration topic and language and science in general, as well as their impression of the students conducting the demonstration. Visitors rated their agreement with each question on a scale from 1-7 where 1 indicated strongly disagree and 7 indicated strongly agree. The interview and rating questions were created to assess Goal 3: In what ways, if any, did the demonstrations improve the COSI visitors' overall experience?

4. Results

4.1. Student Questionnaires

4.1.1. Pre-test

The pre-test questionnaire asked students to rate and explain their interest in science outreach and describe their background experience relevant to science outreach and research. These data address initial levels of interest and knowledge which must be established to determine if the course impacts them (Goal 1). At pre-test, the average level of student reported interest in science outreach was 6.73 out of 10. The explanations for the rating chosen included: pursuing a future career in teaching, science outreach is related to their field of interest, science outreach looks good for their major, holding the view that educating people important for society, and general enjoyment of science outreach. Six of the students had no previous experience with science outreach and the others had a variety of teaching, internship, or peer leadership experience. However, eight of the students had prior research experience in the form of lab research and 11 students had future plans to work in a research lab. Thus, students came into the class with relatively high levels of motivation to do outreach, but with generally little experience with science outreach.

The questionnaire also explored students' initial language knowledge through questions about students' background experience and student goals for taking the course, as well as their agreement ratings with common language myths. Although most of the students had language experience in the form of foreign language (n=12) or language related courses (n=8), none had advanced expertise in the form of a Ph.D. or extensive experience. Students' goals for taking the class included gaining teaching experience/public interaction experience (n=9), research experience (n=7), knowledge about language/linguistics (n=6), lab experience (n=1), or having fun (n=1). Thus, student participants could be characterized as highly motivated novices. Students' level of agreement with 17 language myth statements is reported along with their corresponding post-test ratings in the following section.

4.1.2. Post-test

Thirteen of the original 15 students completed the post-test questionnaire. Data from this questionnaire informs Goal 1 of the evaluation, in that students were expected to increase their language knowledge and confidence in interacting with the public as a result of taking this course. Support for Goal 1 was found with 100% of students reporting that they gained experience recruiting for studies and experience interacting with the public, 92% said they had increased language knowledge, 62% said they gained experience working with a non-profit organization, and additional comments included experience collecting research data and experience approaching people and being interactive. These data provide support for the effectiveness of the course in terms of the students' own subjective experience.

To further assess whether students learned about language, a set of 17 language myth statements were given at both the pre- and post-test. Throughout the course, some but not all of these myths were discussed explicitly. Students' success with these items reflects their level of alignment with and understanding of language scientists' views of language science. Students were

asked to rate their agreement with each statement on a scale of 1-7 where 1 meant that the student strongly believed the statement was false, 4 meant the student did not know if it was true or false, and 7 meant the student strongly believed the statement was true. See Appendix D for the list of language myth statements. Paired samples t-tests were run for each of the pairs of questions in the pre- and post-test using a Bonferroni adjusted significance level of $p < .003$. This p-value was obtained by taking the standard $p < .05$ and dividing it by 17 for the 17 questions. Results revealed no significant differences between ratings at pre- and post-test.

> "I would suggest it to anyone who enjoys teaching or is thinking about teaching. It would make the world of difference for people who teach in the traditional environment to understand how to teach in a non-traditional manner."
>
> -Anonymous Student

It is important to note that a lack of significant effect might have indicated that the students were initially correct about the statement and did not need course information to get the correct response. For example, students at pre- and post-test all rated that they strongly disagree with the statement "English is a language isolate-that is, it is unrelated to any other languages in the world." In this case, students did not show changes from pre- to post-test because they were correct from the beginning. Students were largely in the correct domain at pre-test, with averages for 14 of the 17 questions on the appropriate end of the Agree-Disagree spectrum. Responses to 10 questions showed trends suggesting change in the right direction after taking the course and students rated 2 questions the same at pre- and post-test. Differences between pre- and post-test that were greater than .25 could be considered to be noteworthy, especially as our small sample size that completed both the pre- and post-tests (n=13). Using this criterion, 6 of the 17 questions showed notable change in the appropriate direction. Altogether, these data provide some support that students' language knowledge increased as a result of taking this course, though there is room for improvement.

On the post-test questionnaire, participants also rated their level of agreement with statements about their class experience and interests in the form of a post-test and retrospective pre-test. These questions were intended to probe the impact of the course on students' interest in science outreach (INTEREST: Questions 1, 2), confidence in communicating with the public about science (COMM: Questions 3, 4, 6), research skills and opportunities gained (RESEARCH: Questions 3, 5), and decisions about future plans (FUTURE: Questions 7-12). The design of the course endeavored to increase student agreement in all four areas, particularly for interest in science outreach and confidence with communicating. Students provided ratings between 1-10, where 1 meant strongly disagree and 10 meant strongly agree.

As Table 3 shows, on average students rated their interest and abilities at the end of the semester as higher than at the beginning of the semester. The statements students most strongly agreed with were having an interest in science outreach, believing in the importance of communicating with the public about science, having the ability to adjust demonstrations for different groups, and being comfortable interacting with the public. A paired samples t-test was run for each pair of pre- and post-questions, using a significance level of $p < .004$, based on a Bonferroni correction. A statistically significant difference in agreement rating before and after

taking the course was found for Questions 3, 4, and 6, all relating to students' interaction with the public, and 11, relating to future career plans. These data provide evidence that the course successfully gives students confidence when interacting with the public, supporting Goal 1.

Table 3. Questions about students' experiences and interests

Topic		Retrospective Pre-test		Post-test		Mean Difference (post-pre)
		Mean	SD	Mean	SD	
INTEREST	1. I am interested in science outreach.	6.62	2.1	8.15	1.57	1.53
INTEREST	2. It is important to communicate with the public about science.	8.69	1.55	9.54	0.88	0.85
COMM, RESEARCH	3. I am good at recruiting participants.	4.69	2.56	6.92	2.02	2.23*
COMM	4. I am comfortable interacting with the public about science.	5.54	2.07	8.31	1.93	2.77*
RESEARCH	5. I expected this class to help/this class has helped me get connected with a faculty project.	6.15	2.41	6.23	2.28	0.08
COMM	6. I can adjust my demonstration to be appropriate for different age groups.	6.38	1.98	8.77	1.36	2.39*
FUTURE	7. I want to pursue experiences in science outreach.	5.92	2.25	7.38	2.22	1.46
FUTURE	8. I want to pursue a career in science outreach.	4.46	2.18	5.54	2.11	1.08
FUTURE	9. I want to pursue experiences in language research.	5.08	2.22	5.77	3.35	0.69
FUTURE	10. I want to pursue a career in language research.	3.46	1.85	4.62	2.33	1.16
FUTURE	11. I expected this class to help/this class has helped me decide whether I will pursue future research opportunities.	6.31	1.8	7.85	2.34	1.54*
FUTURE	12. I expected this class to help/this class has helped me decide what I will do after graduation.	5.23	2.13	5.92	2.43	0.69

Note. * indicates a statistically significant difference between post-test and the retrospective pre-test at $p < .004$.

This course also succeeded in helping students plan for their futures. Eleven out of 12 students said they were interested in science outreach. Four students said this course helped them realize that this might not be something they want to pursue in the future. An additional four students said they are more interested in science outreach as a result of the course. Teaching experience was given as another factor contributing to level of interest in science outreach. Nearly all students reported an interest in becoming involved with research after taking the course and all students claimed that skills learned in this course could be applied to other situations including interacting with people, presenting scientific information, and recruiting participants. Twelve

students have plans to begin or complete a graduate or medical program within the next 5 years. In the open comments section students generally praised the course structure, content, and hands-on experiences.

The post-test questionnaire also asked students what they viewed to be the most and least interesting components of the course. Six out of 13 students mentioned doing the demonstrations and interacting with the public at COSI as the most interesting. Three students reported guest lectures as the most interesting. In addition, seeing how labs and museums are run was considered interesting. Regarding the least interesting components, 7 students mentioned guest lectures and 6 people mentioned that the readings could be dry or were not on topics of interest to them. These data may be used to modify the course in the future.

4.2. Student observations

As the goal of the course was for students to receive an overall score of 2 or above, indicating that they performed as well as expected on the science demonstrations, the course was successful in achieving this goal. On average students scored 2.18, 2.30, and 2.33 points for the Accuracy, Engagement, and Explained at Appropriate levels, respectively. The average Success score collapsing across these three domains was 2.27. It should be noted that not all individual students met this goal, however. Three of the 15 students received an overall Success score below 2. Students that failed to meet this criteria either presented inaccurate information, provided too little information, was not sufficiently engaging, or some combination of the three. Thus, 80% of the students in this course successfully performed science demonstration. These student observation scores corroborate the effectiveness of the course in teaching students how to successfully interact with the public and provide evidence of success for Goal 2.

4.3. COSI visitors' interview

COSI visitors were interviewed immediately after viewing a science demonstration presented by a student. Across the 71 groups, COSI visitors saw five different demonstration topics. Three open-ended questions were asked of COSI visitors. Specific data for each question is reported in Table 4, but overall visitors were able to provide at least one piece of accurate information taken from the science demonstration. In addition, nearly all visitors indicated interest in the demonstration and self-reported that the demonstration enhanced their visit to COSI, providing direct support for Goal 3. Finally, if participants responded that the demonstration did enhance their visit, they were asked to elaborate. Several specific comments referred to enjoying the interactive nature of the demonstrations and the additional learning opportunities provided.

Table 4. COSI visitors' interview questions

	Question	Response Category	Number of visitors
1.	Tell me something you learned.		
		Provided accurate information	54
		Provided inaccurate information	0
		Provided no/only general information	14
		No response	3
2.	How interested was your group?		
		Very interested	57
		Somewhat interested	12
		Not interested	2
		No response	0
3.	Did the interaction enhance your visit to COSI?		
		Yes	68
		No	2
		No response	0

Note. In some cases groups chose not to respond to the questions, these non-responses are noted in the table.

See Table 5 for the average responses to each question regarding perception of the student (STUDENT: Questions 1, 2), interest in language (LANG: Questions 3, 4, 7, 10-12), interest in science and research (SCI/RES: Questions 5, 6, 10), and interest in COSI and demonstrations (COSI/DEMO: Questions, 8, 9). Questions relating to students were intended to verify student observation ratings and provide additional data to address Goal 2: Could the students give an accurate, engaging, and appropriate science demonstration at COSI? In addition, questions about interest in language, science, research, and COSI were included as the student demonstrations were expected to increase all of these components. These questions address Goal 3: Did the demonstration improve the COSI visitors' overall experience? Scores could range from 1-7, with 1 indicating strongly disagree and 7 indicating strongly agree. Overall, scores were quite high, with the high scores indicating that visitors thought students were engaging and adapted well to their group. The high scores for engagement and adaptability given by COSI visitors provides additional evidence that students had indeed learned to give an effective science demonstration, meaning they successfully communicated with the public about science. Other high scores show that the visitors would like to return to COSI and would like to see another science demonstration.

We were interested in determining if visitor's assessment of student engagingness and ability to adapt were related to increased interest in science, language, and COSI. Correlation analyses were run among all 12 rating questions. Due to the large number of correlations (66), we should be cautious with the interpretation of any difference with less than $p < .0001$ significance, as less robust significance levels may be spurious. Student engagement was positively correlated with students' ability to adapt to the group ($r = .717$, $p < .0001$) and visitors' interest in science

increasing (r = .529, p < .0001). Student ability to adapt to the group was significantly related to the visitors having a special interest in language (r = .484, p < .0001) and increased interest in science (r = .538, p < .0001). These results suggest that the skills taught to students in the course related to interacting with the public have a positive impact on visitor interests, supporting Goal 2.

Table 5. COSI visitors' views of the students and interest in research

Topic		Average	St. Dev.
STUDENT	Q1: The student was engaging.	5.69	.50
STUDENT	Q2: The student adapted to my group.	5.57	.64
LANG	Q3: I have a special interest in language.	4.02	1.47
LANG	Q4: I have a special interest in the demonstration topic.	4.77	1.03
SCI/RES	Q5: My interest in science has increased as a result of the demonstration.	4.65	1.13
SCI/RES	Q6: My interest in research has increased as a result of the demonstration.	4.62	1.09
LANG	Q7: My interest in language has increased as a result of the demonstration.	4.23	1.42
COSI/DEMO	Q8: I want to return to COSI.	5.82	.43
COSI/DEMO	Q9: I want to visit a demonstration again.	5.63	.80
LANG, SCI/RES	Q10: I want to participate in language research.	4.21	1.57
LANG	Q11: I want to see more demonstrations on language.	4.67	1.23
LANG	Q12: I want to look up more information on language.	4.30	1.36

Interestingly, the abilities of students to be engaging and adapt to the group were not correlated with visitors' desire to return to COSI, but were positively related to visitors wanting to experience another science demonstration. In fact, wanting to return to COSI was only correlated with wanting to see more demonstrations on language (r = .453, p < .0001). Thus, it appears that students succeeded in presenting a successful science demonstration which is related to increased interest in viewing more demonstrations, but is not related to interest in visiting the entire science museum again. These provide some additional support for Goal 3.

5. Conclusion

The effectiveness of this course model was evaluated using a variety of measures to assess three primary goals: 1) Did the students' knowledge of language and confidence discussing science with the public increase?, 2) Could the students give an accurate, engaging, and appropriate science demonstration at COSI?, and 3) Did the demonstration improve the COSI visitors' overall experience?

- Goal 1 was supported by data from the student pre- and post-test questionnaires. Students gained confidence in discussing science with the public and showed modest improvements in their knowledge of language.
- Goal 2 was supported by observation data and COSI visitor ratings of the students' abilities: on the whole, the students learned to provide good language science demonstration.
- Goal 3 was supported by data from the COSI visitors' interviews wherein they overwhelmingly reported a positive impact of the science demonstration on their COSI visit.

Overall, the data supported the effectiveness of the course in training undergraduate and graduate researchers on how to interact with the public informally around language science topics. The students overall rated their interests and abilities as high, and that their interests and abilities increased as a result of taking the course. After taking the course, many students wanted to pursue research or informal education. In addition, most of the students were able to perform demonstrations at COSI at or above the expected level. Finally, the COSI visitors rated the students giving the demonstrations very high with regards to being engaging and adapting to the group. Moreover, visitors reported that they would like to see more demonstrations in the future, which speaks highly of the experience they had. Visitors were generally able to remember at least one piece of information from the demonstration and largely enjoyed the experience. Combining all of these types of evidence demonstrates that the course is effective at teaching students skills in interacting with the public and generally improving their language knowledge and confidence.

Finally, the design of this course may be a good for other STEM education courses. Although the content area may differ, the ability to demonstrate a complex topic in an informal setting should persist. Training future researchers and educators to comfortably discuss complex ideas with the public may support a broader interest in important STEM topics. Relatedly, it would be interesting to see how the presentation of other complex topics at COSI and in similar settings compares with the student-led demonstrations.

6. Suggestions

Although the course overall succeeded in meeting the three goals, it could be improved by focusing more attention on areas where little change occurred, such as student knowledge about language myths. If the instructors decide that success on the language myths is a crucial aspect of the course, they could spend more time in class discussing them explicitly and engaging the students in relevant conversations and demonstrations. Moreover, we found that 20% of the students failed to meet the "expected" success criteria for demonstrations. Ideally, this number

would be near zero so that all students taking the course leave with the ability to confidently engage people in informal scientific conversations. One potential cause of this low performance may be students' shyness. Additional strategies and training may be necessary to help these students to succeed.

In addition, more data in the evaluation would lead to stronger conclusions. We are currently in the process of evaluating the spring 2015 "Training in Science Education Outreach" course using the same materials. These new data will be added to the existing data to create a more complete analysis of the course. In addition, data from former students of the course are currently being collected and will provide additional insight into the long-term effectiveness of the course. Pending the continued success of this course model, it may serve as a basis for other field within STEM education in the future.

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Appendix A

Pre-test Survey for Current Students: Delivered via Qualtrics

Please answer the following questions about your interest in and experience with science outreach to the best of your ability.

1. What is your age?
   ____
2. What is your sex?
   ___ Male
   ___ Female
   ___ Other
3. What is your ethnicity?
   ___White
   ___Hispanic or Latino
   ___Black or African American
   ___Native American or American Indian
   ___Asian/Pacific Islander
   ___other (specify): ____)
4. What year of college are you in?
   ___Freshman
   ___Sophomore
   ___Junior
   ___Senior
   ___Graduate Student
   ___Other (specify): ____)
5. Please rate your current interest in science outreach on a scale from 1-10, with 1 being not at all interested and 10 being extremely interested:
   ____
6. Please rate the following questions on a scale from 1 to 7 where 1 means that you strongly believe the statement is false, 4 means you do not know if it is true or false, and 7 means you strongly believe the statement is true:

	FALSE						TRUE
Some languages are more complex than others.	1	2	3	4	5	6	7
English is a language isolate -- that is, it is unrelated to any other languages in the world.	1	2	3	4	5	6	7
The English language is in general less clear than it used to be.	1	2	3	4	5	6	7
Bad grammar is a sign of lack of effort in self-presentation.	1	2	3	4	5	6	7
Parents teach their children how to talk.	1	2	3	4	5	6	7
All languages have regional variants.	1	2	3	4	5	6	7
It is illogical to have two negatives in a sentence (because two negatives make a positive).	1	2	3	4	5	6	7

Languages differ in the number of sounds (i.e. phonemes) they have.	1 2 3 4 5 6 7
Some animals, such as monkeys and gorillas, can learn a human language.	1 2 3 4 5 6 7
Children can understand language before they can speak it.	1 2 3 4 5 6 7
Babies babble in their native language (babies acquiring different language babble differently).	1 2 3 4 5 6 7
Listeners can tell approximately how old you are from the way you speak.	1 2 3 4 5 6 7
All sign languages are primarily forms of pantomime.	1 2 3 4 5 6 7
All languages change over time.	1 2 3 4 5 6 7
A child exposed to two languages will never learn either of them well.	1 2 3 4 5 6 7
You can tell how smart someone is by their accent.	1 2 3 4 5 6 7
All the languages of Europe are descended from the same language.	1 2 3 4 5 6 7

7. What is your major?

   _____

8. What are you expecting to gain from this course?

   _____

9. What experience do you have with science outreach?

   _____

10. What experience do you have with studying language (examples include foreign language or linguistics courses and volunteering in a language lab).

    _____

11. Why are you interested in science outreach?

    _____

12. Describe your prior research experience. (Examples include working as a research assistant in a lab and volunteering at a museum.)

    _____

13. Describe your future plans for research experience. (Examples include working as a research assistant in a lab and volunteering at a museum.)

    _____

Appendix B

Post-test survey for current students: Delivered via Qualtrics

Please answer the following questions about your interest in and experience with science outreach to the best of your ability.

1. Please rank the following class components from least helpful (1) to most helpful (8) for your success with science demonstrations.

_____ assigned readings

_____ class discussions

_____ feedback on demonstrations

_____ guest lectures

_____ practice on the floor

_____ interacting with COSI staff

_____ pressure to succeed

_____ working with other students

_____ other (specify as helpful or not helpful): _____

2. What skills did you gain from this course? Please check all that apply.
   ___Increased language research knowledge
   ___Experience recruiting for studies
   ___Experience interacting with the public
   ___Experience working with a non-profit organization
   ___Other (specify: _____)

3. Please rate the following questions on a scale from 1 to 7 where 1 means that you strongly believe the statement is false, 4 means you do not know if it is true or false, and 7 means you strongly believe the statement is true:

	FALSE						TRUE
Some languages are more complex than others.	1	2	3	4	5	6	7
English is a language isolate -- that is, it is unrelated to any other languages in the world.	1	2	3	4	5	6	7
The English language is in general less clear than it used to be.	1	2	3	4	5	6	7
Bad grammar is a sign of lack of effort in self-presentation.	1	2	3	4	5	6	7
Parents teach their children how to talk.	1	2	3	4	5	6	7
All languages have regional variants.	1	2	3	4	5	6	7
It is illogical to have two negatives in a sentence (because two negatives make a positive).	1	2	3	4	5	6	7

Languages differ in the number of sounds (i.e. phonemes) they have.	1 2 3 4 5 6 7
Some animals, such as monkeys and gorillas, can learn a human language.	1 2 3 4 5 6 7
Children can understand language before they can speak it.	1 2 3 4 5 6 7
Babies babble in their native language (babies acquiring different language babble differently).	1 2 3 4 5 6 7
Listeners can tell approximately how old you are from the way you speak.	1 2 3 4 5 6 7
All sign languages are primarily forms of pantomime.	1 2 3 4 5 6 7
All languages change over time.	1 2 3 4 5 6 7
A child exposed to two languages will never learn either of them well.	1 2 3 4 5 6 7
You can tell how smart someone is by their accent.	1 2 3 4 5 6 7
All the languages of Europe are descended from the same language.	1 2 3 4 5 6 7

4. Please indicate your level of agreement with each statement from 1-6 before taking the class and currently:

(1: strongly disagree, 2: disagree, 3. Somewhat disagree 4: somewhat agree, 5: agree, 6: strongly agree)

	Before Class	Current
I am interested in science outreach.	1 2 3 4 5 6	1 2 3 4 5 6
It is important to communicate with the public about science.	1 2 3 4 5 6	1 2 3 4 5 6
I am good at recruiting participants.	1 2 3 4 5 6	1 2 3 4 5 6
I am comfortable interacting with the public about science.	1 2 3 4 5 6	1 2 3 4 5 6
I want to pursue a career in science outreach.	1 2 3 4 5 6	1 2 3 4 5 6
I expected this class to help/ this class helped me get connected with a faculty project.	1 2 3 4 5 6	1 2 3 4 5 6
I can adjust my demonstration message to be appropriate for different age groups.	1 2 3 4 5 6	1 2 3 4 5 6
I want to pursue experiences in science outreach.	1 2 3 4 5 6	1 2 3 4 5 6

I want to pursue experiences in language research.	1 2 3 4 5 6	1 2 3 4 5 6
I want to pursue a career in language research.	1 2 3 4 5 6	1 2 3 4 5 6
I expected this class to help/ this class helped me decide whether I will pursue future research opportunities	1 2 3 4 5 6	1 2 3 4 5 6
I expected this class to help/ this class has helped me decide what I will do after graduation.	1 2 3 4 5 6	1 2 3 4 5 6

5. Why are you interested in science outreach?
   _____
6. Have any other factors or events (outside of this course) contributed to your current level of interest in research and science outreach? If so, please explain.
   _____
7. In what ways has this course has changed how understand science as a practice?
   _____
8. What components of this course did you find **most** interesting and why?
   _____
9. What components of this course did you find **least** interesting and why?
   _____
10. Have you learned things to help you in your future career? If so, please explain.
    _____
11. Are you currently or do you have future plans to become involved with research outside of this class? If so, please explain.
    _____
12. Where do you think you will apply the skills learned in this class?
    _____
13. What are you education and career plans for the next 5 years?
    _____

Appendix C

COSI Visitor Survey (for Adults): Delivered in person by evaluator

Demonstration viewed:_____

1. What is something (or multiple things) you learned from visiting the science demonstration?
   _____
   _____
   _____
   _____
2. How interested in the science demonstration were you and the others in your group?
   _____
   _____
   _____
   _____
3. Did the science demonstration enhance your visit to COSI? If so, how?
   _____
   _____
   _____
   _____

Other notes:

4. Have you visited COSI before? ____Yes ____No

   If yes, how often do you visit COSI?

   ___more than once a week
   ___between 1 and 4 times a month
   ___between 1-5 times a year
   ___between 6-11 times a year

5. Have you experienced a science demonstration at COSI before? ____Yes ____No
   If yes, how often?
   ___more than once a week
   ___between 1 and 4 times a month
   ___between 1-5 times a year
   ___between 6-11 times a year

6. Please indicate your level of agreement with each statement:

1: strongly disagree, 2: disagree, 3. Somewhat disagree 4: somewhat agree, 5: agree, 6: strongly agree

	Disagree Agree

The student giving the science demonstration was engaging.	1 2 3 4 5 6
The student giving the science demonstration adapted to my group.	1 2 3 4 5 6
I have a special interest in language.	1 2 3 4 5 6
I have a special interest in the science demonstration topic.	1 2 3 4 5 6
My interest in science has increased as a result of the science demonstration.	1 2 3 4 5 6
My interest in research has increased as a result of the science demonstration.	1 2 3 4 5 6
My interest in language has increased as a result of the science demonstration.	1 2 3 4 5 6
I want to return to COSI.	1 2 3 4 5 6
I want to visit a science demonstration again.	1 2 3 4 5 6
I want to participate in language research.	1 2 3 4 5 6
I want to see more science demonstrations on language.	1 2 3 4 5 6
I want to look up more information on language.	1 2 3 4 5 6

7. In your group, how many people are in each age group?
    a. Birth-4 years _____
    b. 5-10 years _____
    c. 11-18 years _____
    d. 19-40 years _____
    e. 41-60 years _____
    f. 61 years or older _____
8. What is your sex?
    ___ Male
    ___ Female
    ___ Other
9. What is your relation to other group members?
    ___parent
    ___teacher
    ___sibling
    ___other (specify): _____)

Appendix D

1. Some languages are more complex than others.

2. English is a language isolate- that is, it is unrelated to any other languages in the world.

3. The English language is in general less clear than it used to be.

4. Bad grammar is a sign of lack of effort in self-presentation.

5. Parents teach their children how to talk.

6. All languages have regional variants.

7. It is illogical to have two negatives in a sentence (because two negatives make a positive).

8. Languages differ in the number of sounds (i.e. phonemes) they have.

9. Some animals, such as monkeys and gorillas, can learn a human language.

10. Children can understand language before they can speak it.

11. Babies babble in the native language (babies acquiring different languages babble differently).

12. Listeners can tell approximately how old you are from the way you speak.

13. All sign languages are primarily a form of pantomime.

14. All languages change over time.

15. A child exposed to two languages will never learn either of them well.

16. You can tell how smart someone is by their accent.

17. All the languages of Europe are descended from the same language.