

Summative Evaluation:

**Fusion Science Theater National Training
and Dissemination Program**

NSF AISL Grant DRL11-14568

Joanne Cantor, Ph.D., Evaluator
Professor Emerita, University of Wisconsin-Madison

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Abstract: Summative Evaluation

Fusion Science Theater National Training and Dissemination Program

Fusion Science Theater (FST) uses elements of playwriting to make informal science education more engaging as well as educational. FST shows incorporate an overarching scientific question that is asked and then answered by a series of participatory exercises and demonstrations. The shows also use “embedded assessment” of learning, which asks children to “vote their prediction” both before and after these activities. The FST National Training and Dissemination Program had three major goals: (1) To develop and implement a Performance Training Program to train professional audiences to perform successful FST shows in their own communities; (2) to develop and deliver workshops to teach FST methods to a wide range of teachers and informal science educators; and (3) To publicize, promote, and deliver FST shows and methods to a diverse professional audience. By all measures and from all perspectives, the project team met and surpassed these goals.

Goal 1: A three-day, face-to-face Performance Training Workshop (PTW) trained six groups from around the country to perform an FST show, *Will It Light?*, which deals with the conductivity of solutions. Five of the groups included undergraduates; the sixth was from a science museum. After the training, five out of six of these groups gave at least three performances for children in their own communities, and these shows were highly successful in terms of enthusiastic audience engagement, improved attitudes toward science, and statistically significant learning gains. Next, in a Museum Pilot that was beyond the scope of the promised deliverable, staff at five museums and a group from one university performed FST shows using only materials adapted from the PTW, with no face-to-face or online training. In addition to *Will It Light?*, they performed two other FST shows and one interactive activity. Assessment revealed that these shows were as successful as the shows emanating from the in-person training.

Goal 2: The project team presented 23 methods workshops around the country. These workshops targeted K-12 teachers, college faculty, and museum staff who not only learned about the methods, but also used them to design parts or all of science presentations. The workshops were enthusiastically received and earned extremely high ratings. Most importantly, 80 percent of attendees responded that they were “extremely” likely to use the methods in their own work.

Goal 3: FST staff generated publicity through the 23 workshops plus at least 29 presentations at conferences and educational institutions, and they have developed two FST Show Performance Kits (involving three shows), which are now available for purchase through the Institute for Chemical Education. Kits include scripts, background, and everything needed to mount a show in addition to a Performance Training Handbook, which was adapted from the materials used in the PTW. All FST scripts that are not in a kit are available by request online. Several research articles reporting on FST methods and results are now submitted for publication or in production.

In summary, grant activities have demonstrated that successful FST shows can be performed with either face-to-face or materials-based training; that FST methods can be taught in workshops and are highly valued by attendees; and that materials are now publicly available to spread the use of FST shows and methods even more broadly.

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Summative Evaluation: Fusion Science Theater National Training and Dissemination Program NSF AISL Grant DRL11-14568

Fusion Science Theater (FST), founded in 2006 by Holly Walter Kerby, uses elements of playwriting to make informal science education more engaging as well as educational. FST shows incorporate an overarching scientific question that is asked and then answered by a series of participatory exercises and demonstrations. Most of the shows also use the “embedded assessment” of learning which asks children to “vote their prediction” both before and after these activities. Under a previous NSF grant (#DRL07-32142), several FST shows were found not only to produce an enthusiastic response from children; they improved children’s attitudes toward learning science, and perhaps most importantly, they achieved measurable and statistically significant learning outcomes. This latter outcome is especially remarkable because ISE demonstration shows rarely report or even attempt to measure learning.

The FST National Training and Dissemination Program had had three major goals: (1) To develop and implement a Performance Training Program to train outreach professionals to perform successful FST shows in their own communities; (2) to develop and deliver workshops to teach FST methods to a wide range of teachers and informal science educators; and (3) to publicize, promote, and disseminate FST shows and methods to a diverse professional audience. This document provides a summative evaluation of the major accomplishments of the grant and the manner in which these goals have been met.

DELIVERABLE 1: Performance Training Program

The first goal of the project was to develop and implement a Performance Training Program for people who perform demonstration shows as informal science education.

Training materials and two new plays were developed and piloted to prepare for a face-to-face Performance Training Workshop (PTW). *Will It Light?*, a show about the conductivity of solutions, was selected for the training. Six groups were recruited to attend the training workshop in Madison, WI. Five of the groups were from American Chemical Society-affiliated undergraduate groups: Alma College (Alma, MI); Sewanee: The University of the South (Sewanee, TN); Southeast Missouri State University (Cape Girardeau, MO); Union University (Jackson, TN); and the University of Nevada (Las Vegas, NV). The universities were selected to represent institutions of various sizes, affiliations, and demographics. Each of these groups consisted of two students and at least one faculty supervisor. The sixth group was made up of two staff members of the Interpreters Program at the New York Hall of Science and their advisor. The 12 students and staff members were evenly divided by gender, and four of them were from underserved demographic groups. As part of their

participation, the groups agreed to give at least three performances of an FST show in their home communities after attending the workshop and to send back data for evaluation.

The workshop was held at Madison Area Technical College on September 21-23, 2013. The program began at 6 pm on Day One (Friday) with introductions, dinner, an overview of the workshop, and script assignments. Day Two (Saturday) featured instruction modules on the use of voice and body, interactions with children in the audience, performance of the demonstrations, facilitation of the physical dramatization, and the process of assessment. These modules were interspersed with rehearsal sessions coached by FST staff. The day's program ended with a mock performance by the advisors, followed by dinner and more rehearsal. The workshop culminated on Day Three (Sunday) with three live performances to children and their parents at the Madison Children's Museum. Each trainee performed one half of *Will It Light?*

Back in their home communities, the participants led members of their local organizations in the production work needed to perform *Will It Light?* This included building sets and props, scheduling performances, and rehearsing the show. An FST liaison kept in touch with the groups through email, phone, Skype, and a special Performance Training Workshop Facebook page established for this purpose. The Facebook page also allowed local participants to keep in touch with each other by posting and responding to group questions, photos, and comments.

The Performance Training Program was evaluated using two methods:

- 1) Analyzing the success of the shows that participants presented in their own communities, via the data and videos participants sent back; and
- 2) Analyzing the workshop experience itself, using questionnaires filled out by participants and their advisors.

Evaluation of the Trainees' Performances in Their Home Communities

Five of the six groups that attended the Performance Training Workshop performed the show at least three times in their communities and returned a video of one performance and data from all shows. The data involved before-and-after ballots measuring concept attainment embedded in the show and a short attitude questionnaire administered at the show's conclusion. These performances were attended by audiences in the targeted age range (5-11 years) of approximately 500 children who filled out the ballots and/or the questionnaires. With the help of the FST Evaluator, all five of these groups were successful in receiving IRB approval from their institutions for the research.¹

Because minority and low-income children are important targets for science education outreach, trainees were requested to recruit children from these audiences to the extent

¹ The University of Nevada, Las Vegas belatedly presented only one performance to a very small audience of children. Data from this show are not included in the discussion. This group had a variety of difficulties including an advisor with a very busy schedule, an IRB that refused to review the protocol, and group members who had health problems.

possible. Each cooperating partner group filled out a Performance Report Form (See p. A-1) after each show and estimated the proportion of minority and low-income children in each audience. Of the 16 performances, 4 were perceived to have more than half minority child attendees. Trainees could judge the socioeconomic status of the audience in only 12 of the sessions. Of these, 7 were judged to have a majority of low-income children. Therefore, it can be concluded that an appreciable number of children from underserved populations attended these performances.

Two FST team members reviewed the videos submitted by the five groups according to a rubric and concluded that they were well rehearsed and well performed. Feedback emphasizing strengths and areas for improvement was provided on each video to group members via video-conferencing.

The most important assessment of the Performance Training Program is whether it enabled participants to perform successful FST shows in their own communities. As can be seen in the following two sections, the children attending the performances achieved significant learning gains, enjoyed the performances, and improved their attitudes toward learning science.

Assessment of Children's Concept Learning

Will It Light? examines the nature of conductivity of pure water and various aqueous solutions. As with the majority of Fusion Science Theater shows, learning was assessed using ballots administered both before and after the demonstrations and dramatization that help children figure out the correct answer. The concept question was, "Will the light bulb light in pure water?" and the response choices were 1, "I don't know," 2, "Yes, it will light," and 3, "No, it will not light." [Option 3 is the correct answer.] Children were also asked to indicate whether they were a boy or a girl and to write their age on the ballot. Ballots were handed in after each "vote," but they were numbered so that each child's before-and-after ballots could be matched for analysis of learning. Unmatched ballots were not included in analyses. Figure 1 shows the ballot.




First Vote			<input type="text"/>
I am a <input type="checkbox"/> boy <input type="checkbox"/> girl		I am _____ years old	
Will the light bulb light in pure water?			
1 I don't know 	2 Yes, it will light 	3 No, it will not light 	

Figure 1. Ballot used to assess concept learning for *Will It Light?*

With the sites combined,² the ballot data showed that 28% of the children got the answer right before the demonstrations, and 43% responded correctly after the demonstrations. This increase was significant by the McNemar Test for related samples ($p < .001$). Figure 2 shows that the percent of children who answered the concept question correctly increased from before to after the demonstrations at all sites. At Union, SEMO, and Sewanee, the three sites with the highest numbers of child attendees, the increase was significant by the McNemar Test for related samples. The New York Hall of Science data ballots were not matched, so their data were analyzed using the Chi Square test. Since the size of the before-after difference is largely similar between the sites, the lack of significance in the smaller two data sets is most likely attributable to their small sample sizes.

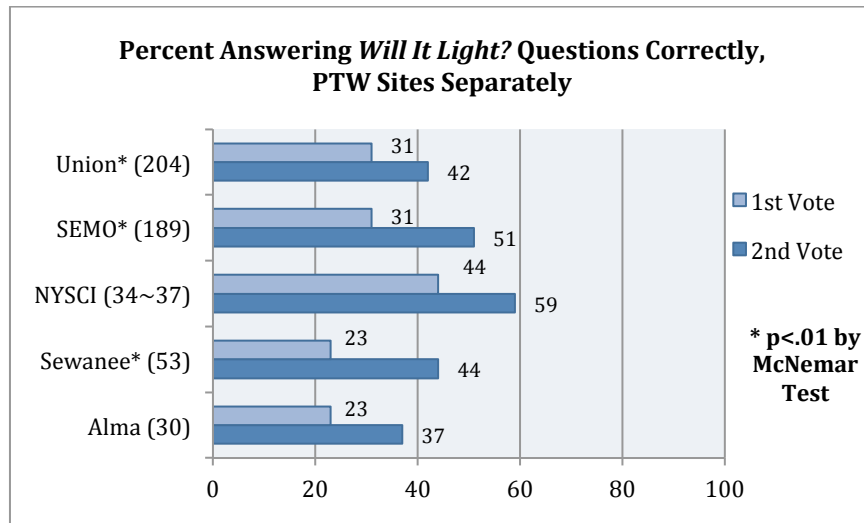


Figure 2. Percent of children who responded correctly before vs. after the demonstrations in *Will It Light?* at the performances presented by the PTW trainees in their own communities. (N's for each site are in parentheses.)

Assessment of Children's Attitudes

Children were given the attitude form at the beginning of the session and filled it out at the end of the show. There were four multiple-choice questions, all of which could be answered by choosing one of four options, 1, "not at all ☹️," 2, "a little bit 😊," 3, "pretty much 😊😊," or 4, "very much! 😊😊😊." (See p. A-2 for a copy of the instrument.) The question tapping engagement/interest was, "How much did you like the show?" The questions tapping attitudes toward science were: "The show made me feel like I can understand science," "The show made me want to learn more science," and "The show made learning science fun." A final item read, "Let us know what you thought of the show in your own words."

²The concept-learning data from the New York Hall of Science is not included in the combined data because NYSCI did not use number-matched ballots. Their concept-learning results were analyzed separately and can be seen in Figure 2..

Figure 3 reports the attitude data for the sites on all four attitude items. As can be seen from the figure, performances by all five groups produced very high ratings of liking and understanding the show, wanting to learn more science, and perceiving science as fun.

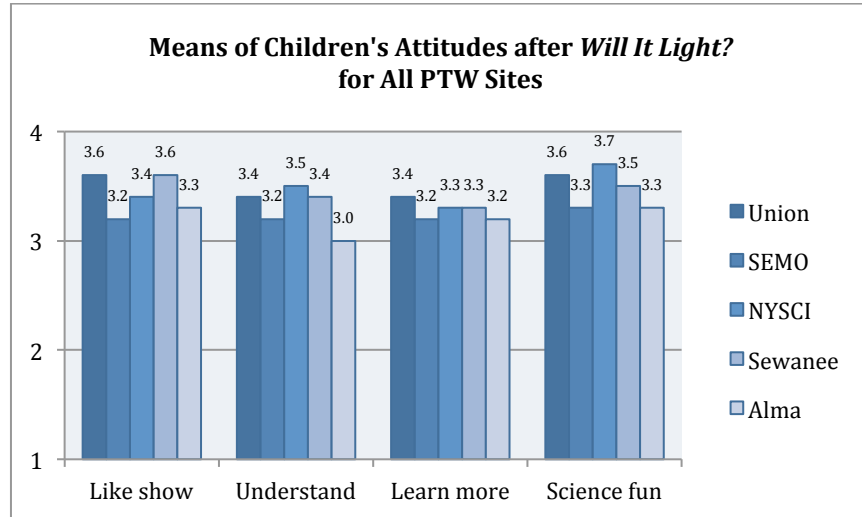


Figure 3. Means of children's attitude ratings after *Will It Light?* at the performances presented by the PTW trainees in their own communities.

When children filled out the comments section of the attitude questionnaire, their written answers reflected a great deal of enthusiasm for the shows. Because there were so many comments, they were categorized according to the following rubric:

Very Positive, with superlative words or positive words with adverbial intensifiers or exclamation points: e.g., "Beyond awesome!" "I thought that it was the best show that I have ever seen! Great show!" "It was really fun and made me think that science wasn't something made up. It was true!" "The show really made me think about science but I never thought it could be so fun!!!"

Positive, but without superlatives: e.g., "It was cool," "It was pretty good," "I didn't like science before but now I do," "I thought you made me learn more here than school."

Neutral or both positive and negative: e.g., "It was ok," "I like it but you could let Spencer talk," "I like it and I hope you can come back but have more volunteers and stop talking like we're 5."

Negative: e.g., "kinda confusing," "boring," "I hate it."

Figure 4 displays the proportion of each type of comment and illustrates the level of exuberance children showed for the performances the trainees presented. As the figure shows, 92% of the comments were positive or very positive. The entire list of comments is presented on pages A-3 to A-9, along with the age of the child who made the comment and the way the comment was categorized.

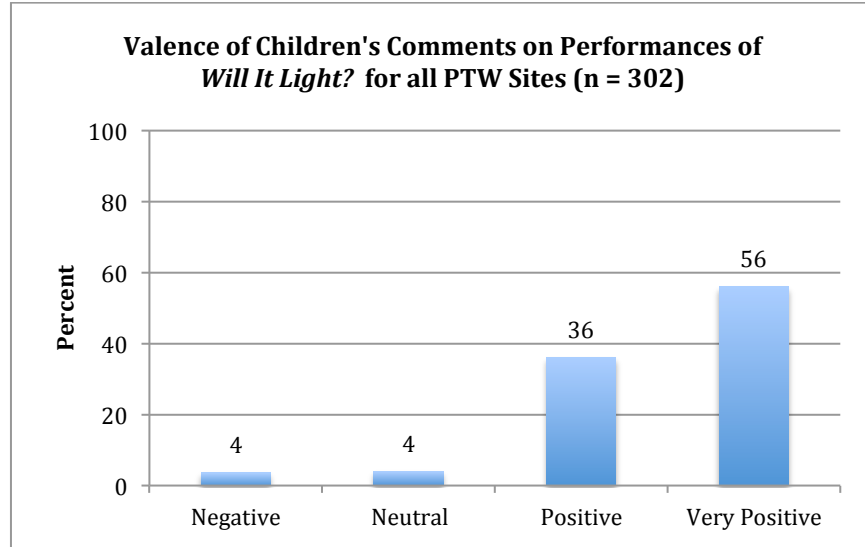


Figure 4. Percent of children's written comments on community performances of *Will It Light?* that were categorized as Negative, Neutral, Positive, and Very Positive.

In summary, the performances delivered by the attendees at the Performance Training Workshop were highly successful on all measures. Ratings and comments showed that the children were not highly engaged in and appreciative of the shows; they reported that the show improved their attitudes toward science. Moreover, the embedded assessment revealed learning gains were strong and consistent.

Evaluation of the Performance Training Workshop Itself

Beyond assessing the effectiveness of the training in the groups' success in producing shows, the secondary evaluation focused on the trainees' and advisors' evaluations of the training.

Participants' Feedback on the Performance Training Workshop

When they arrived for the workshop on Friday afternoon, trainees were asked to fill out a brief questionnaire assessing their attitudes toward science education and toward Fusion Science Theater methods. Then, after they performed their shows on Sunday, they were given a second questionnaire assessing their evaluations of the training, their performances, and their attitudes about going forward with the presentation of shows in their home communities. See pages A-10 to A-12 for copies of these questionnaires.

Feedback on training weekend. The first four questions on the post-show questionnaire were as follows:

- 1) "How well do you think the show went?"
- 2) "How well do you feel the training prepared you to perform the show?"
- 3) "How enthusiastic are you about performing this show on your home turf?"
- 4) "How enthusiastic are you about providing leadership to your home group in doing this show?"

Response options were “not at all,” “somewhat,” “moderately,” and “very” *well* for Questions 1 and 2, and “unenthusiastic,” and “somewhat,” “moderately,” and “very” *enthusiastic* for Questions 3 and 4.

As can be seen from Figure 5, trainees’ responses regarding how well the show went, how well the training prepared them and their enthusiasm for performing the show in their home communities hovered between 2.9 and 3.3 on a 4-point scale, reflecting generally positive attitudes toward the training and enthusiasm for both performing at home and leading their peers in putting on these performances.

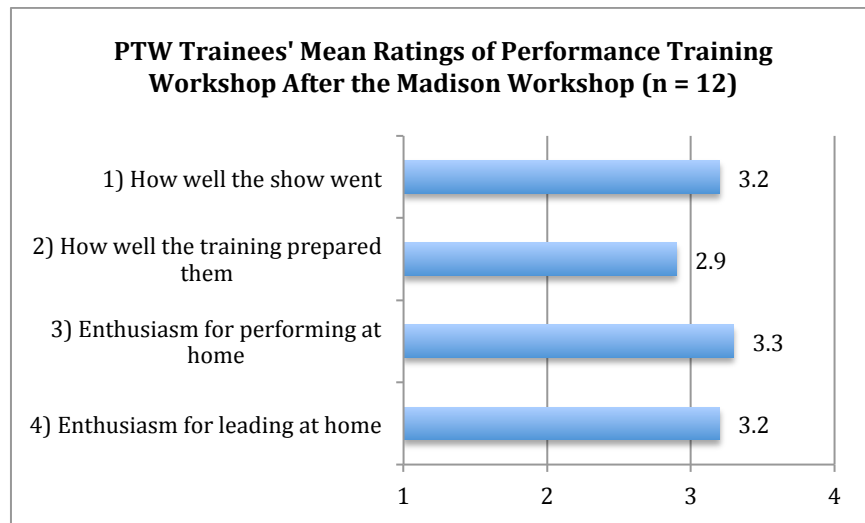


Figure 5. Means of trainees' attitudes about Performance Training Workshop after workshop in Madison.

Attitudes beyond the session. Because some of FST’s previous work suggested that the process of participating in Fusion Science Theater activities might affect performers’ attitudes, both the pre-workshop and post-workshop surveys contained the following three items:

- 1) “I am interested in a career that involves communicating or teaching STEM content.”
- 2) “I am confident in my ability to teach or communicate science.”
- 3) “Fusion Science Theater methods are effective in communicating STEM content.”

All three items could be answered by choosing “not at all (1),” “somewhat (2),” “moderately (3),” or “very (4).” In addition, because trainees may not have been familiar with Fusion Science Theater before participating in the workshop, Item 3 offered a fifth choice, “I don’t know.”

Figure 6 shows the means on these items.

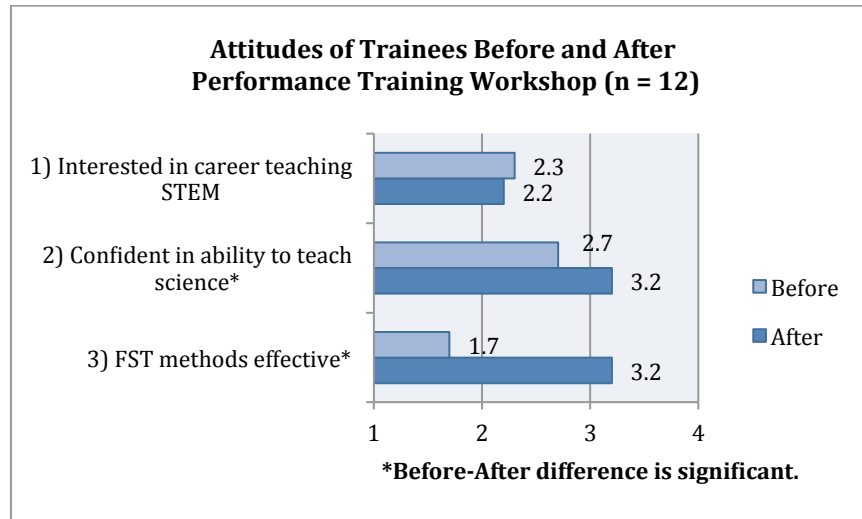


Figure 6. Means of trainees' attitudes before vs. after the Performance Training Workshop.

As the figure shows, interest in a career teaching STEM moved slightly in a negative direction. A *t*-test on the difference between means before vs. after the weekend revealed that the difference was trivial, however ($M = 2.3$ vs. 2.2 ; t ($df = 11$) = 1.00 ; $p = .34$).

In contrast, the figure also shows that levels of confidence in the ability to communicate STEM content *increased* from before to after the workshop. A *t*-test on the means showed this difference to be significant ($M = 2.7$ vs. 3.2 ; t ($df = 11$) = -2.24 ; $p < .05$). In other words, trainees' confidence in their ability to communicate science increased over the course of the weekend.

As for the ratings of the effectiveness of Fusion Science Theater methods, two-thirds of the trainees chose "I don't know" at the beginning of the training. To perform a *t*-test, the "don't know" responses were assigned a value of 1.0 (the same as "not at all"). The *t*-test revealed a highly significant increase in the perceived effectiveness of FST methods ($M = 1.7$ vs. 3.2 ; t ($df = 11$) = -5.06 ; $p < .001$).

A follow-up questionnaire sent to the trainees after they had completed their performances indicated that, in retrospect, they continued to evaluate the training highly and maintained their enthusiasm for performing *Will It Light?* in the future. They also were similarly enthusiastic about performing other FST shows.

Advisors' Feedback on the Performance Training Workshop

Seven advisors attended the Workshop because one institution sent two advisors. Immediately after their advisees had performed their shows at the Madison Children's Museum, the advisors filled out a questionnaire assessing their feedback on the training weekend. [See pp. A-13 to A-14 for a copy of the questionnaire.] The most important numerical responses related to the following questions:

- 1) One purpose of the training workshop was to train participants to perform a Fusion Science Theater (FST) show in their own community. How well do you think the workshop achieved this goal?
- 2) Another purpose of the training workshop was to inspire and train participants to lead rehearsals and performances of FST scripts after returning to their home group. How well do you think the training achieved this goal for the attendees from your institution?
- 3) How enthusiastic are you about having your students rehearse and perform *Will It Light?* to audiences in your community?
- 4) Do you believe your colleagues at other colleges and museums would be interested in performing FST shows?

Answers to these questions could range from 1 to 4, corresponding to “not at all,” “somewhat,” “moderately,” and “very” *well*, for Questions 1 and 2. These same modifiers applied to *interested* for Question 4. For Question 3, the options were “unenthusiastic” and “somewhat,” “moderately,” and “very” *enthusiastic*.

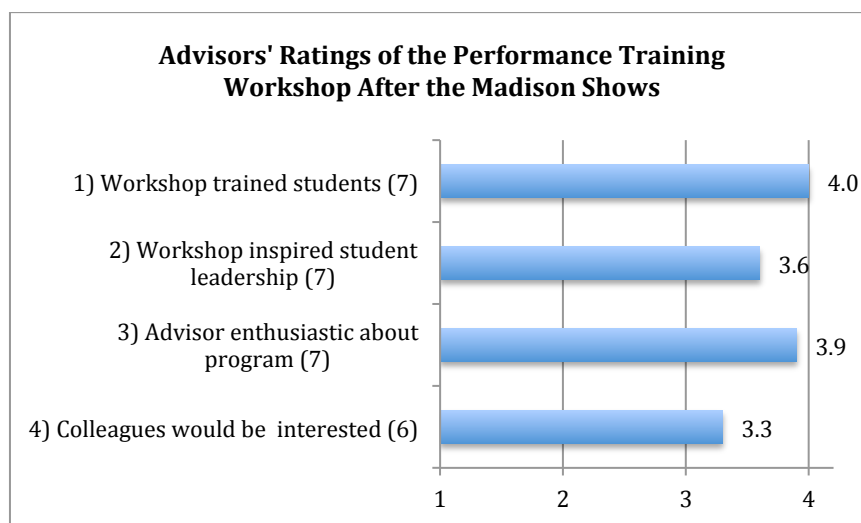


Figure 7. Means of advisors' evaluations of the Performance Training Workshop.

Figure 7 shows that the advisors' numerical responses were extremely positive, giving the training overall a 4.0 on a 4-point scale, and their own enthusiasm for their students performing in their home communities a 3.9. They also gave high marks to the workshop in inspiring students to lead, and they thought that colleagues at other institutions would be moderately to very interested in performing FST shows.

In summary, the Performance Training Workshop showed that volunteer groups can perform successful FST Shows to local audiences with relatively brief, face-to-face training; that they enjoy the experience of teaching science through FST methods; and that their attitudes toward FST and their confidence in their teaching ability may be moved in a positive direction. This suggested that broad dissemination of successful FST Shows to volunteers from universities and museums across the country is feasible.

Further Performance Training: The Museum Pilot

The success of the Performance Training Workshop raised the question of whether interested volunteers could perform FST shows given only the performance training materials without face-to-face instruction. This possibility would make dissemination far more cost effective and sustainable than the live workshop or any online course facsimile. This hypothesis was tested by developing scripts and Performance Training Packages (aka: FST Performance Kits) for three different shows and piloting them with staff of five museums and one additional student group. Although not specifically proposed in the grant application, this Museum Pilot program advanced all three of the grant's deliverables by increasing the number of performances and therefore the impact of FST scripts; by demonstrating the effectiveness of FST's dramatic design and assessment methods to the museum community; and by increasing the network of professionals who use art-based techniques to increase science literacy.

Five museums were recruited to the pilot and signed a Memo of Understanding, agreeing to participate in evaluation activities that would provide data on the impact of these shows. These museums were: the Science Museum of Minnesota (Minneapolis), the Bakken Museum (Minneapolis), the Carnegie Science Center (Pittsburgh), the Durango Discovery Museum (Durango, CO), and the Children's Science Center (Herndon, VA). The museums varied in terms of which shows they performed, which contexts they performed in, and which types of evaluation activities they implemented. For example, *That's the Way the Ball Bounces* was performed by trained actors on the museum floor of the Science Museum of Minnesota. Likewise, *Will It Light?* was performed by actors on the floor of the Bakken. *Will It Light?* was also adapted and performed as a part of a camp by a single outreach specialist from the Carnegie Science Center. *Bounceman* was performed by actors at Durango, but it was also performed by children participating in the Youth Leadership Council at the Children's Science Center. The bottom line, however, is that all five museums presented shows that were successful with their audiences, achieved major goals of the FST project, and were viewed positively by the staff who participated.

In addition to these museums, Dr. Hannah Sevian, a chemical education researcher at the University of Massachusetts-Boston contacted the PI to procure scripts for her students to perform for outreach to Dever-McCormack Middle School in Boston. Sevian's students performed *Will It Light?*, *If I Were an Atom*, a song and dance that demonstrates the application of the Kinetic Molecular Theory to atoms in a solid, and *Slime Design*, an activity developed by the PI and Patricia Galvan, director of ACS Kids & Chemistry. These students rehearsed and performed these shows with minimal support from the PI.

Evaluation Results for the Museum Pilot

The Science Museum of Minnesota performed *That's The Way the Ball Bounces*, which deals with the "bounceability" of polymers. According to the Museum's "Science Live!" Director Stephanie Long, the Museum has included the show in its rotation since November 2012 and plans to continue its use into 2016. More than 3,000 visitors viewed sixty performances of the show from November 2012 through April 2013. Performances that were presented in February and March of 2013 were evaluated using methods similar to those used by the Performance Training Workshop participants. The combined data showed that there was a major and significant increase in concept knowledge (from 46%

before, to 84% after, N = 184, $p < .001$ by McNemar Test) among the children attending the performances.

Both the Bakken Museum and the Carnegie Science Center performed the longer-form show *Will It Light?* Embedded assessment showed that concept knowledge increased significantly, from 20% to 60%, using data from the two museums combined (N = 20, $p < .05$ by McNemar Test). The Durango Discovery Museum and the Children’s Science Center both performed *Bouncemania*, a shortened version of *That’s the Way the Ball Bounces*.

Although not all of the shows presented by museums in the Pilot involved embedded assessment, all the museums administered the same child attitude questionnaire that was used for the Performance Training Program. (See p. A-2 for the questionnaire.) Figure 8 shows that all five museums produced shows that achieved extremely high ratings. The N’s for these analyses are as follows: Bakken (8), Durango (58), Carnegie (17), Children’s Science Center (34), and Science Museum of Minnesota (51). Children’s comments about the shows were also very positive.

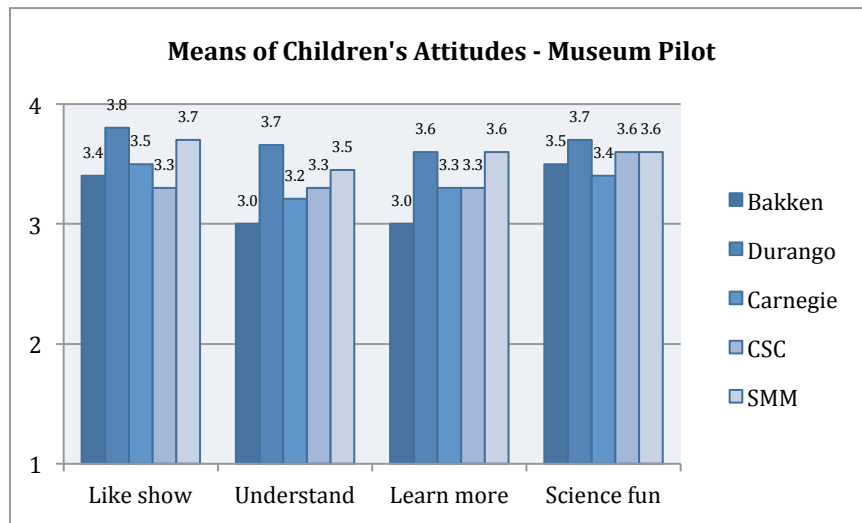


Figure 8. Means of Children’s Attitudes after shows presented by museums as part of the Museum Pilot.

According to Stephanie Long of the Science Museum of Minnesota, *That’s the Way the Ball Bounces* has been a “huge hit” with families and school groups. She also reported that it was more frequently requested than any other show in the program by visiting school groups. The staff of the other museums made comments that were almost uniformly positive. For example:

The kids loved it and it really stuck with them!... At the end of the 5-week summer program [they] created an activity journal outlining their favorite activities. Several kids included drawings and stories about *Will It Light?* One of the 2nd graders depicted the entire setup including chemical symbols and most of the signage That was so gratifying!!!! (Carnegie).

This show has definitely helped our museum meet our mission...it has certainly sparked an interest in science in local kiddos. Thanks! (Durango).

We have been especially influenced by the methods used by Fusion Science Theater to construct the shows themselves. The notion of putting the explanation before the demonstration and adding data collection to the show itself is fascinating and something that we are already starting to implement into our new and existing programs. (Bakken)

The University of Massachusetts-Boston students' performances to middle-school students were an unqualified success. Twelve undergraduates who performed these shows filled out questionnaires regarding their perceptions of the children's responses and their own attitudes about the experience. The means of their responses to questions about how well the show engaged and entertained the children, how well it taught them science, and how well it improved their attitudes toward science were all between 3.3 and 3.5 on a four-point scale. These undergraduates were equally enthusiastic about performing more shows and about the value of the show for community outreach. In their ratings, the undergraduates were unanimous in indicating that the materials provided them helped them prepare "very well" (4 on a scale from 1 to 4) for their performances.

Dr. Sevia, the advisor to the students, emailed the PI on the day of the show to report the triumph of her students' effort. Some quotes from that email include the following:

... the 8th graders that my freshmen did the plays for today were incredibly well behaved the entire time. They were focused. They asked great questions. The teacher said he's never seen them like this before and he didn't know it was possible. He said he thinks that most of the kids have never done anything like this before. I wish you could have seen how excited those kids were to make slime with the knowledge behind some of the chemistry of slime ... I loved hearing them say, when they were stirring the chemical B into the PVA, "I'm making it crosslink now ... it's crosslinking." It was so awesome!

Dr. Sevia also said,

[... These shows] teach science. That is much better than only generating excitement about science.

These reports made it clear that museum staff and undergraduate students could perform shows that were engaging, educational, and fun for both audience and participants, with FST-developed materials and without any direct training. This knowledge led to the development and dissemination of FST Show Performance Kits, which are described in the section on Dissemination.

DELIVERABLE 2: FST Methods Workshops

The goal of Deliverable 2 was to develop and present workshops to teach the methods that are used to write FST shows. Four workshops were promised in the grant proposal; twenty-three were delivered in the four years of the grant. The workshops were presented to a wide range of formal and informal educators including K-12 teachers, faculty from two- and four-year colleges, outreach specialists, and museum staff. Several workshops also targeted STEM undergraduates, graduates, and post-doctoral students.

All workshops covered the derivation of FST methods from elements and structure of story, including motivating and guiding learning through questions and inviting students into the “story of their own learning,” and most sessions included making the abstract concrete through physical dramatization (Act-It-Outs), and synching assessment and learning through embedded assessment. In addition, most gave examples of how these methods can be used in informal and/or formal educational settings. Most of the workshops invited participants to use the methods to design or redesign parts or all of an activity, lesson, or show. Three workshops involved using story to communicate science research. A full list of the workshops’ locations, contents, and audiences is given on pp. A-15 to A-16.

In the early years of the grant, participants seemed frustrated with their inability to write their own shows and/or lessons, although they continued to express interest in using FST methods. Two major successes occurred in workshops presented in May 2014 at the Center for Materials Sustainability at the University of Oregon. The full-day “FST Designer Workshop” helped graduate students and post-docs design and workshop their own outreach shows using FST methods. The “Using Story to Communicate Science Research” workshop (90 min) was designed to help graduate students, post-docs and faculty of the Center to use elements of story to better communicate science. Both workshops were rated highly by participants, but more importantly, both workshops allowed participants to achieve the workshop goal: Participants in the Designer Workshop worked in teams to create three viable shows, and all attendees of the Communicating Science workshop crafted and delivered brief talks about their research using the model of a story.

The successes of these workshops sparked invitations for more Communicating Science workshops. The most recent of these was delivered as part of the Alan Alda Communicating Science Summer Institute at Stony Brook University in June of 2015. The Institute is now in conversation with the PI about continuing involvement.

Evaluation of Fusion Science Theater Methods Workshops

Sixteen of the methods workshops that were presented during the grant period were formally evaluated using questionnaires filled out by participants at the end of the session. Although workshops differed, there was enough similarity among them that a core of evaluation items was applicable to most sessions (see p. A-17 for an example). Both the ratings and the comments on these workshops showed them to be highly successful.

A total of 310 attendees filled out the questionnaires. The four questions that were common to all sessions were:

- (1) How satisfied were you with the session overall?
- (2) How satisfied were you with the manner in which the content was presented?
- (3) How well did you feel you understood the methods presented?
- (4) How likely are you to use [*or interested are you in using*] the methods presented in your [own work]?

Two other items were included in questionnaires that were employed at a subset of workshops:

(5) How effective do you think [these methods] are in communicating STEM [or other] content? (N = 166)

(6) How interested are you in making your organization’s demonstration shows more learning centered? (N = 105)

Answers to all questions were chosen from 1 = “not at all”; 2 = “somewhat”; 3 = “moderately”; 4 = “extremely” or “extremely well.”

Figure 9 shows that the means of all these ratings were extremely high, never dipping below 3.7 on a four-point scale. The evaluations show that the content, manner of presentation, and comprehensibility were all highly appreciated by attendees and that participants appreciated the value and importance of the methods.

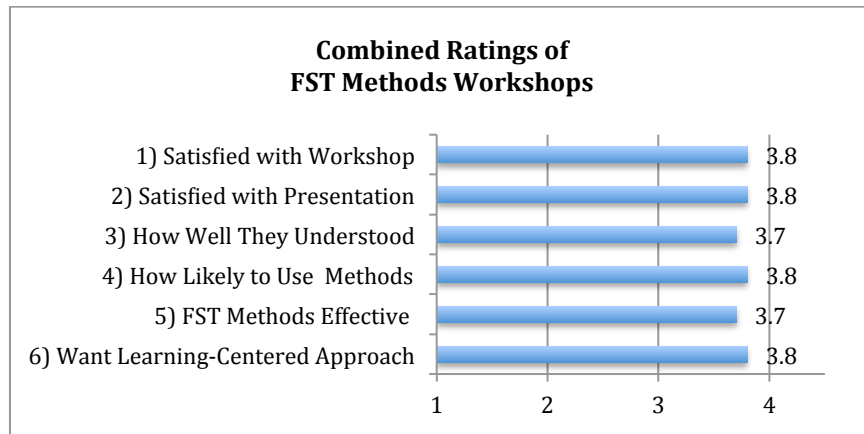


Figure 9. Means of evaluations by participants in FST Methods Workshops.

To provide a better view of how universally appreciated these workshops were, Figure 10 shows that the overwhelming majority of attendees gave the highest possible rating (“extremely” or “extremely well”) on all items. What is particularly notable in terms of the goal of disseminating FST methods is that 80 percent of the participants said they were extremely interested in or likely to use the methods in their own work.

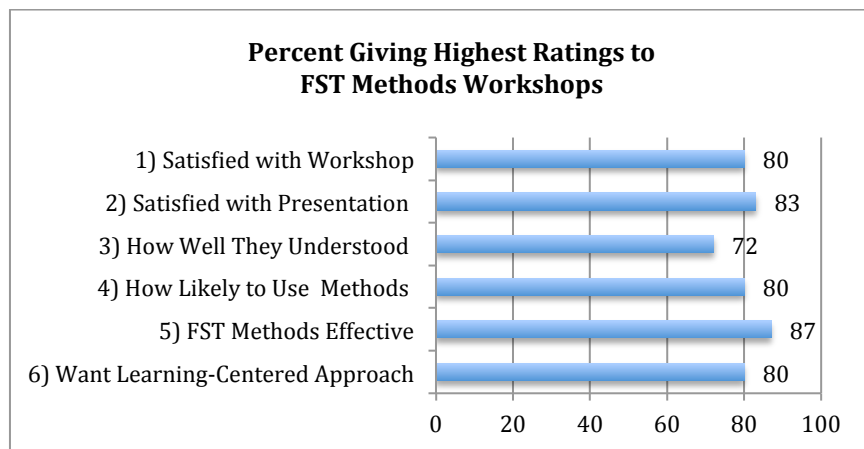


Figure 10. Percent of attendees giving the highest possible ratings to the FST Methods Workshops.

All sessions generated enthusiastic comments from the participants, comments that also suggest that the goals of the workshops had been met. Some typical examples follow:

I really appreciated Holly talking about LEARNING as an important focus to outreach! THANK YOU SO MUCH! (University of Wisconsin Outreach Course, Year 1).

I really enjoyed learning these techniques. I feel these will be very helpful in teaching otherwise intangible science concepts to my young children. (Wisconsin Science Festival, Year 1).

Loved the way you can deliver / engage difficult science concepts in a nonthreatening, fun and inviting environment that students can (should) enjoy. Reinforces that learning is fun . . . even science ☺. (Biolink Workshop, Year 2).

Thank you. The information was motivating. I am thrilled to be more creative with boring material. I am energized! Thank you ☺. (Lakeshore Technical College, Year 2).

Love the ideas, will make changes to how we do shows. (American Chemical Society Workshop, Year 3)

I love the idea of explaining concepts before showing the results of the experiment and having kids vote before and after the explanation. What a great way to do super quick totally informal assessment of your explanation, too! (National Education Outreach Network [NEON] / Association of Science-Technology Centers [ASTC] Workshop, Year 3)

I feel this workshop was extremely beneficial to me, as I can be very shy when it comes to talking about my research or science in general. I thought the partner work was good, but I got the most out of speaking in front of the entire group and receiving feedback, even though I was very scared. I know it may be time consuming, but I feel it would be a great experience for everyone to tell their story to the entire group. (University of Oregon Story Workshop, Year 3)

I loved coming up with our own demos for the different topics that matter for our research since it really made us think about how we can present our research in a way that appeals to the audience and tells a story. (University of Oregon Designer Workshop, Year 3)

I love the concept of implementing a vote in order to make them care more about the result (University of Wisconsin Outreach Workshop, Year 4).

Math doesn't have to be lecture all the time. It's okay to be silly in front of class. (Ohio State University, Year 4).

In summary, these workshops were successful in impressing educators with the value and usefulness of FST methods and with the importance of learning-centered informal science education. They enabled many participants to design their own demos or shows, and helped others learn to communicate their own research more effectively to audiences. Finally, attendees were strongly motivated to use these methods in their own work.

Deliverable 3: Dissemination of Fusion Science Theater Ideas and Products

The goal of Deliverable 3 was to promote Fusion Science Theater in a way that would increase the dissemination of FST show performances and promote the use and appreciation of FST methods by professionals around the country. Deliverable 1 was devoted to the training of show performers, and Deliverable 2 was devoted to enabling professional audiences to use FST methods in creating their own demonstration shows and explaining their own research. This final section discusses further activities that were performed under the grant that have disseminated and publicized FST-related knowledge and activities.

Distribution of FST Show Performance Kits

The idea of producing and disseminating FST Show Performance Kits grew out of the success of the Museum Pilot, which demonstrated that informal science educators could mount successful FST shows without face-to-face training if they received scripts along with sufficient information to perform the shows.

In the fourth year of the grant, the PI worked with Elizabeth Moore and Linda Craft of the Institute of Chemical Education at the University of Wisconsin to turn three FST shows into two Performance Kits. One kit is for *Will It Light?*, the show used for the Performance Training Program. The other kit is a bundle of two short shows, *Bounceman!* and *Atom in a Solid*, both used in the Museum Pilot. Each kit includes scripts, an introduction to the Fusion Science Theater philosophy, instructions on building sets, digital versions of signs and music clips, a video of a previous performance, and instructions on where to purchase and how to alter the needed equipment and materials. The kit also includes the Performance Handbook, which was developed during the transition from the Performance Training Program to the Museum Pilot. The Handbook contains modules teaching how to use the voice and body effectively, how to interact with children in the audience, how to perform the demonstrations, how to facilitate the physical dramatization, and how to assess outcomes.

Will It Light? (25 min) is performed by a scientist and silent assistant who lead the investigation into the nature of conductivity by testing and modeling the flow of electricity through select substances. The major concept taught by this show is conductivity of pure substances and solutions. *If I Was an Atom* (6 min) is an interactive, kinesthetic dramatization of how atoms move in the solid phase. The main concept is the Kinetic Molecular Theory. *Bounceman!* (12 min) is a one-person, street-style show that features a *WrestleMania*-style match between Smart/ Stupid balls. The audience predicts which contestant will be crowned “The World’s Bounciest Ball.” The main concept is that the molecular structure determines polymer properties.

Kits were promoted at the Biennial Conference of Chemical Education in August 2014 and the National Education Outreach Network [NEON] /Association of Science-Technology Centers [ASTC] Conference in October 2014. By the time of release in March 2015, there were 35 pre-orders. By June 30, 16 of the orders had been filled. Descriptions, price, and promotion for the kits can be found at <http://ice.chem.wisc.edu/FST.html>.

In May 2015, the PI came to a tentative agreement to kit an FST activity called *Slime Design* with the American Chemical Society Kids in Chemistry Division. This kit and the kits produced and distributed by the Institute of Chemical Education will allow groups from all over the country to perform FST shows without face-to-face or online training. Completed scripts that have not been made into kits are described on the Fusion Science Theater website and are available for dissemination by request. These include *The Boiling Point* (vaporization of water, 35 min), *The Burning Question* (combustion rates of reaction, 35 min), *That's the Way the Ball Bounces* (how molecular structure determines material properties, 20 min) and *The Glow Show* (effect of temperature on kinetics of chemical reaction in a glow stick, 30 min).

Online Presence

FST staff have developed an extensive website, fusionsciencetheater.org. It provides basic information about Fusion Science Theater: How it works, how evaluation provides evidence that it works, information on the shows and workshops that are available, promotional videos, information about buying kits and acquiring scripts, information for potential donors and the press, and a contact page. In addition, at least 15 videos of FST shows and promotional materials are posted on Vimeo and Youtube (see p. A-18).

FST Troupe

Although it was not funded through the grant, a Fusion Science Theater Troupe of Performing Arts students was created with support from Madison College. The troupe performed FST shows at elementary schools, libraries, family science nights, and afterschool events in the South-Central Wisconsin area, reaching more than 1500 students.

Presentations and Performances for Professional Audiences

In addition to the workshops already described under Deliverable 2, the Fusion Science Theater team delivered at least 29 presentations or posters in the four years of the grant. Most notable of these were an invited talk at the prestigious Gordon Research Conference in Chemical Education Research and Practice (2013) and a plenary talk at the Biennial Conference of Chemical Education (2014), both by the PI. All of these talks delivered information about Fusion Science Theater methods and its success. These talks have challenged three assumptions of chemists and chemistry teachers about informal chemical education: 1) that spectacular demonstrations are an effective way to engage children in chemistry; 2) that these traditional shows teach chemical concepts, a claim unsubstantiated by evaluation; and 3) that evaluation is an unnecessary burden to outreach efforts. These FST presentations have generated great enthusiasm and interest in the importance and potential of informal chemical education that both teaches and assesses learning outcomes in a way that makes the experience even more engaging for the child.

A full list of the presentations and Performances is provided on pp. A-19 to A-20.

Publications

A paper by Kerby, DeKorver, Cantor, Weiland, and Babiarz, titled “A Demonstration Show that Promotes and Assesses Conceptual Understanding via Incorporation of Elements and Structure of Drama” has been submitted to *The Journal of Chemical Education*. The paper includes data from *The Boiling Point*, a show that was developed under the earlier NSF grant. That earlier grant also yielded a publication by Kerby, Cantor, Weiland, Babiarz, and Kerby, titled “Fusion Science Theater Presents *The Amazing Chemical Circus: A New Model of Outreach That Uses Theater To Engage Children in Learning*, *Journal of Chemical Education* (2010), 87 (10), pp 1024–1030.

The PI is currently working with FST staff on four other papers. The first addresses the failure of traditional demonstration shows to promote cognitive gains or to try to assess such gains. The outcomes of FST shows will be provided as evidence that demonstration shows can promote and assess conceptual learning. The second will discuss the advantages of using a paired-prediction question to frame a demonstration. The conceptual change model will act as the theoretical framework for this discussion, and data from *The Ball Bounces* will be used to demonstrate the success of the FST model. The third paper will describe the successful training of ACS-affiliated undergraduate students during the Performance Training Program. Data from students’ local performances of *Will It Light?* will be used to demonstrate the effectiveness of the training and the show. The fourth is a more theoretical paper. It summarizes and critiques past efforts to use story to teach science and explains how FST methods overcome problems that have prevented earlier success.

In summary, consistent gains have been made in the dissemination of Fusion Science Theater concepts and products. Many informal science educators from universities and museums around the country have been trained either in person or at a distance to perform successful shows. Many other professionals have attended the 23 workshops, where they were able to use FST methods to develop new demonstrations or entire shows or to use elements of story to communicate more effectively with the public about science. Many more have been introduced to the philosophy and methods of this new form of science education by attending the 29 presentations, performances, and posters that were delivered. Many children around the country have enjoyed the fun and fascination of FST shows as well. In addition, the FST website has blossomed into a venue where interested parties can learn about FST methods and products, and access videos of performances, order complete kits for three shows, and request scripts of four other completed shows. Finally, FST has made a start in contributing to the informal science education literature by submitting papers detailing the theories behind FST methods and the findings that have emerged.

Conclusions: Successes, Limitations, and Recommendations

By all measures and from all perspectives, the project team has met and widely exceeded the goals it set forth in proposing the three deliverables.

Deliverable 1: Five out of six of the groups who attended the in-person Performance Training Workshop gave at least three performances for children in their own communities, and these shows were highly successful in terms of enthusiastic audience engagement, improved attitudes toward science, and statistically significant learning gains. And, in a Museum Pilot that was beyond the scope of the deliverable promised in the grant, staff at five museums and a group from one university performed FST shows using only materials adapted from the PTW, with no face-to-face or online training. Assessment revealed that these shows were as successful as the shows emanating from the in-person training.

Deliverable 2: Although the proposal had promised only four methods workshops, the project team presented 23 workshops around the country. These workshops targeted K-12 teachers, college faculty, and museum staff who not only learned about the methods, but also used them to design parts or all of science presentations. The workshops were enthusiastically received and earned extremely high ratings. Most importantly, 80 percent of attendees responded that they were “extremely” likely to use the methods in their own work.

Deliverable 3: FST staff generated publicity through the 23 workshops plus at least 29 presentations at conferences and educational institutions, and they have developed two FST Show Performance Kits (involving three shows), which are now available for purchase through the Institute for Chemical Education. Kits include scripts, background, and everything needed to mount a show in addition to a Performance Training Handbook, which was adapted from the materials used in the PTW. All FST scripts that are not in a kit are available by request online. Several research articles reporting on FST methods and results are now submitted for publication or in production.

In summary, grant activities have demonstrated that successful FST shows can be performed with either face-to-face or materials-based training; that FST methods can be taught in workshops and are highly valued by attendees; and that materials are now publicly available to spread the use of FST shows and methods even more broadly.

Limitations and Recommendations

Assessment of Outcomes. The project team has done a impressive job of demonstrating that Fusion Science Theater activities are successful within the constraints of informal science education. Assessment of learning and attitudes needs to be quick and easy; otherwise, it is difficult to induce young children to comply. This said, it must be acknowledged that a single question does not tap the subtleties of the learning that occurs in such settings. Moreover, simple before-and-after designs cannot discover which elements of a presentation are essential to the learning that occurs. Although the assessment methods used in this grant are appropriate to supporting the contention that children learned the central concepts presented in these shows (particularly in light of the fact that most ISE projects do not assess learning at all), future research on these shows would benefit from more intensive explorations of the components of the shows that scaffolded children’s learning, using in-depth interviews with children. Moreover, there was an indication in the comments of participants in the Museum Pilot that some children retained their new knowledge over long periods. Future research might want to find ways to assess the duration of knowledge gain, and for that matter, attitude change. These types of assessments were understandably too costly and labor-intensive to be included in this grant, but the project team might consider including such assessments in future grant proposals. Another valuable approach

would be to design methods workshops in a way that would allow the team to re-contact attendees to determine whether and how attendees actually used FST methods in their own work and what the outcomes were.

Dissemination. The project team has made an admirable start at publicizing the philosophy and outcomes of Fusion Science Theater work. Their presentations and workshops have appeared in all the appropriate venues to reach the professionals who can benefit from and further disseminate the fruits of these endeavors. One area that they should look to for further dissemination is social media. Because using social media effectively is very time-consuming and requires a certain specialized knowledge, FST should be encouraged to explore ways of adding a social-media expert to the team for its next ventures. It seems clear that most people who have come in contact with FST ideas and products are enthusiastic. It would be wonderful to harness that enthusiasm and communicate it virally, to turn these outcomes into a movement that could promote more effective informal science education nationwide and more effective science communication generally.

Performance Report Form

Date of Performance: _____

Venue/Location: _____

Street Address: _____

Child Attendee Demographics:

Circle your best estimates of the composition of the child audience for the show.
Then circle the source or sources of your judgment.

Approximate Proportion of **Minority Kids**

Almost none	About ¼	About half	About ¾	Almost all minority	No Clue
-------------	---------	------------	---------	---------------------	---------

How did you judge? appearance language other info: _____

Approximate Proportion of **Kids from Low-Income Homes**

Almost none	About ¼	About half	About ¾	Almost all low-income	No Clue
-------------	---------	------------	---------	-----------------------	---------

How did you judge? appearance of neighborhood statistics about neighborhood
other: _____

Comments (e.g., Did the kids seem engaged? Were there any surprises or difficulties?) Continue on reverse side if space is needed.

- Enclose all the before- and after- ballots
- Enclose all the attitude surveys
- (Enclose all consent forms if they are required)
- Enclose this form and send to Joanne Cantor in pre-addressed, prepaid mailer.
- Questions to jrcantor@wisc.edu

Child Attitude Questionnaire

NOW THAT YOU'VE SEEN OUR SHOW,
WE'D LOVE TO HEAR WHAT YOU THINK:

1. What did you think of the show? (circle your answer)

	Not at all ¹	a little bit ²	pretty much ³	very much! ⁴
How much did you like the show?	☹	☺	☺☺	☺☺☺

2. How do you feel about these statements? (for each question, circle the answer you agree with):

	Not at all ¹	a little bit ²	pretty much ³	very much! ⁴
a. The show made me feel like I can understand science	☹	☺	☺☺	☺☺☺
b. The show made me want to learn more science	☹	☺	☺☺	☺☺☺
c. The show made learning science fun	☹	☺	☺☺	☺☺☺

3. Are you a boy or a girl? (circle one)

BOY ¹	GIRL ²
------------------	-------------------

4. How old are you? _____ Years

5. LET US KNOW WHAT YOU THOUGHT OF THE SHOW IN YOUR OWN WORDS.

(You can use the other side if you need to).

Thank you!

Children's Comments on PTW Performances (Rated for Valence)

Rating* ³	Age	Comment
4	5	I thought it was awesome!!
4	5	I loved it.
4	6	Good, I liked it very much!
4	6	It was so so so awesome!
4	6	It was awesome!
3	6	I thought the show was exciting!
4	7	It was very fun!
4	7	I loved it.
4	7	I loved it.
4	7	I loved it!
4	8	It was fun and funny. I loved it and I want to see it again.
4	8	I thought the show was great and in school we were learning about matter.
4	8	I really like this how the guy who didn't talk made it better.
4	8	It was awesome!
4	8	I (drew a heart) it (drew a smiley face)
4	8	I think it was well I loved. Wow you used all of that stuff. Thanks for coming.
4	8	I love it.
4	8	Drew smiley faces
4	8	You did very good job.
4	8	Very fun
4	8	I thought the show was very good! I liked the part when they lighted up the Christmas tree.
4	8	I thought the show was very awesome and cool and I really liked it.
4	8	I thought it was cool. I loved it.
4	9	I thought the show was amazing.
4	9	I liked the show very much. It was cool.
4	9	Awesome.
4	9	It was very good.
4	9	It was cool and I wanna see it again and again.
4	9	You are awesome.
4	9	It was fun!!!
4	9	I loved the show
4	9	I loved it very much. Thank you
4	9	The show was amazing!
4	9	The show was amazing!
4	9	Love
4	9	It was very good!
4	9	It was interesting!
4	9	It was great. I learned a lot now about electricity.
4	9	It was great
4	9	It was awesome! I liked the hand motions too and thank you for the show

³ Rating key: 1 = Negative; 2 = Neutral or both Positive and Negative; 3 = Positive; 4 = Very Positive or Positive! or Superlative (e.g., great, awesome, wonderful, etc.).

4	9	It was awesome!
4	9	It was awesome
4	9	I thought that the show was awesome and the scientists were great!
4	9	I thought it was very fun and I liked the experiences that we learned about and I thought it was a very good science experience
4	9	I thought it was really cool! And fun!
4	9	I thought it was great and hope you come again
4	9	I thought it was fun to learn about science!!!
4	9	I thought I could be a scientist when I grow up and it was so funny I hope you come again
4	9	I think it was the best. I loved it.
4	9	I really liked it. It was fun and funny.
4	9	I really liked it . It was very fun
4	9	I real like the show that was fun!! (drew a smiley face)
4	9	I loved it. It was cool!
4	9	I loved it
4	9	I loved it
4	9	I love science now that you made it fun for us to learn
4	9	I love it!!!!!!!!!!!!!!!!!!!!!!!!!!!!!! P.S. I got all the questions right J---- S---- Boy Scouts Pack 48
4	9	I love it! Best science fun ever!
4	9	I love it
4	9	I liked the show!
4	9	I liked it!
4	9	I liked it very much and it was cool to me.
4	9	I liked it a lot and it was kinda funny
4	9	I liked it
4	9	I learn something today. It was great.
4	9	I (drew a heart) it
4	9	Great
4	9	Explanation of 2 a and b: I already want to learn science. And I already understand science. [He gave "not at all" ratings for both.] Overall great show! (though it did not make me like science more (smiley face)
4	9	Awesome
4	9	You were the best! You were so good!
4	9	It was very, very good.
4	9	It was great.
4	9	It was awesome from what I saw at the end when I got here.
4	9	It was awesome and next time I'm coming back for sure.
4	9	I thought this was a great play! (drew a smiley face)
4	9	I thought that it was the best show that I have ever seen! Great show!
4	9	I thought it was very interesting.
4	9	I thought it was really cool and I would love to see it again!
4	9	I thought it was awesome. Can you do it again?
4	9	I thought it was awesome.
4	9	I thought it helped me and it was awesome! Keep up the good work!
4	9	I think that is spectacular!
4	9	I think it was really fun and made me think that science wasn't something made up. It was true.
4	9	I love it even though I hardly seen all of it!
4	9	I liked it a lot and it was funny.

4	9	Funny!
4	9	Fun, awesome, cool
4	9	Beyond awesome!!!
4	9	Awesome, fun. It makes me want to learn more science.
4	10	I liked it very much. I hope I can see it again.
4	10	Awesome.
4	10	The show really made me think about science but I never thought it could be so fun!!!
4	10	It was really helpful with electrical charges.
4	10	It was really fun and cool.
4	10	I thought it was fun and great.
4	10	I thought it was a great show to let kids understand science more.
4	10	I loved it. Can you do it with fire next time?
4	10	I loved it and I can't wait to see the next one.
4	10	The show was super awesome! Thank you
4	10	It was very good!!!
4	10	It was so cool
4	10	It was great.
4	10	It was great!
4	10	It was great it taught me a lot.
4	10	It was good!
4	10	It was fun!!
4	10	It was fun!
4	10	It was awesome!!!
4	10	It was awesome!!!
4	10	It was awesome and I liked the light
4	10	It was awesome
4	10	It make me feel perfect.
4	10	I thought it was really fun and cool. I wish you all could come once a week.
4	10	I thought it was great!!!
4	10	I thought it was awesome
4	10	I thought it was awesome
4	10	I think the show was very good and it will help us in school and at home.
4	10	I loved it. It was the best thing I have ever seen. I hope that guy speaks
4	10	I love science
4	10	I love it. Keep it up!
4	10	I love it. It made me to like it more.
4	10	I liked this show. It was wonderful and cool
4	10	I liked it. I thought it was very good
4	10	I liked it very much
4	10	I liked it a lot
4	10	I like it very much!
4	10	Great! I thought tap water wasn't going to light but minerals have salt particles.
4	10	Great show!
4	10	Great job
4	10	Drew a heart.
4	10	Awesome
4	10	Awesome

4	10	You guys are awesome and I thought it was awesome! I will light (unintelligible) if I see it again.
4	10	The show is very funny and interesting.
4	10	It was really cool.
4	10	It was nice and cool. I have always never like science, but now I do. Thank you! P.S. the most funniest show ever!
4	10	It was hilarious and fun.
4	10	It was great.
4	10	It was fun!
4	10	It was cool!!! (drew a smiley face)
4	10	It was awesome and fun. I think you should do it next year for 4th grade.
4	10	I thought this show was awesome and it made science look super fun!
4	10	I thought the show was awesome!
4	10	I thought it was very fun and funny!
4	10	I thought it was very cool and entertaining show overall.
4	10	I thought it was super.
4	10	I thought it was a great show and hope to see another.
4	10	I think it was awesome.
4	10	I really loved this show. It is really cool to me! It is so awesome.
4	10	I really learned a lot about the particles and what will light, and what won't light. Thanks.
4	10	I loved the show! It was on awesome educational program I hope to see again! Thanks a bunch! It was so much fun.
4	10	I liked it!
4	10	Awesome. Thank you!
4	11	It was fun!
4	11	It was fun and interesting to watch. I loved it.
4	11	It was awesome!!!
4	11	It was awesome and exciting.
4	11	I loved it!!!
4	11	Very good!!
4	11	Thought it was fun!!!
4	11	The show was very cool and fun.
4	11	That show was very fun. Too bad I can't see it next year. I'll be in the 6th grade.
4	11	Love it
4	11	It was very, very interesting.
4	11	it was great!
4	11	It was great
4	11	It was awesome. I would like to know how you do it! Thanks!
4	11	I thought that is was very awesome and important
4	11	I thought it was very interesting and fun.
4	11	I loved it now I love to learn science now. Thank you
4	11	It was informative and awesome.
3	5	I thought the show was nice. It was fun. I liked participating.
3	5	I liked it
3	5	Drew smiley face
3	6	Thank you
3	6	It was a good show
3	6	I liked it

3	6	You can use the bath water. I like the show.
3	6	It was a good show.
3	6	I like it because it was fun.
3	7	I want to learn more about science because I want to become a scientist.
3	7	I thought it was nice.
3	7	It was very good
3	7	It was ok but it was fun too!
3	7	It was cool
3	7	Good-but too long for little kids to sit still. It was fun.
3	8	I thought that it was fun.
3	8	It made science seem fun
3	8	You helped us learned about light and all the waters.
3	8	It was good.
3	8	It was good.
3	8	It was cool.
3	8	It was a good show to me.
3	8	I learned about science more than I did
3	8	If you put water in a light bulb it will light.
3	8	That was fun.
3	8	It was pretty good
3	8	I thought that you made me learn more here than school.
3	8	I thought it was good.
3	8	I think it well. I learned that minerals are similar to salt so that's how it made the light glow.
3	8	I liked the show and I understand that positive goes to negative and negative goes to positive and salt water and tap and bottle water light up but pure water and sugar water do not light up and I understand that you need something to fill the gap.
3	8	Cool
3	8	Cool
3	9	I thought it was good.
3	9	I liked the show thanks!
3	9	It was funny and it help me learn.
3	9	It was fun when we do so much stuff.
3	9	It was fun
3	9	It was cool.
3	9	It was cool and it was fun to watch it lite up. Did yall have fun?
3	9	I liked it like all the kinds of water.
3	9	Thank you
3	9	It was good thank you.
3	9	It was good
3	9	It was funny and good.
3	9	It was funny and cool
3	9	it was fun. Even though I knew some of the stuff already, I still learned a little.
3	9	It was fun and cool and made want to do science more often
3	9	It was fun a little bit (drew smiley face)
3	9	It was fun
3	9	I thought that it was good because science is very good safe.
3	9	I thought it was cool to learn about electricity.

3	9	I like learning about science
3	9	I like it
3	9	I learned a lot more about electricity, thanks
3	9	Thank you
3	9	It was interesting.
3	9	It was fun. P.S. I hope you come again!
3	9	I thought that it was a fun, interesting, and funny way to learn about electricity!
3	9	I thought it was good.
3	9	I thought it was funny and that people learned a lot.
3	9	I think it was fun and funny and helped me learn.
3	9	I like it.
3	10	I think it was good because it is a good lesson of science.
3	10	I think it was fun.
3	10	It was wholesome.
3	10	It was fun learning it.
3	10	It was fun and it helped me learn.
3	10	It was cool.
3	10	It was cool and fun.
3	10	It was cool
3	10	You had to think about stuff and I like to think
3	10	Thought it was fun
3	10	it was entertaining. It was very shocking
3	10	It helped me learn science more.
3	10	I thought it will help people with electricity.
3	10	I thought it was funny.
3	10	I thought it was fun.
3	10	I thought it was fun and funny.
3	10	I liked it.
3	10	I liked it and it was fun
3	10	I liked it
3	10	I like it all
3	10	I good show about science.
3	10	drew a smiley face
3	10	Cool
3	10	The show was good and the actors were nice it was a good show.
3	10	Science is pretty fun. The bottle of water made me think yes will it light.
3	10	It was pretty cool, but not amazingly fun.
3	10	It was nice. I liked it when you informed all of us don't try this at home. Keep on doing it. (drew a smiley face)
3	10	It was interesting and I can learn more about electricity.
3	10	It was good.
3	10	It was fun. The people were funny too.
3	10	It was fun.
3	10	It was fun because I got to be in the show.
3	10	It was cool.
3	10	It helps me learn a lot in science.
3	10	I thought it was interesting.
3	10	I like it. I hope you do it again.
3	10	I didn't like science before but now I do.
3	11	It was pretty good.

3	11	It was pretty cool
3	11	It was fun. I was water so I got to dance. I love science. it is my favorite subject!
3	11	I thought the show was good and I would like to learn more like I did today. Thank you (drew a smiley face)
3	11	I liked the show.
3	11	Good
3	11	It was entertaining.
3	11	It was cool?
3	11	I liked the show it was funny/entertaining. I enjoyed and learned from it. I understand science better
2	9	It wasn't as bad as I thought it would be.
2	9	I like it and I hope you can come back but have more volunteers and stop talking like we're 5.
2	9	I lagfe [sic] ones I can lite. It was ok! :(
2	10	Like it but you could let Spencer talk!
2	10	It was ok!!
2	10	I thought it would be about food.
2	10	I liked it but you could put more fun in it.
2	10	We got to miss some school.
2	10	It was okay.
2	10	It was ok.
2	11	it was ok
2	11	It has to have a charge to light!
1	7	It was a little bit confusing.
1	9	It needs to be more exciting.
1	9	Too long too slow
1	9	Kinda confusing.
1	10	Bad
1	10	It was ok but it was a little boring.
1	10	It was boring.
1	10	I thought it was really dumb and cheesy. I thought the volunteers didn't do enough. I thought the girl up there was stupid because she kept interrupting! Never want to see it again!
1	10	I did not understand it at all. [this person gave us four 4's]
1	11	I hate it.
1	11	You should put more stuff in it.
?	9	Very much
?	10	Very much
?	10	It was awesome we got to miss school!
?	11	Ice cream sounds good.

PERFORMANCE TRAINING PROGRAM: PRE-WORKSHOP SURVEY

As part of your participation in this training, we are asking you to fill out 3 brief questionnaires (one now, one on Sunday, and one after you've performed shows on your home turf.) In addition to using your answers to make our training more effective, we will be using them as part of our research. Your responses will remain confidential. None of your responses will be identified as coming from you, and you may skip any questions you don't want to answer.

Before you participate in the training program, we'd like your responses on the following items (circle your answers):

1. I am interested in a career that involves communicating or teaching STEM content.				
Not at all (1)	Somewhat (2)	Moderately (3)	Very (4)	
2. I am confident in my ability to teach or communicate science.				
Not at all (1)	Somewhat (2)	Moderately (3)	Very (4)	
3. Fusion Science Theater methods are effective in communicating STEM content.				
Not at all (1)	Somewhat (2)	Moderately (3)	Very (4)	I Don't Know (7)

4. Have you participated in science outreach before this? (circle one)

Yes

No

If yes, what type or types have you engaged in? (Circle your answer(s))

demonstration shows

hands-on activities

other: _____
(please specify)

5. Please indicate your year in college (circle one):

Freshman
School

Sophomore

Junior

Senior

Grad Student

Not in

6. Please indicate your school or employer: _____

7. If in school, Please indicate your major: _____

8. Please indicate your gender (circle one):

Male

Female

THANK YOU!!

PERFORMANCE TRAINING PROGRAM: POST-WORKSHOP SURVEY

Now that you have performed a show, we'd like you to fill out this brief questionnaire. In addition to using your answers to make our training more effective, we will be using them as part of our research. Your responses will be confidential. None of your responses will be identified as coming from you, and you may skip any questions you don't want to answer.

1. How well do you think the show went?

Not well at all (1)	Somewhat well (2)	Moderately Well (3)	Very Well (4)
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2. How well do you feel the training prepared you to perform the show?

Not well at all (1)	Somewhat well (2)	Moderately Well (3)	Very Well (4)
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3. How enthusiastic are you about performing this show on your home turf?

Unenthusiastic (1)	Somewhat enthusiastic (2)	Moderately enthusiastic (3)	Very enthusiastic (4)
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4. How enthusiastic are you about providing leadership to your home group in doing this show?

Unenthusiastic (1)	Somewhat enthusiastic (2)	Moderately enthusiastic (3)	Very enthusiastic (4)
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5. Various elements of the training are presented below. Which element was the most helpful? Choose 1 to 3 elements that you found the most helpful and tell us why they were helpful

- | | | | |
|-------------------------------|-------------------|------------------------------|------------------------|
| Video with discussion | Initial read-thru | Voice | Physicality |
| Experiments & interaction | Memorization | | Production Information |
| Adapting | Character | Act-It-Outs | Evaluation |
| Rehearsals throughout the day | | Dress rehearsal and feedback | |

Element	Why it was helpful

Were any of the elements listed above unnecessary or not useful? If so, list them and say why.

6. We interspersed the informational elements with the rehearsal opportunities so that you could put new skills and understandings to use as they were needed. How well did this work in making the training effective?

Not well at all (1)	Somewhat well (2)	Moderately Well (3)	Very Well (4)
------------------------	----------------------	------------------------	------------------

7. Use this space to comment on any aspect of the training workshop. Please give us advice about how we can make this training better in the future.

The following questions are about you:

8. I am interested in a career that involves communicating or teaching STEM content.				
Not at all (1)	Somewhat (2)	Moderately (3)	Very (4)	
9. I am confident in my ability to teach or communicate science.				
Not at all (1)	Somewhat (2)	Moderately (3)	Very (4)	
10. Fusion Science Theater methods are effective in communicating STEM content.				
Not at all (1)	Somewhat (2)	Moderately (3)	Very (4)	I Don't Know (7)

11. Please indicate your year in college (circle one):

Freshman Sophomore Junior Senior Grad Student Not in School

12. Please indicate your school or employer: _____

13. If in school, Please indicate your major: _____

14. Please indicate your gender (circle one):

Male Female

THANK YOU!!

PERFORMANCE TRAINING PROGRAM: POST-WORKSHOP SURVEY FOR ADVISORS

You are our “experts” so we want to know what you think of Fusion Science Theater (FST) methods and our training process. Your feedback will be incredibly valuable to us as we assess and improve the FST Performance Training Program. Rest assured, your responses will be kept confidential and not identified as coming from you. Also, because this assessment is formative, your responses will only be used in our reports to NSF and will not be presented or published in a public forum. You may also skip any questions you don’t want to answer.

Name _____ Institution _____

1. One purpose of the training workshop was to train participants to perform a Fusion Science Theater (FST) show in their own community. How well do you think the workshop achieved this goal?

Not well at all (1)	Somewhat well (2)	Moderately Well (3)	Very Well (4)
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2. Another purpose of the training workshop was to inspire and train participants to lead rehearsals and performances of FST scripts after returning to their home group. How well do you think the training achieved this goal for the attendees from your institution?

Not well at all (1)	Somewhat well (2)	Moderately Well (3)	Very Well (4)
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3. How enthusiastic are you about having your students rehearse and perform “Will It Light?” to audiences in your community?

Unenthusiastic (1)	Somewhat enthusiastic (2)	Moderately enthusiastic(3)	Very enthusiastic (4)
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4. Various elements of the training are presented below. Choose 1 to 3 elements that you found the most helpful and tell us why they were helpful.

- | | | | |
|-------------------------------|-------------------|------------------------------|------------------------|
| Video with Discussion | Initial read-thru | Voice | Physicality |
| Experiments & Interaction | Memorization | | Production Information |
| Adapting | Character | At-It-Outs | Evaluation |
| Rehearsals throughout the day | | Dress rehearsal and Feedback | |

5. Were any of the elements listed above unnecessary or not useful? If so, list them and say why.

(over)

6. We interspersed the informational elements with the rehearsal opportunities so that new skills and understandings could be put to use as they were needed. How well do you think this worked?

Not well at all (1)	Somewhat well (2)	Moderately Well (3)	Very Well (4)
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7. Please give us some suggestions on how to make the workshop more effective and enjoyable for you and your group.

About FST:

8. Do you believe your colleagues at other colleges and museums would be interested in performing FST shows?

Not at all (1)	Yes, somewhat interested (2)	Yes, moderately interested (3)	Yes, very interested (4)
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9. What do you think would be the best way to engage groups from colleges and museums like yours in performing FST scripts?

10. Do you think the training program could be delivered effectively online? Please give us some advice about that.

11. Use this space to comment on any aspect of the training workshop. Please give us advice about how we can make this training better in the future.

THANK YOU!!!!

Characteristics of Fusion Science Theater Methods Workshops⁴					
(See codes below)					
Date	Venue (Length)	Workshop Content	Participant	Focus	
YEAR 1					
Sept 2011	*Wisconsin Science Festival (120 min)	1(A, B), 2	K5 teachers	F	STEM
Jan 2012	*Madison College Spring Convocation, (75 min)	1, 2, 3	2Y College Faculty	F	Gen
Mar 2012	*Wisconsin Society of Science Teachers (WSST) Conference in Madison, WI (120 min)	1, 2, 3	HS teachers	F	STEM
Mar 2012	National Science Teachers Association (NSTA) Conference (50 min)	1, 2, 3	HS, MS teachers, Museum	Mixed	STEM
Mar 2012	American Chemical Society (ACS) Conference-- Undergraduate Program (120 min)	1, 2, 3, 5	Undergrads	I	STEM
April 2012	*UW Madison Outreach Course "Engaging Children in Science" (120 min)	1, 2, 3	Undergrads	I	STEM
May 2012	Santa Clara University, Santa Clara, CA (75 min)	1, 3	Undergrads	F	Gen
June 2012	*Bio-Link Conference, Berkeley, CA, (210 min)	1, 2, 3	HS & CC faculty	F	STEM
YEAR 2					
Jan 2013	*Lakeshore Technical College Convocation, Cleveland, WI (75 min)	1, 2, 3	CC faculty	F	Gen
Jan 2013	Spring Green Elementary School, Spring Green, WI (75 min)	1, 2, 3	K5 teachers	F	STEM
Mar 2012	*Wisconsin Society of Science Teachers (WSST) Conference, Wausau, WI (60 min)	1, 2, 3	HS, MS teachers	F	STEM
April 2013	*Wisconsin Technical College General Education Workshop, Wausau, WI (60 min)	1,2	CC faculty	F	Gen

⁴ 1 = Derivation of Fusion Science Theater methods and form from elements and structure of story, including A, Motivating and guiding learning through questions (Investigation as Plot); B, Inviting students into the "story" of their own learning (Connecting Character); C, Making the abstract concrete through physical dramatization (Act-It-Outs), models, and story; D, Synching assessment and learning outcome through embedded assessment (Vote Your Prediction). 2 = Examples of how these methods can be used in informal and/or formal settings. 3 = Participants use methods to design or redesign parts of activities, lessons, shows, etc. 4 = Participants use methods to design complete lessons, shows, or activities. 5 = Using story to communicate science research. Focus: F = Formal Science Education, I = Informal Science Education. *Workshop was formally evaluated.

YEAR 3					
Sept 2013	*American Chemical Society (ACS) Conference, Undergraduate Program, Indianapolis, IN (120 min)	1, 2, 3	Undegrads	I	STEM
Oct 2013	*NEON workshop at ASTC (90 min)	1, 2, 3, 4	Museum educators	I	STEM
May 2014	*University of Oregon, Center for Sustainable Material Chemistry (75 min)	5	Grads, Post doc, U faculty	I	STEM
May 2014	*University of Oregon, Center for Sustainable Material Chemistry (1.5 days)	1, 2, 3, 4	Grads, Postdoc	I	STEM
YEAR 4					
Oct 2014	ASTC in Raleigh, NC (90 min)	1, 2, 3, 4	Museum	I	STEM
Nov 2014	Madison Area Technical College (60 min)	1, 2	CC Faculty	I	Gen
Feb 2015	*Ohio State University (90 min)	1, 2, 3, 4	Grads, Postdoc, Faculty	F	Gen
Mar 2015	*Project WISE, University of Wisconsin-Madison (75 min)	1, 2, 3	Undergrads	I	STEM
Mar 2015	*Virginia Commonwealth University (90 min)	1, 2, 3	Grads, Postdoc, U Faculty	F	STEM
April 2015	*UW Madison Outreach Course "Engaging Children in Science" (90 min)	1, 2, 3	Grads, Postdoc, U Faculty	I	STEM
June 2015	Alan Alda Center for Communicating Science Summer Institute (60 min)	1, 2, 5	Grads, Post doc, U Faculty	I	STEM

EXAMPLE OF POST-SESSION SURVEY FOR METHODS WORKSHOPS

As part of your participation in this workshop, we would like you to fill out this questionnaire. In addition to using your answers to make our training more effective, we will be using them as part of our research. Your responses will remain confidential. None of your responses will be identified as coming from you.

Now that you have participated in this session, I'd like your opinions of its effectiveness.

1. How satisfied were you with the session overall? (circle your choice):

Not at all (1)	Somewhat (2)	Moderately (3)	Extremely (4)	No Opinion (0)
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2. How satisfied were you with the effectiveness of the session materials?

Not at all (1)	Somewhat (2)	Moderately (3)	Extremely (4)	No Opinion (0)
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3. How satisfied were you with the manner in which the content was presented?

Not at all (1)	Somewhat (2)	Moderately (3)	Extremely (4)	No Opinion (0)
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4. How well did you feel you understood the concepts being explained?

Not at all (1)	Somewhat (2)	Moderately Well (3)	Extremely Well (4)	No Opinion (0)
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5. I believe that the methods presented can be effective in communicating my course content.

Not at all (1)	Somewhat (2)	Moderately (3)	Extremely (4)	I Don't Know (0)
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6. How interested are you in using the methods presented in your own teaching?

Not at all (1)	Somewhat (2)	Moderately (3)	Extremely (4)	I Don't Know (0)
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7. Please comment on any aspect of the session or the methods presented. (Use the back if necessary).

Fusion Science Theater Videos Available Online

Vimeo		
Year up	Content	Views (as of 6-28-2015)
2014	Promo for Fusion Science Theater shows https://vimeo.com/75637562	10
2013	Atom in a Solid https://vimeo.com/68354340	72
2013	The Amazing Chemical Circus https://vimeo.com/68274166	29
2013	Highlights of Will It Light? https://vimeo.com/68042385	59
2013	Promo for The Burning Question https://vimeo.com/68042385	7
2012	Promo for Ball Bounces https://vimeo.com/68042302	22
2012	Promo for Will It Light? https://vimeo.com/68042385	50
2012	Race to the Glow (entire show) https://vimeo.com/40258777	39
2011	Ball Bounces (entire show) https://vimeo.com/24200880	77
2011	If I were an Atom (entire show) https://vimeo.com/24200612	95
2011	Burning Question (entire show) https://vimeo.com/24199101	94
2010	Fusion Science Theater (longer promo) https://vimeo.com/20814886	1500
YouTube		
2014	Trailer for Troupe & Project https://www.youtube.com/watch?v=LF5_ZbEWHZY	380
2014	Kids' Reactions to Shows https://www.youtube.com/watch?v=7qGzIxsHSA	92
2014	Will It Light Promo https://www.youtube.com/watch?v=vIz_v3sETnU	167

Presentations and Performances about Fusion Science Theater (Independent of Workshops)			
Date	Event	Performance	Presentation
May 2012	Residency at Santa Clara University, Santa Clara, CA	✓	
June 2012	BioLink Fellows Conference, Berkeley, CA	✓	
July 2012	Biennial Conference on Chemical Education, State College, PA	✓	✓
Aug 2012	ACS National Meeting, Philadelphia, PA		✓
Oct 2012	Association of Community College Trustees National Meeting, Boston, MA	✓	
Oct 2012	Association of Science-Technology Centers National Meeting, Columbus, OH	✓	✓
Oct 2012	Madison College Sesquicentennial Madison, WI	✓	
Jan 2013	Lakeshore Technical College Convocation, Cleveland, WI	✓	✓
Jan 2013	Spring Green Elementary School Spring Green, WI	✓	
Mar 2013	Wisconsin Society for Science Teachers, Wausau, WI		✓
Apr 2013	Wisconsin Technical College General Education Convention, Wausau, WI		✓
Apr 2013	East Side Community Center Madison, WI	✓	
May 2013	Sauk Trails Family Science Night Middleton, WI	✓	
May 2103	American Association of Museums, Baltimore, MD	✓	
June 2013	Gordon Conference on Chemical Education, Newport, RI		Invited talk
July 2013	Goodman Community Center Madison, WI	✓	
Sept 2013	American Chemical Society National Meeting, Indianapolis, IN	✓	✓
Oct 2013	Association of Science-Technology Centers National Meeting, Albuquerque, NM	✓	✓
Mar 2014	Undergraduate Program American Chemical Society National Meeting, Dallas, TX	✓	Invited talk
Mar 2014	Keynote, Two Year College Chemistry Consortium, Collins College, McKinney, TX		Keynote
Apr 2014	MadTheory Symposium, Performance Philosophy Collective, Madison, WI		Keynote
July 2015	Evaluation in Informal Science Education class at University of Wisconsin, Madison, WI		✓

Aug 2014	Biennial Conference on Chemical Education, Grand Valley State University Allendale, Michigan		Plenary
Oct 2014	Association for Science and Technology Centers, Raleigh, NC		√
Feb 2015	The Ohio State University, Columbus, OH		Invited talk
Mar 2015	Virginia Commonwealth University, Richmond, VA		Invited talk
Apr 2015	Project WISE. University of Wisconsin, Madison, WI	√	Invited talk
May 2015	Science Outreach in After School Clubs Class, University of Wisconsin, Madison, WI		√
June 2015	Gordon Research Conference on Chemistry Education Research and Practice, Bates College, Lewiston, ME		Poster