The Art of Science Learning: Shaping the 21st-Century Workforce

Summative Evaluation Report
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INTRODUCTION

Project Overview

Funded by the National Science Foundation (#0943769), the Art of Science Learning (ASL) is a national initiative designed to achieve two goals:

1. Create an extensive professional community of interest amongst those interested in the use of arts-based approaches in informal science education; and
2. Bring more creative, interdisciplinary approaches to informal STEM (Science, Technology, Engineering, Math) education through the integration of artistic skills, processes, and experiences.

ASL was launched with a series of three national conferences, one in Washington, DC (April 6-7, 2011), one in Chicago (May 16-17, 2011), and one in San Diego (June 14-15, 2011). The conferences brought together a diverse group of practitioners, educators, researchers and policymakers from the worlds of science, education, the arts, and business, in order to share ideas and resources, actively experience arts-based learning, and identify relevant best practices. In essence, these conferences served as a platform for the development of three key project deliverables: a) an online knowledge base for science educators working in all forums and media; b) a research agenda for future quantitative studies; and c) a workforce development report connecting the arts education and corporate perspectives in order to offer actionable policy recommendations on how arts-based learning can be used to develop a competitive 21st-Century STEM workforce.

Evaluation Objectives

The Institute for Learning Innovation (ILI)[1] was contracted by Learning Worlds Institute to conduct evaluation efforts in support of ASL. Specifically, evaluation was designed to answer five overarching questions, developed by the project team in collaboration with the evaluators:

1. Who participates in the conferences? What perspectives, experiences, and expectations do they bring with them to the conferences?
2. What is the nature of participants' conference experience?
3. What impacts do the conferences have on participants' attitudes and understanding related to arts-based learning in the sciences?
4. What do conference participants anticipate will be their own behavior changes or future actions as a result of participation?
5. To what degree and in what ways are participants actively engaged in ongoing work of post-conference communities?

Relevant evaluation results were presented to the project team after each conference in order to inform continued planning and development efforts. In October 2011, following all three conferences, ILI produced an interim report of top-line findings focused on the first three questions. This report expands

[1] The Institute for Learning Innovation (ILI), is a nonprofit research and evaluation organization based in Maryland. In July 2012, ILI's Board of Directors declared that the organization would dissolve, and set about closing all current contracts. Jessica and Sharisse completed the work described in this report while employed by ILI. After they left the organization in April and June 2012 respectively, they were contracted by Learning Worlds Institute as independent consultants to finish writing this report.

on that interim report, providing results focused on all five evaluation questions. It is authored by Sharisse Butler and Jessica Luke, drawing on the work they completed while employed by ILI.

METHODS

The following methods were employed to answer the evaluation questions.

Pre-Conference Registration Questions

The researchers crafted a series of 6 questions designed to collect baseline data from participants as part of the online conference registration process. All registrants were asked to complete these questions so it amounted to a population sample. (See Appendix A.)

Participant Observations

The researchers attended each of the three conferences as participant observers, actively engaging in conference dialogue and activities, and gathering insights on the conference's potential for impact on individual participants. In addition, a third researcher, Jim Kisiel, attended the final conference in San Diego. As a science educator and an outsider to the previous two conferences, Jim offered a different lens through which to view the culminating conference proceedings.

Pre- and Post-Conference Personal Meaning Maps (PMM)

Developed by John Falk, PMM is similar to concept mapping (Falk & Storksdieck, 2005). Individuals are given a piece of paper with a cueing word, phrase or image in the center (in this case, "Arts STEM learning"), and asked to write down as many words or thoughts as come to mind related to the cue. Where PMM is used to measure attitudinal change, the individual goes through this process both prior and subsequent to an educational intervention, and responses are compared along 4 coding dimensions developed by Falk.

Typically an individual's responses form the basis for an open-ended interview in which the individual is asked to explain why they wrote what they did, and to expand upon their thoughts and ideas relative to the cue. These aural responses are then recorded verbatim on the same piece of paper by the interviewer, using a different color ink. For the purposes of this study, researchers adapted the PMM method for use in a large-group setting. Specifically, conference participants were asked to first respond to the cue, and then to turn their paper over, identify one concept from the front, and expand on it in 2-3 sentences in order to clearly articulate how that concept was related to "Arts STEM learning" for them. The pre-conference map was distributed and completed by all participants attending the opening plenary session; post-conference data collection was administered during the closing plenary. Because many participants were not in attendance at the closing plenary sessions, this sample may not be representative of all in attendance. (See Appendix B.)

Post-Conference Online Questionnaire

An online questionnaire, yielding both quantitative and qualitative data, captured the immediate impact of the conference on participants' awareness, knowledge, attitudes, and behavioral intent related to arts-based learning in the sciences. The questionnaire was distributed to all who registered, regardless of which specific sessions they may have attended, and therefore is likely more representative of the conference population than are the findings from the Personal Meaning Maps. (See Appendix C.)

Written Post-Conference Reflections

Sixteen months after the conference experience, two individuals with particular knowledge of the development and continuation of post-conference communities of practice were asked to share their experiences and understandings of conference outcomes at the individual, community, and/or national levels. These individuals – John Reaves and Paige Simpson – were selected by the Principal Investigator, and emailed two questions to which they responded in writing.

RESULTS

Summative evaluation results are described here, according to the five main evaluation questions.

1) Who participates in the conferences? What perspectives, experiences, and expectations do they bring with them to the conferences?

Registration data, recorded by the ASL project team, suggests that a total of 141 professionals participated in the Washington, DC conference; a total of 144 professionals participated in the Chicago conference; and a total of 135 professionals participated in the San Diego conference. Table 1 shows the distribution of participants' professions as self-reported in their online conference registration.[2] The biggest difference between the three conferences is seen in the high number of artists who registered for the DC conference (24%) as compared to Chicago and San Diego (1% and 3%).

Table 1: Registrants' professions as reported in online conference registration

	DC (n=70)		Chicago (n=143)		San Diego (n=103)	
Profession	#	%	#	%	#	%
Science educator (formal or informal)	21	30%	59	41%	37	36%
Arts educator (formal or informal)	21	30%	33	23%	29	28%
Artist (visual or performing arts)	17	24%	2	1%	3	3%
Other	8	11%	29	20%	19	18%
Researcher	1	1%	11	8%	5	5%
Scientist, engineer, or mathematician	2	3%	3	2%	6	6%
Corporate leader	0	0%	4	3%	4	4%
Policy maker	0	0%	2	1%	0	0%

As another measure of registrant diversity, conference registrants were asked to indicate whether they were currently members of any of the professional organizations listed in Table 2. Results show the range of professional affiliations represented at the ASL conferences.

[2] The data in Table 1 do not capture those who registered on site for the conferences; although attendance numbers were similar across conferences, many participants registered for the DC conference on site, and therefore the numbers for those represented in Table 1 are lower for DC.

Table 2: Registrants' affiliation with relevant professional organizations

Organization	DC (n=70)	Chicago (n=143)	San Diego (n=103)	TOTAL
American Association of Museums	6	13	9	28
American Association for the Advancement of Science	4	5	5	14
American Educational Research Association	0	4	6	10
Americans for the Arts	6	12	9	27
Association of Science – Technology Centers	3	6	6	15
National Art Education Association	7	14	5	26

In addition to questions about professional identity, online registration questions asked about registrants' interest in the conference topic. As this was an open-ended question, responses were coded according to the rubric described in Table 3. Responses such as "conference sponsor" and "speaker" were not coded, given that they represented a very particular association with the conference.

Table 3: Rubric for coding registrants' descriptions of their particular interest in the conference topic

Scale Description	Examples
1 Minimal response: Response uses some language appropriate to conference topic, and is often expressed in terms of an interest.	Ex 1: *Merging Arts and Sciences (DC)* Ex 2: *Advancing the arts in America. (Chicago)* Ex 3: *I like teach art using science. (Chicago)* Ex. 4: *Representing science concepts through art (San Diego)*
2 Expanded response: Response is focused on an aspect of the conference topic, and is often more descriptive of what the registrant is already involved in doing. It is less philosophical, sophisticated, and detailed as a category 3 response.	Ex 1: *We integrate the arts into many of science education projects and think it helps engage a wider audience and enhances both art and science education. (DC)* Ex 2: *I love that architecture is at the heart of STEAM; I want to learn more how others are bringing these areas together; particularly to see new examples of activities that push the intersection. (Chicago)* Ex 3: *I am also an artist, and work with renowned artists in the development of my educational materials. I rely on art to present difficult astrophysics concepts. (San Diego)*
3 Elaborated response: Response demonstrates a great understanding of the conference topic and is shared with a higher level of detail. Responses in this category often express personal philosophical perspectives.	Ex 1: *I believe there is a lot of overlap in pedagogical and curricular methods used in arts and engineering, particularly as they relate to design and creativity, and that these methods could be more fruitful if both "sides" were more aware of the methods and objectives engaged by the other. I sense that this conference will help me productively think through these issues. (Chicago)* Ex 2: *I am an engineering education faculty that has been conducting empirical research and starting a curriculum innovation called the Synthesis and Design Studios that involves integrating arts into engineering education. (Chicago)* Ex 3: *It is becoming increasingly difficult to keep our education system at pace with the advance of research. I think that using art as a medium for science education will become critical if we are to keep the general public engaged (and funding) science research. (San Diego)*

Table 4 presents the distribution of participants' interest in the conference topic, as coded according to the rubric above. There were statistically significant differences in responses between the three cities. Specifically, the differences in the mean ranks suggest that those who registered for the San Diego conference were more elaborate and philosophical in their descriptions of their interest in the conference topic than were those who registered for Chicago. Furthermore, those who registered for Chicago were more elaborate and philosophical in their descriptions of their interest in the conference topic, than were those who registered for Washington, DC.

Table 4: Registrants' descriptions of their interest in the conference topic

	DC (n=122)		**Chicago (n=125)**		**San Diego (n=87)**		**Significance** Kruskal Wallis Asymp. Sig.
	%	Mean Rank	%	Mean Rank	%	Mean Rank	
1 minimal	47%	153.55	49%	163.81	28%	192.37	.006
2 expanded	47%		33%		56%		
3 elaborated	6%		18%		16%		

Registrants were also asked to share what they hoped to take away from their conference experience. Table 5 shows that descriptions fell primarily into three categories: 1) new practical ideas for integrating the arts and science, 2) networking with colleagues, and 3) gaining an understanding of existing research or having new ideas for research. (Other expectations named less frequently were about gaining new understandings, learning to advocate, and sharing personal knowledge and strategies.) These expectations are in keeping with the marketing of the conference (e.g., "Learn new ways to use methods from the creative arts to develop hands-on, imaginative approaches to science education, attract students to the STEM disciplines and retain their interest;" "showcase interdisciplinary methods and techniques used by educators and artists;" "share current research into the impact of arts-based approaches on science education.")

Table 5: Registrants' expectations for the conference

	DC (n=66)		**Chicago (n=108)**		**San Diego (n=79)**	
Expectation category	#	%	#	%	#	%
Practical ideas	64	97%	96	89%	74	94%
Networking	8	12%	38	35%	21	27%
Understanding of / ideas for research	4	6%	4	4%	4	5%

Below are examples representative of comments from each of these categories.

Practical ideas:

> *New strategies using the arts to make me a more effective science teacher. (San Diego)*
>
> *Ideas for more hands-on teaching. (DC)*
>
> *I am very interested in ideas for engaging undergraduates, particularly non-majors, in science. I am hoping to be inspired with new ideas of how the arts can be integrated with science to make students more engaged and excited about science. (DC)*

New ideas, best practices, and inspirational projects to incorporate into the curriculum. (Chicago)

Networking:

To build an on-going relationship with a cohort of peers from both the arts and science education fields. (DC)

I hope to meet others who have experience in this arena and who are interested in collaborating and continuing the discussion. (Chicago)

Understanding of / ideas for research:

Data to demonstrate that art increases math/science performance. (San Diego)

Strategies using the arts to make me a more effective science teacher and information on research which supports the use of these strategies. (San Diego)

Often two or three of these categories of comments appeared within a single response:

I want to learn how the arts can be and are being incorporated into science education, and to meet others interested in this area. I'd also like to know what (if any) research has been done on the impact of a transdisciplinary (science and the arts) approach. (Chicago)

2) What is the nature of participants' conference experience?

In this section of the report, we present data related to four aspects of the conference experience: a) participation in the conference; b) overall conference experience; c) conference dialogue; and d) perceptions of conference goals.

a) Participation

In the post-conference online questionnaire, participants were asked to indicate which conference sessions they had attended, providing a picture of overall conference participation. Table 6 shows attendance for the key conference components, revealing a slight trend of dropping attendance in the afternoon of Day 1 and on Day 2, more so for Washington, DC and San Diego than for Chicago.

Table 6: Self-reported participation in conference components

	DC (n=52)		Chicago (n=60)		San Diego (n=53)	
Conference component	#	%	#	%	#	%
Keynote / opening plenary	51	98%	58	97%	51	96%
Metaphorming	49	94%	58	97%	49	93%
Idea harvesting	39	75%	49	82%	42	79%
Afternoon plenary (end of day one)	40	77%	50	83%	40	76%
Working groups	41	79%	57	95%	44	83%
Closing plenary	26	50%	54	90%	39	74%

Below, Table 7 shows participation in the working groups specifically, and confirms a trend observed by researchers at the conferences themselves, namely that the workforce working groups were attended by fewer participants than the research and practice working groups.

Table 7: Self-reported participation in working groups

	DC (n=51)		Chicago (n=60)*		San Diego (n=53)	
Working group	#	%	#	%	#	%
Research	24	47%	33	55%	18	34%
Practice	12	24%	18	30%	15	28%
Workforce	6	12%	9	15%	14	27%
None	9	17%	6	10%	6	11%

*Some in Chicago attended more than one; although 60 respondents answered this question, the numbers by working group total 66.

b) Overall participant experience

In addition to documenting the nature of participants' conference attendance, the post-experience online questionnaire also asked participants to rate their agreement with the statement, "The conference addressed my specific questions and issues" on a 7-point scale, where one was strongly disagree and seven was strongly agree. Results are presented in Table 8. No significant differences were found between the three cities.

Table 8: Degree to which participants felt the conference addressed their specific questions and issues

	DC (n=51)	Chicago (n=60)	San Diego (n=53)
Mean	4.2	4.32	4.7
Median	4.5	5.0	5.0

In addition, respondents were asked to elaborate upon their rating in an open-ended question. Qualitative analysis of those responses associated with a rating of 3 or less on the 7-point scale revealed some general trends, trends which are consistent with responses to the question of what respondents would like to have changed about the conference (see later in this section). More specifically, across all three conferences, roughly half of those whose ratings indicated their questions and issues were not addressed said they regretted not being able to take away more concrete strategies and teaching ideas:

> *Though it was an important part of the conference and excellent learning opportunity, I didn't realize so much time would be devoted to the mission of art and science learning. I needed more activity based information and plans to be already set so I would feel comfortable bringing back new information and immediately incorporating into programs and activities already in place. (Chicago)*

> *I had the impression that the conference was going to be more about incorporating art into the teaching of science and ways to do that. My expectations were just off since that was not really what it was about. (San Diego)*

In Washington, DC and Chicago, about a quarter of the respondents giving a rating of three or lower also expressed a desire for more definition and focus:

> *Everyone kept talking about creativity and art and using other terms but these are so broad; it would have been nice to have someone actually give an operationalized definition of these terms. (Chicago)*

It became rather confusing whether we all thought we were there for the same thing, or whether some attendees thought it was also about using science as an opportunity to teach art. Confusing. (DC)

In San Diego, respondents no longer expressed a need for definition and focus in relation to this question. However, in both San Diego and Chicago, a couple of respondents expressed concern that there was too much emphasis on stating problems and questions and not enough on discovering solutions and identifying next steps:

I feel like a lot of questions were posed, but not answered during the conference. (San Diego)

Respondents to the post-conference online questionnaire were also asked to comment on the highlight of their conference experience, as well as what they would have liked to change about the conference. Individual speakers were prominently identified as highlights in all three locations, though more so in Washington, DC than in Chicago and San Diego. Specifically, in Washington, DC, 87% of the highlights offered by participants were related to individual speakers; in Chicago, 40% of comments were about individual speakers; and in San Diego, 35% of responses were speaker-related. In Chicago and San Diego, various speakers were mentioned, whereas in Washington, DC one speaker in particular (Charles Limb) dominated the responses:

I liked hearing Dr. Limb speak about the way musicians' brains functioned when performing memorized songs vs. "free-style" songs. I think it was really interesting to see how this can correlate to classroom and museum learning-- to me it showed that engaging the brain in ways beyond just memorization can make a larger impact and encourage greater brain function. (DC)

Hearing from/interacting with multiple perspectives and networking were top highlights for participants in Chicago (13% of comments) and in San Diego (14% of comments). In Washington, DC, only 2% of comments related to such interactions:

Hearing the different perspectives from artists and business people and educators. I am an educator and at most educator conferences we go to, we all speak the same language and talk about the same things. I was very interested to hear how others outside of education talk about education and their own projects. (Chicago)

Networking was frequently mentioned as a highlight for participants, especially in Chicago (47% of comments). Both in DC and San Diego, 22% of comments were about networking:

Meeting many people in the Chicago Arts community. Networking with other teachers. (Chicago)

Several themes remained fairly consistent across conferences in response to what participants would have changed, though there were also some differences. Better structuring of time, with a desire for more time to interact and network, was something mentioned by conference participants in all three cities, and it increased slightly with each conference (25% in Washington, DC; 32% in Chicago; and 45% in San Diego). A representative response is as follows:

Too much information for such a short period. EVERYONE was exhausted before the end of Day One. Information overload. Not enough time for people to engage in each other and learn about who was there. (San Diego)

Better framing of Metaphorming, the session led by Todd Siler, was suggested in all three locations, but decreased slightly with each conference (18% in Washington, DC; 16% in Chicago; and 11% in San Diego):

I didn't feel the metaphorming was worthwhile. It initially prompted some interesting discussion (but in the way that ANYTHING would prompt interesting discussion). But the guidelines and processing was so broad/amorphous/open-ended that there didn't seem to be any payoff. (Chicago)

Respondents from all three conferences expressed a need for more practical examples and take-aways, though this was more keenly felt in Chicago than in DC or San Diego (16% in Washington, DC; 45% in Chicago; and 12% in San Diego):

Perhaps it wasn't the intent of this conference, but I think some of the teachers there would have liked to leave with some concrete lesson plan ideas on what they can do in their own classrooms. (Chicago)

An expressed desire for more definitions framing the conferences decreased with each venue (11% in Washington, DC; 8% in Chicago; and 5% San Diego), likely due to the fact that the project team addressed this issue in both Chicago and San Diego:

I wish I felt like I knew where things were going. I think there were a lot of assumptions that were never-really addressed. For instance, there was talk of 'arts-based education', but this was never clearly defined to me. Were they talking about the processes of art that could be used to facilitate science learning? Or is it about the 'spirit of innovation and creativity'? Or is it about understanding the science of art (e.g. physics of dancing, the chemistry of painting) and the integration of these disciplines. This was foggy, which made the meeting foggy overall. (San Diego)

Seven participants (one in DC, two in Chicago, and four in San Diego) had negative responses to the lack of diversity (in terms of gender and ethnicity) of the speakers:

I would like the format and content to have invited more perspectives than it did. One way to approach this would be by making the presenters more diverse (in age, racial/ethnic background, etc.); another would be by inviting, rather than preemptively quelling, dissent amongst attendees. (Chicago)

Seven participants in San Diego felt that the speakers and conversations in their working groups were not well managed or facilitated. These responses did not come from any single working group:

I wish we had more time during the final break - out sessions. . . . Our presenters were unfocused and it took too much time to really get to the meat of the conversation. I also felt that our chair was a little tentative about getting things moving. (San Diego)

Respondents from all three conferences noted the diversity of participants, and respondents from San Diego and Chicago commented positively upon this. Several respondents from San Diego and DC acknowledged difficulties this presented for them in accomplishing their own conference goals:

> *I would have like the focus to be more on educators. I feel the outcome of the conference was scattered and not quite useful or fulfilling to my professional development. (San Diego)*

c) Conference dialogue

The ASL project team expressed a particular interest in the nature of participants' dialogue during the conferences. One question on the post-conference online questionnaire addressed this evaluation question, asking participants to rate on a 7-point scale their agreement with the statement, "I engaged in art/science learning conversations with people from disciplines other than my own." Table 9 below presents average ratings for each conference, and suggests that the typical conference participant felt they often engaged in relevant dialogue with others. There were no significant differences in ratings across the three conferences.

Table 9: Self-reported engagement in 'learning conversations' with people from other disciplines

	DC (n=51)	**Chicago (n=60)**	**San Diego (n=53)**
Mean	5.57	6.02	5.0
median	6.0	6.0	5.0

d) Perceptions of conference goals

Respondents to the post-conference online questionnaire were asked in an open-ended question how they would describe the goals of the conference. Then they were asked, again in an open-ended question, how well they felt those goals were achieved. Finally, they were asked to distribute 15 points across 5 different conference components to reflect how they felt those components contributed to the fulfillment of their perceived conference goals.

Qualitative analysis of responses to the question, "How would you describe the goals of the Art of Science Learning conference?" showed some consistencies across conferences as well as some key differences. Descriptions of conference goals that centered around planning for advocacy or finding solutions were offered by about a quarter of respondents across all conferences (25% in Washington, DC; 23% in Chicago; and 26% in San Diego):

> *To begin a national dialogue on the benefits and value of using arts integration across STEM learning. To develop a cohort of advocates and researchers to promote and test out these benefits. To advocate for policy in going from STEM to STEAM. … To garner support for hands on learning experiences that produce a holistic education. (DC)*

Responses about exchanging specific information remained fairly consistent across the three conferences, though more of these comments appeared in Washington, DC (22% in DC; 17% in Chicago; and 17% in San Diego):

> *Show ways that art and science are integrated highlight organizations that successfully integrate art and science. (Chicago)*

Responses about creating a working community increased with each conference (4% in Washington, DC; 12% in Chicago; and 19% in San Diego):

> *To generate a sense of community amongst those with similar ambitions to change the way STEM disciplines are taught by integrating the arts. (San Diego)*

Many respondents attending in Chicago and San Diego mentioned the goal of increasing understanding/awareness of the value of integrating art and science (30% in Chicago; and 21% in San Diego):

> *To raise awareness on the importance of an integrated approach to teaching science. (Chicago)*

While the idea of increasing understanding was present within a few of the Washington, DC responses, those were not specifically about understanding the *value* of these efforts. Instead, several attending the DC conference described the goals as exploratory and open-ended in nature (11%):

> *To open up the conversation... (DC)*

> *The goals were clear but very open ended. (DC)*

> *Explore the importance of the integration of art and science in education. (DC)*

Two new categories of responses appeared in San Diego: "create an NSF proposal' and "create a research agenda" (which is more specific than responses in the "plan for advocacy" category mentioned above). Together, these categories represented 11% of comments:

> *I think the goals were to bring together people who care about kids' education in both formal and informal settings and to use them to set an agenda for the upcoming year of an NSF grant. (San Diego)*

> *I thought that one primary goal was to articulate a research agenda—identifying relevant questions, appropriate methods, and potential resources to execute this agenda. (San Diego)*

Some respondents made statements about goals being unclear and/or unmet. This occurred less often in Chicago and San Diego, perhaps due to a change in introductory remarks after the first conference (22% in Washington, DC; 10% in Chicago; and 13% in San Diego):

> *I'm not really sure. It was very unclear to me. It seemed like it was a combination of strategic planning for something bigger and sharing ideas, but it was really neither. (Chicago)*

Respondents were asked to comment on how well they felt the conference goals were achieved. Responses to this open-ended question were coded according to the degree to which they expressed this achievement. However, in Chicago and San Diego, a fourth category emerged in response to this open-ended question, specifically about this question being difficult to answer because "only time will

tell." The number of responses in this category in San Diego is a positive finding, indicating that conference participants there were aware of the conference goals not being confined to the conference experience itself, but extending beyond that into the future.

Table 10: Participants' assessments about the achievement of conference goals

	DC (n=51)	Chicago (n=58)	San Diego (n=52)
Not achieved / goals unclear Ex: *I can't answer this based on the fact that the goals were not transparent. (Chicago)*	23%	24%	18%
Somewhat achieved Ex: *I think this goal was partially achieved. There was wide representation across disciplines and geographically, and a number of people built relationships/teams they plan to continue beyond the conference. However, the conference did not end with any clear next steps. I also think there may have been a disconnect between the goals of the participants and the organizers. (San Diego)*	55%	31%	29%
Will only know in future Ex: *Time will tell. I think to a certain extent those goals were beginning to be met, but systemic change takes time and money and resources. (San Diego)*	N/A	3%	16%
Achieved / well achieved / optimistic they will be Ex: *Well. A lot of information was shared. (DC)*	22%	42%	37%

Respondents were asked to demonstrate how the key components of the conference contributed to the achievement of goals by distributing 15 points across the 5 conference components shown in Table 11. They were asked to "use these points to indicate the relative importance of each component in meeting the conference goals." As indicated in Table 11, participants generally felt that the individual speakers best achieved the conference goals, in keeping with their reporting that these speakers were the highlight of their conference experience. Participants' perceptions differed between the three cities. Specifically, those in Chicago were significantly less likely to say that individual speakers contributed to the achievement of conference goals than were participants in either Washington, DC or San Diego.

Table 11: Distribution of points assigned to components as they contributed to conference goals

	DC (n=51)		Chicago (n=58)		San Diego (n=52)	
	% of Points Assigned	mean	% of Points Assigned	Mean	% of Points Assigned	mean
Individual speakers/presenters*	35%	5.26	25%	3.59	38%	6.85
Informal conversations with participants	19%	2.89	24%	3.53	19%	3.44
Working group sessions	15%	2.16	16%	2.24	16%	2.92
Idea harvesting group sessions	14%	2.05	16%	2.37	15%	2.68
Metaphorming workshop	13%	1.98	13%	1.83	10%	1.86
None	4%	.58	6%	.93	1%	.17
Total	100%		100%		100%	

*Statistical significance found between means of points assigned across conference cities.

3) What impacts do the conferences have on participants' attitudes and understanding related to arts-based learning in the sciences?

This section of the report presents data according to two different dimensions of conference impacts: a) participants' ratings of specific desired outcomes, both for the conference overall and for Metaphorming specifically (since Todd Siler administered his own questionnaire within this conference component); and b) participants' open-ended responses through Personal Meaning Maps.

a) *Participants' ratings of specific conference outcomes*

Participants were asked on the post-conference online questionnaire to rate their agreement with a series of six outcome-based statements on a 7-point scale (see Table 12). Across all the statements, the average rating was between 4 and 5 (except for one). Only one difference was found between cities; for the statement "I have ideas for how art/science can be integrated," the mean rating significantly increased from the Washington, DC and Chicago conferences to the San Diego conference. For all other statements, there were no significant differences.

Table 12: Participants' mean ratings of specific conference outcomes

As a result of participating in the conference...	**DC (n=55)**	**Chicago (n=60)**	**San Diego (n=53)**
I better understand the challenges associated with integrating art/science	4.83	5.17	5.38
I have a greater appreciation for why art/science learning is valuable	4.91	5.05	5.47
I have new ways of thinking about art/science learning	4.65	4.95	5.32
I have ideas for how art/science can be integrated*	4.56	4.95	5.91
I feel like I'm part of an ongoing community around art/science learning	5.20	5.03	5.43
I can articulate the benefits of integrating art/science learning	4.85	3.35	5.51

*Significant difference from DC & Chicago to San Diego.

Todd Siler, who designed and facilitated Metaphorming workshops at each of the conferences, uses a standard questionnaire with all his workshops, and this was incorporated into the post-conference online questionnaire at the request of the project team. Respondents were asked to check whether or not they experienced the "attributes of the Metaphorming process." Table 13 presents the results to this question. In Chicago, five of the attributes received over 50% positive responses. In Washington, DC and San Diego, two of the attributes (teamwork and creativity) received over 50% positive responses. Open-ended questions were also asked about the Metaphorming workshops, but those findings are not included here because a) those questions were not designed and administered by ILI; and b) because the purpose of those questions was formative in nature and findings were used to inform subsequent workshops.

Table 13: Metaphorming goals (numbers and percentages of "yes" responses)

	DC (n=50)		Chicago (n=58)		San Diego (n=49)	
Goal / attribute	#	%	#	%	#	%
Builds Teamwork: Did you enjoy working with others and collaborating?	38	70%	43	74%	39	79%
Boosts Creativity: Do you think you were *being creative*, while making and mining the meanings of your 5-D Symbolic Model?	35	76%	38	66%	34	69%
Breaks Mental Barriers and Self-Imposed Limitations: Did the process of making and exploring your Model help you and others understand your views?	23	46%	30	52%	24	49%
Stimulates Curiosity and Critical Thinking: Did you raise new questions or critically examine new ideas and their possibilities, through your Symbolic Model?	21	42%	33	57%	23	47%
Inspirational: Do you feel more inspired and motivated to achieve a Goal?	15	30%	24	41%	22	45%
Helps Solve Problems: Were you able to pose or solve a problem, or develop an opportunity, by making your Model? Did you come up with some fresh, practical solutions?	17	31%	25	43%	20	41%
Challenges Yourself: Do you feel you challenged yourself and learned new things?	18	36%	26	45%	19	39%
Fosters Better Communication: Were you able to express yourself better and communicate your feelings and thoughts, using your Model as a visual aid?	21	43%	31	53%	18	38%

b) *Participants' open-ended responses to the conference as measured through Personal Meaning Maps*
Personal Meaning Maps (PMMs) were administered at the outset of each conference, and again at the closure of the conference. Participants were given a piece of paper with the words "Arts" and "STEM Learning" in the middle, and asked to write or draw whatever came to mind. On the back of the paper, they were given space to elaborate on one theme that they articulated on the front. (See Appendix B.) Before the conference began, they were asked to do this exercise in one color of ink, and those responses constitute the "pre" responses. At the end of the conference, they used a different color ink and were able to add to or edit their original responses, as well as elaborate on a new concept, and those responses constitute the "post" responses.

Personal Meaning Maps were analyzed according to three dimensions – fluency, breadth, and depth. Fluency measures the number of relevant vocabulary words used by participants to articulate their thinking about arts and STEM learning. Table 14 shows this data, presenting the average number of words used by conference participants in each of the three cities.

Table 14: Pre- and Post-conference PMM analysis - fluency

DC (n=44)	Chicago (n=69)	San Diego (n=57)
Range=1-67 PRE Median=30 POST Median=23 *Significant decrease pre-post*	Range=0-59 PRE Median=22 POST Median=20 *No significant change*	Range=0-58 PRE Median=25 POST Median=13 *Significant decrease pre-post*

The second dimension of the PMM analysis quantifies the breadth of participants' thinking about arts and STEM learning, or the number of different ways they conceptualized this topic. ILI researchers first coded the different ways in which participants approached the topic; this coding rubric is summarized in Table 15 below.

Table 15: Conceptual Categories for Arts – STEM learning PMMs

Category	**Description & Examples**
(1) Discipline-specific: STEM	Approaches topic from a specifically STEM perspective, using science and STEM-related terms and concepts, including products and examples of STEM. This often appears visually on the page as a list below "STEM learning." e.g. , *formulas, logical thinking, analyze, numbers, investigation, math*
(2) Discipline-specific: Arts	Approaches topic from a specifically Arts discipline perspective, using arts-related terms and concepts, including products and examples of the arts. This often appears visually on the page as a list below "Arts." e.g. , *photography, painting, opera, beauty, stimulation of artist and viewer*
(3) Relationship between STEM and Arts*	Addresses issues relating to the relationship between STEM or STEM learning and the arts. This may come in the form of a question, a critique, a claim, or a drawing (such as arrows or a Venn diagram)
Subcategories:	(1) bidirectional e.g. , *bridges* (with arrows)
	(2) integration e.g. , *STEAM*
	(3) shared processes / shared brain activity e.g. , *problem-solving, thinking through making*
	(4) unidirectional e.g. , *merging the arts into academic subjects*
	(5) disciplinary or human ex. e.g. , *landscape architecture, daVinci*
(4) Pedagogy	Names or describes approaches to teaching or ways of learning. e.g., *hands-on and brains-on, big picture vs. rote learning, engaging students in learning process*
(5) Benefits (skills and processes)	Names or describes skill that can be gained or processes in which one is involved through the arts and/or STEM learning. Often these are visually independent of the words on the paper, but sometimes are visually connected to one or the other. e.g., *associative thinking skills, curiosity*
(6) Actions and changes needed	Describes a problem that needs to be addressed or changed, or an action to take. Sometimes this is conceived of externally of the participant, and sometimes the language is about what the individual participant needs or plans to do. e.g., *arts are marginalized in USA, communities of practice, how to make connections meaningful?*
Subcategory:	(1) need for integrity in both. e.g., *risk of treating the arts merely as an instrument, concern that the arts are being appropriated into arts-based learning in ways that devalue the arts, both sides feel cheapened*

After coding the PMM data according to these categories, researchers then summed the total number of *different* categories employed by each participant, and compared responses pre- to post-conference. These results are presented in Table 16, and clearly show that the total number of concepts used by participants decreased pre- to post-conference. Although this finding may seem counter-productive at first thought, we have found this same trend in other PMM studies, and we interpret it to indicate a consolidation of thinking on a particular topic (Storksdieck & Falk, 2005; Luke et al., 2002). In other words, participants moved from a wide range of possible thinking around "arts and STEM learning" to a more specific, relevant, and detailed set of concepts on the topic.

In addition, the results in Table 16 suggest that by the end of the conference, participants were significantly less likely to think about the topic in terms of one particular discipline (e.g., either arts OR STEM) and were more likely to think about the topic from a holistic point of view (e.g., STEAM) and to articulate the shared processes between the two disciplines. This finding is aligned well with the goals of the Art of Science Learning conferences.

Table 16: Pre-Post conference PMM analysis - breadth

	DC (n=44)	**Chicago (n=69)**	**San Diego (n=57)**
Total # of concepts:			
	Range=0-6 PRE Median=3.5 POST Median=3.0 *Significant decrease*	Range=0-5 PRE Median=3.0 POST Median=2.0 *No significant change*	Range=0-6 PRE Median=3.0 POST Median=2.0 *Significant decrease*
Specific concepts:			
(1) STEM	PRE=50% POST=16% *Significant decrease*	PRE=29% POST=9% *Significant decrease*	PRE=67% POST=7% *Significant decrease*
(2) Arts	PRE=50% POST=16% *Significant decrease*	PRE=37% POST=7% *Significant decrease*	PRE=68% POST=9% *Significant decrease*
(3) Relationship between Arts and STEM	PRE=82% POST=71% *No significant change*	PRE=75% POST=69% *No significant change*	PRE=63% POST=51% *No significant change*
Subcategories of concept 3:			

	Unidirectional
	PRE=21% // POST=0
	Significant decrease
		Unidirectional
		PRE=15% // POST=10%
		No significant change
			Unidirectional
			PRE=4% // POST=7%
			No significant change

	Bidirectional
	PRE=7% // POST=18%
	Significant increase
		Bidirectional
		PRE=10% // POST=13%
		No significant change
			Bidirectional
			PRE=12% // POST=25%
			No significant change

	Shared processes
	PRE=43% // POST=27%
	Significant decrease
		Shared processes and brain activity
		PRE=52% // POST=44%
		No significant change
			Shared processes
			PRE=37% // POST=16%
			Significant decrease

	Integration/Whole
	PRE=25% // POST=34%
	Significant increase
		Integration/Whole
		PRE=18% // POST=31%
		Significant increase
			Integration/Whole
			PRE=23% // POST=12%
			No significant change

	N/A	Disciplinary Example/Specific Person Example
		PRE=25% // POST=3%
		Significant decrease
			Disciplinary Example/Specific Person Example
			PRE=16% // POST=11%
			No significant change

(4) Pedagogy	PRE=48% POST=55% *No significant change*	PRE=41% POST=38% *No significant change*	PRE=23% POST=9% *No significant change*
(5) Benefits – skills and processes	PRE=66% POST=52% *No significant change*	PRE=56% POST=49% *No significant change*	PRE=46% POST=35% *No significant change*
(6) Action	PRE=43% POST=61%	PRE=28% POST=74%	PRE=26% POST=70%

	No significant change	*Significant increase*	*Significant increase*
Subcategory of concept 6:			
	N/A	Integrity in Both PRE=7% POST=12% *No significant change*	N/A

The third dimension along which PMM data were analyzed was depth. ILI researchers created a detailed rubric assessing the level of detail and sophistication inherent in the ways participants elaborated on their thinking about Arts and STEM learning.; this rubric is presented in Table 17 below.

Table 17: Depth scale for PMMs (with Chicago examples):

Scale Rating	**Description and Examples**
(0) Unrelated response	A response that does not relate to the conference topic.
(1) Minimal response	Response reflects some understanding of the conference topic, but at a superficial level. Response may not address the relationship between the STEM learning and the arts, or may consist primarily of very basic questions.
	Practice example: *Hands-on / includes many subjects / cross curricular; combine all elements so students can make a deep, meaningful and purposeful connection.*
	Theoretical example: *Critical thinking is the key to unlocking creativity in art and innovation in STEM. Critical thinking is key for coming up with new ideas in any field.*
(2) Expanded response	Response is focused on an aspect of the conference topic and addresses to some degree the relationship between STEM learning and the arts. Responses in this category are not as sophisticated or detailed as those in category 3.
	Practice example: *Visualization is a creative process that can be utilized both by scientists and artists. In order to conceptualize new ideas you need to be able to start putting ideas into forms.*
	Theoretical example: *Arts & STEM learning is the interaction of a person with the outside world. Any question we have can be traced back to our sense of discovery and how we express that discovery.*
(3) Elaborated response	Response demonstrates a great understanding of the conference concepts and is shared with a higher level of detail. Responses in this category often include statements that are calls to specific action.
	Practice example: *It is important to impress upon students, early on, the shared nature of arts & sciences. We need to implement arts & science learning separately, as they both require expert teaching, but their connections will help students succeed in more disciplines (as opposed to one or the other).*
	Theoretical example: *This conference attracted people interested in this concept and people who are scared of this idea. There is a fear that one will overshadow the other. I think artists and scientists need to let go of their firm grip on "disciplines" and see this more collaboratively with blurred lines. It will be difficult to define "art" and "science" so let's define something else that comes easier, such as "21st century skills" and evaluate/research the focus on processes. Art and Science are equally important for our survival as a species.*

After coding participants' responses using this rubric, researchers then compared participants' pre-conference responses with their post-conference responses. Table 18 presents the results from this analysis, showing that across all three conferences, participants' offered more detailed and elaborate conceptualizations of their particular "arts and STEM learning" concepts after the conference than before.

Table 18: Pre-and post-conference PMM results – depth

Scale rating	**DC (n=44)**	**Chicago (n=69)**	**San Diego (n=57)**
1=minimal 2=expanded 3=elaborated	PRE Median=2 (Mean=1.98) POST Median=2 (Mean=2.34) *Significant increase*	PRE Median=2 (Mean=1.93) POST Median=2 (Mean=2.13) *Significant increase*	PRE Median=2 (Mean=1.61) POST Median=2 (Mean=1.89) *Significant increase*

4) What do conference participants anticipate will be their own behavior changes or future actions as a result of participation?

For all three conferences, participants were asked in the post-conference online questionnaire what one thing they might do in the next six months as a result of the conference. In a qualitative analysis of responses to this open-ended question, several themes emerged across all three conferences. Implementing new approaches to teaching was mentioned by participants, though it was mentioned more often from Chicago participants (13% of responses in Washington, DC; 37% of responses in Chicago; and 14% of responses in San Diego):

> *I have been making small changes in my lesson plans to incorporate more creative thinking and creative expression. Just this week I changed a lesson plan based slightly based on what I learned at the conference. (Chicago)*

"Plans to find or create new partnerships and collaborations" was also a theme in responses from participants at all conference, though again, most often from Chicago (16% of responses in Washington, DC; 30% of responses in Chicago; and 14% of responses in San Diego):

> *Collaborate with the art, music and p.e. teacher to coordinate their lessons with science lessons and vice versa - we already collaborate with the language arts and math teacher. (DC)*

Respondents from all three conferences said they planned to discuss what they learned and share ideas, either in a general sense (see first example below) or in very specific ways (see second example below). This type of response was more prominent from Washington, DC participants than from participants at the subsequent two conferences (22% of responses in Washington, DC; 12% of responses in Chicago; and 14% of responses in San Diego):

> *Take the information that was shared and use it to better communicate the importance of the arts and creativity. (DC)*

> *I will share what I learned from Dr. Limb's presentation with a special task force focused on the brain, learning, and the arts. (DC)*

In San Diego, 43% of participants said they would either work to build community or at least make an effort to remain part of the community. This finding is in striking contrast to the primary focus from the previous two conferences on implementing ideas. (No one from Chicago mentioned this, and only 2 people – or 1% – mentioned this in Washington, DC.)

> *Continue to stay in touch with the group, as possible, and help evolve strategies. (San Diego)*

> *I will participate in the Balboa Park working group on this topic. In fact, we met today and have more meetings planned within the next few weeks. (San Diego)*

> *I'm already in the process of creating an online searchable database for scientists, artists and educators to connect with each other. (San Diego)*

Because San Diego was the last of the three conferences, and the conference organizers hypothesized that there would be a heightened awareness at that point in the trajectory of conferences about post-conference agendas and action-items, two additional questions were added to the post-conference online questionnaire. The first new question was, "What do you believe will be the outcome(s) of the working group in which you participated?" The majority of responses to this question were about specific meetings planned to take place in San Diego (n=13) and continued conversation or networking (n=10). Typical comments included the following:

> *We are planning another meeting at the Old Globe next week. Note: Three of these responses were from non-local participants who are disappointed they will not benefit.*

> *Collaboration, exposure and support for individual efforts. I am also hoping they all connect and support one another.*

Many respondents, however, said they were unclear or doubtful about what was going to take place (n=10), the majority of whom had attended the research working group:

> *Outcomes were not clear. The discussion was dominated by other people's tangents and unfortunately this inhibited the effectiveness of the workshop.*

The second new question was, "What is your understanding of next steps that will be taken by conference organizers and participants?" The largest number of responses (n=11) had to do with creating a forum for continued conversation or networking:

> *Establishment of a network if resources are available to support infrastructure and growth.*

Other types of responses made by 8 participants each included seeking more funding from the National Science Foundation, creating a report based upon work done during the conference, meetings in San Diego, and the pulling together of resources and ideas to be made available to participants and interested others:

Sounds like there is to be an assessment of outcomes (?) which would lead to the development of an NSF proposal. Not clear to what extent participants will be involved in this, though.

I think it will be taking our ideas, along with everything that the speakers and researchers have done, and presenting it in the form of a study or paper to actually get STEAM implemented in schools.

I have already begun to collaborate with the arts teachers at my school on my science lessons for next year.

Seven participants responded to this question with a lack of clarity on the subject; most of them had attended the research working group:

I did not leave with any understanding of this, sorry.

5) To what degree and in what ways are participants actively engaged in ongoing work of post-conference communities?

Two informants were asked to speak to this issue approximately one and a half years after the first conference in Washington, DC. Paige Simpson and John Reaves were selected as informants by the project team, based on the intimate role these two have played within post-conference activities. Two questions were asked of Paige and John, and their responses are shared below:

1) In your experience, in what specific ways has the Art of Science Learning conference series served as a catalyst for the forming or strengthening of national and/or local communities of practice around the application of arts-based learning to informal science education?
2) What do you believe have been the outcomes thus far of that community (or those communities) of practice, on either the level of individual participants and/or on a larger scale of the institutions and communities these individuals influence?

Paige Simpson
Interim Executive Director and Director of the Balboa Park Learning Institute

Simpson combined her answers to the two questions into the following single response.

For San Diego, the Art of Science Learning conference was in the right place, at the right time. We have a strong arts and science community, and momentum had been building but in pockets of activities among different stakeholders. The conference provided the space to bring everyone together and reveal common interests.

Afterward, several groups spun out of the convening, and kept a decent level of activity for about a year. One was more geared towards the application of bringing art and science together for workforce development purposes and one for educational goals. We also created a small sub-group for Balboa Park people specifically. It is really difficult to maintain collective interest in a topic after a conference, so the self-formation and continuance of these groups was pretty impressive. However, without a concrete goal or galvanizing event/project, they weren't able to be self-sustaining.

Rather than disappearing though, the groups segued into other groups/projects. One is a group previously known as "The STEAM Manifesto" that had become dormant. After the conference, the group was re-energized and re-branded as "Full STE[+A]M Ahead." In this new iteration, there are quarterly networking events that showcase different STEAM projects and market other related events that may occur between meetings. Many of the people who were at the ASL conference continue to participate, but new people have come onboard as well.

Another group that was recently formed was the San Diego Innovation Alliance. The co-founders, myself and John Eger, were largely brought together by the ASL conference. Other conference attendees are also participating in the Alliance, but as that group has wrestled with its purpose/focus, it has become clear that STEAM is a part but not all of the interests of this group.

I think another important point related to the purpose/content issue is that the other post-ASL groups previously described also played with clarifying their interests. I think it's fair to say that, in San Diego at this point, people are not bound to the application of arts-based learning into STEAM. There was much discussion about the two-way exchange of STEM and the arts and thus the focus becomes much broader.

Having the Partnership and San Diego be a part of Phase II is another way of extending what came out of the first conference. People have been waiting for this project, and now that it is coming to fruition, we will see how original conference attendants continue to build on their experience. We'll also see how they zero back in on the specific agenda of ASL, which is the application of arts-based learning to STEM. This project also serves as the avenue for connecting San Diego to a larger national dialogue, because of the incubator sites in other cities. If not for this, I think San Diego would remain focused on our own region as there is still much work to do in bringing everyone here together around these issues.

The communities of practice that have been connected, established or refined as a result of interaction with ASL have provided professional development and networking outlets for individual participants. They have also raised collective awareness of the need for San Diego to come together in recognizing our strengths in STEAM and need for coordinating various entities and efforts and promoting the region as a whole.

John Reaves
Executive Director, Learning Worlds Institute

1) In your experience, in what specific ways has the Art of Science Learning conference series served as a catalyst for the forming or strengthening of national and/or local communities of practice around the application of arts-based learning to informal science education?

For myself and most of the 400+ participants, I think the conferences flipped a switch. If arts-based learning was an abstract value for us, we saw that it could be concrete and actionable. If it had seemed a peripheral value from a pedagogical point of view, it suddenly took center stage at the intersection of creativity, innovation, and literacy. If ABL was part of our private practice as artists, scientists, and educators, we saw that it could be a program and a community. If we were already engaged in a local program, we saw that the program could have national partners or be supported by policy initiatives.

As a result of the conference, participants were validated and energized. Their horizons were expanded. They began to reach across disciplines, between geographies, and upward within their own

organizational structures. In a metaphor from science, a super-saturated solution was seeded and crystals began to form spontaneously. The potential now exists for linking the crystals into larger structures and networks.

By exploring ABL-related "foundational" issues in a structured way, the conferences also set the stage for developing communities of interest, not just communities of practice. Without this groundwork, emerging communities of practice would have to grope their way to a separate consensus on the need for doing fundamental research, enhancing educational practices, and exploring the potential impact of ABL on workforce development. As a result, these activities were accelerated.

Social media sites like artsciencematchup.org and STEAM-related online groups like The Art of Science Learning on Linkedin have the potential to help catalyze that process and actualize the relationships forged by the conference. We're seeing an organic increase in online activity on AOSL sites, as well as more discussion of STEAM topics on STEM sites; those channels are now available to support ongoing initiatives in the coming months.

2) What do you believe have been the outcomes thus far of that community (or those communities) of practice, on either the level of individual participants and/or on a larger scale of the institutions and communities these individuals influence?

Today's teachers work within a difficult environment of multiple stakeholders and constraints. It is extremely challenging to try something new. This was clear in all the conversations and workshops at the conferences. Recent national trends working their way to the local level, including standardized curricula and testing, have exacerbated that challenge. ABL communities of practice give individual educators the necessary confidence, as well as examples and models, to experiment with ABL approaches.

At the organizational level, communities of practice help schools and school system turn small experiments into programs with impact. Relevant precedents, evidence, and arguments are necessary to address institutional barriers. The conferences shared much of this material, and relationships between ABL supporters continue to expand the conversation.

ABL and STEAM concepts are also becoming more widely talked about and accepted in the public dialogue about U.S. education, beyond the arts integration and art / STEM communities. This dialogue itself is complex and involves a variety of communities and interest groups. Higher visibility helps enormously to validate ABL and strengthen the perception of ABL's potential, in the face of competing agendas.

CONCLUSIONS

The Art of Science Learning initiative was designed to achieve two goals: 1) to create an extensive professional community of interest relative to the use of arts-based approaches in informal science education; and 2) to bring more creative, interdisciplinary approaches to informal STEM education through the integration of artistic skills, processes, and experiences. Three national conferences brought together a diverse group of practitioners, researchers and policymakers across disciplines to share resources and practices. Summative evaluation of the ASL initiative provided insight into who participated, how they experienced the conferences, and what impacts the conferences had.

Who participated in the ASL conferences?

Summative data show that all three Art of Science Learning conferences were well-attended, with registration at each conference totaling between 135-144 participants. Even more important is that the conferences were attended by a diverse group of professionals, including educators, researchers, and policy-makers, as well as people from various disciplines including science, art, and history. Not surprisingly, participants indicated a strong interest in the relationship between art and science education. Participants' interests differed by conference only in that they expressed more a more detailed, philosophical interest in the topic in San Diego as opposed to in Chicago or Washington, DC.

What was the nature of participants' conference experience?

Participants came to the conference expecting opportunities to network with colleagues, learn about new ideas for integrating arts and science, and better understand the research in this area. Participants generally felt the conference met their expectations to a degree.

Conference highlights for participants were the individual speakers and presentations, as well as the opportunity to talk informally with colleagues. Suggested changes included a less densely packed agenda, as well as more practical examples and take-aways.

What were the impacts of the ASL conferences?

On the whole, the conference achieved its goal of helping participants to better understand how the arts can contribute to STEM learning. Comparisons between pre- and post-conference data show that participants consolidated their thinking about the integration of arts and STEM learning; they were less likely after the conference to approach the topic from the point of view of one particular discipline (e.g., arts OR science) and more likely to think holistically about it (e.g., STEAM) and to articulate shared processes between the two disciplines. In addition, participants' post-conference elaborations of their thinking were richer, and more detailed.

San Diego participants expressed awareness that the conference goals would be achieved beyond the conference event itself, and many from San Diego took proactive measures to be a part of a continued local community begun or strengthened by conference participation. Paige Simpson, Interim Executive Director and Director of the Balboa Park Learning Institute, confirms that new groups did indeed begin convening. While they did not all continue meeting longer than a year, some morphed into new and previously dormant initiatives and networking groups. Simpson notes that in San Diego, the emphasis may be less on the application of the arts to STEM, and more on "two-way exchange of STEM and the arts." (The evaluation findings support this observation, with twice as many participants commenting on the bidirectional nature of the relationship between the arts and STEM learning after the conference as compared to before the conference.) Simpson believes that the conferences and the local involvement in Phase II are bringing San Diego into the "larger national dialogue" on these issues.

John Reaves, the Executive Director of Learning Worlds Institute, has witnessed a similar shift, where those previously involved in the issues on a local level are now situating their work in a broader national context and have a policy-level focus. He notes that social media sites, such as *artsciencematchup.org*, are supporting the ongoing dialogue and new initiatives.

Next Steps

Last month, the National Science Foundation awarded a grant (#1224111) for a second phase of the Art of Science Learning initiative entitled "Integrating Informal STEM and Arts-Based Learning to Foster

Innovation." The grant will fund arts-based incubators for innovation in STEM learning in San Diego, Chicago, and Worcester, Mass. Additionally, the grant will support the development of a new arts-based STEM curriculum; experimental research to measure the impact of arts-based learning on creativity, collaboration, and innovation; and public programs using the project's activities to advance civic engagement with STEM.

The incubators – hosted by San Diego's Balboa Park Cultural Partnership, Chicago's Museum of Science and Industry, and Worcester's EcoTarium – will bring together 30 cross-disciplinary innovation teams of STEM professionals, artists, educators, business leaders and students. The teams will learn arts-based techniques for generating, transforming, prototyping and communicating creative ideas and apply them to STEM-related civic innovation challenges. Participants will also collaborate on the development of new educational projects that integrate arts-based approaches into STEM learning.

Innovation festivals, art/science innovation symposia, prototype demonstrations and a culminating interactive exhibition, created by the Reuben H. Fleet Science Center in San Diego and traveling to each incubator site, will reach national audiences with compelling stories about the civic impact of innovation at the intersection of art, science and learning.

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Appendix A: Online Registration Questions

Date
Name
Email
Address, City, State, Zip Code, Country
Phone (home and cell)

Which of the following best describes your profession?

science educator (formal or informal)
arts educator (formal or informal)
artist (visual or performing arts)
scientist, engineer, or mathematician
corporate leader
policymaker
researcher
other: _____

Please describe your involvement, if any, with the arts or sciences in either professional or nonprofessional capacities.

Check any of the following organizations for which you are currently a member:

American Association of Museums
American Association for the Advancement of Science
American Educational Research Association
Americans for the Arts
Association of Science – Technology Centers
National Art Education Association

Briefly share your particular interest in the conference topic.

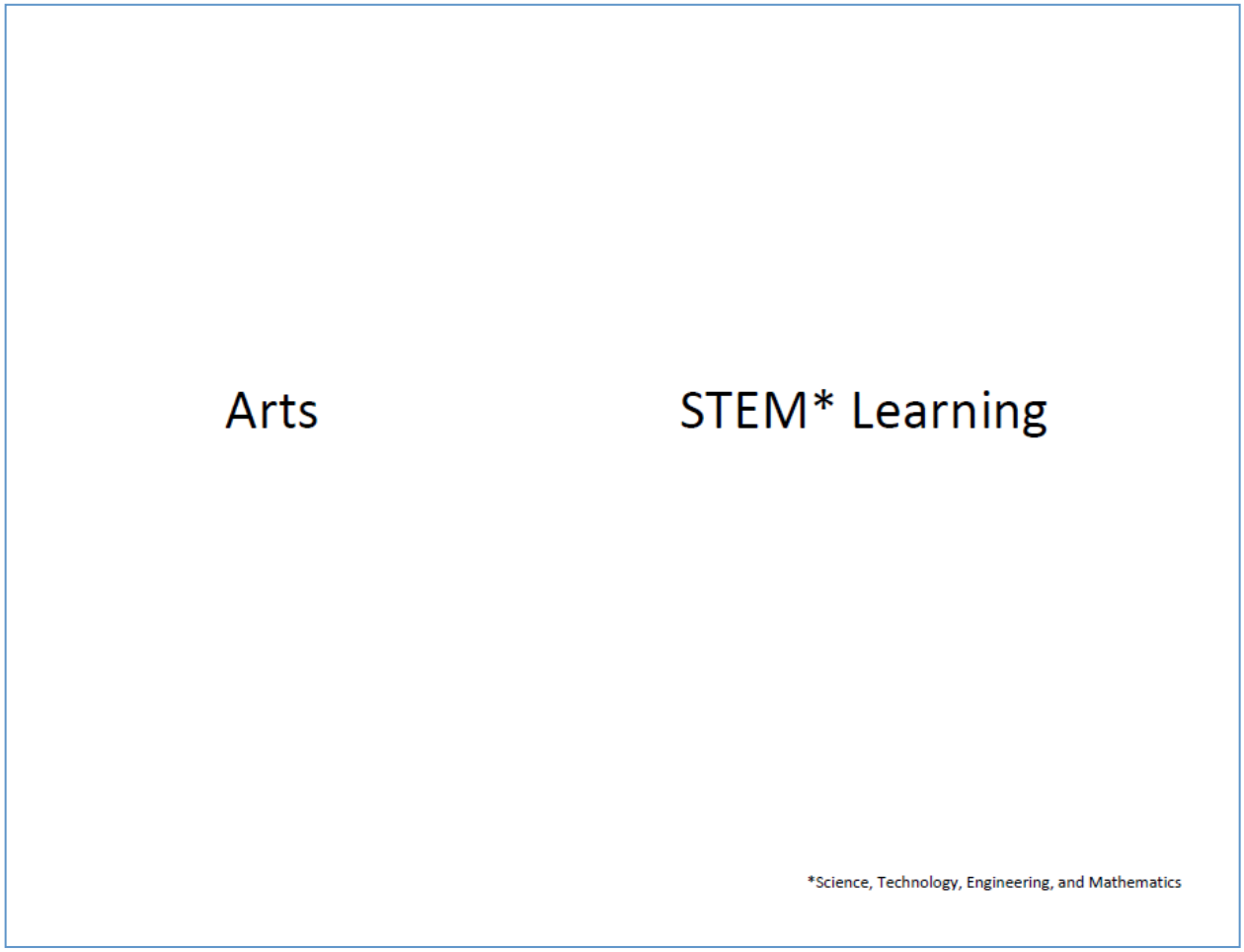
What do you hope to take away from your conference experience?

How did you hear about the Art of Science Learning conference in [San Diego]?

Job Title
Company
Website

Appendix B: Pre-Post Personal Meaning Map

FRONT:



BACK:

1) Concept: _____

2) In 2-3 sentences, tell us the MOST important thing we need to know about how this concept relates to Arts and STEM Learning.

---

3) Concept: _____

4) In 2-3 sentences, tell us the MOST important thing we need to know about how this concept relates to Arts and STEM Learning.

Appendix C: Post-Conference Online Questionnaire

Art of Science Learning post-conference - San Diego

Please give us feedback on your Art of Science Learning conference experience. This questionnaire will take approximately 10 minutes to complete, and your comments will help conference planners know what the conference meant to individual participants.

Tell us what the conference meant to you.

What was the highlight of the conference for you, and why?

What is one thing you would have liked to change about the conference, and why?

Rate the degree to which you agree with the statement below.

	Strongly Disagree (1)	Disagree (2)	Somewhat Disagree (3)	Neither Agree nor Disagree (4)	Somewhat Agree (5)	Agree (6)	Strongly Agree (7)
The conference addressed my specific questions and issues. (1)	❍	❍	❍	❍	❍	❍	❍

Please explain your rating for how well the conference addressed your specific questions and issues.

Rate your agreement with the following statements.

As a result of participating in the conference...

	Strongly Disagree (1)	Disagree (2)	Somewhat Disagree (3)	Neither Agree nor Disagree (4)	Somewhat Agree (5)	Agree (6)	Strongly Agree (7)
…I have new ways of thinking about art/science learning (1)	❍	❍	❍	❍	❍	❍	❍
…I have a greater appreciation for why art/science learning is valuable (2)	❍	❍	❍	❍	❍	❍	❍
…I can articulate the benefits of integrating art/science learning (3)	❍	❍	❍	❍	❍	❍	❍
…I have ideas for how art/science can be integrated (4)	❍	❍	❍	❍	❍	❍	❍
…I better understand the challenges associated with integrating art/science (5)	❍	❍	❍	❍	❍	❍	❍
…I engaged in art/science learning conversations with people from disciplines other than my own (6)	❍	❍	❍	❍	❍	❍	❍
…I feel like I'm part of an ongoing community around art/science learning (7)	❍	❍	❍	❍	❍	❍	❍

If you do one thing in the next 6 months based on this conference, what will it be? Please be as specific as possible.

Now step back a little, and give us some feedback on the overall conference.

How would you describe the goals of the Art of Science Learning conference?

In your opinion, how well were those goals achieved?

How did the key components of the conference contribute to achieving its goals?

To answer this question, you have 15 points to distribute across the 5 conference components listed below. Use these points to indicate the relative importance of each component in meeting the conference goals; if you feel that none of the components made a contribution, then put all of your points in the category labeled "none."

_____ Individual speakers/presenters (1)
_____ Metaphorming workshop (2)
_____ Idea harvesting group sessions (3)
_____ Working group sessions (4)
_____ Informal conversations with participants (5)
_____ None (6)

Which working group did you participate in? (Check all that apply.)

- ❑ Research (1)
- ❑ Practice (2)
- ❑ Workforce (3)
- ❑ None (4)

What do you believe will be the outcome(s) of the working group in which you participated? [Only asked in San Diego]

What is your understanding of next steps that will be taken by conference organizers and participants? [Only asked in San Diego]

Tell us about the nature of your conference experience.

How did you hear about the conference?

- ❍ a friend or colleague (1)
- ❍ a listserv: (2) _____
- ❍ a website or blog: (3) _____
- ❍ other: (4) _____

Which of the following sessions did you attend? [Customized for each conference]

	Did you attend?	
	Yes (1)	No (2)
Larry Rosenstock presentation (1)	❑	❑
Harvey White with John Eger presentation (2)	❑	❑
Robert Root-Bernstein and Randy Cohen presentation (3)	❑	❑
Metaphorming workshop (4)	❑	❑
Idea Harvesting groups (5)	❑	❑
Afternoon plenary (Idea Harvesting reports back and observations) (6)	❑	❑
Ramesh Rao presentation (7)	❑	❑
Working groups (8)	❑	❑
Maurizio Seracini presentation (9)	❑	❑
Carrie Fitzsimmons presentation (10)	❑	❑
Closing plenary (Working Groups reports back) (11)	❑	❑

Did you facilitate any of the conference sessions and/or are you an advisor to the project?

- ❍ Yes (1)
- ❍ No (2)

What was your experience of the Metaphorming workshop?

The following are noted attributes of the Metaphorming process. Please check whether you experienced the following attributes.

	Yes (1)	No (2)
Boosts Creativity: Do you think you were being creative, while making and mining the meanings of your 5-D Symbolic Model? (1)	❍	❍
Stimulates Curiosity and Critical Thinking: Did you raise new questions or critically examine new ideas and their possibilities, through your Symbolic Model? (2)	❍	❍
Breaks Mental Barriers and Self-Imposed Limitations: Did the process of making and exploring your Model help you and others understand your views? (3)	❍	❍
Challenges Yourself: Do you feel you challenged yourself and learned new things? (4)	❍	❍
Builds Teamwork: Did you enjoy working with others and collaborating? (5)	❍	❍
Inspirational: Do you feel more inspired and motivated to achieve a Goal? (6)	❍	❍
Fosters Better Communication: Were you able to express yourself better and communicate your feelings and thoughts, using your Model as a visual aid? (7)	❍	❍
Helps Solve Problems: Were you able to pose or solve a problem, or develop an opportunity, by making your Model? Did you come up with some fresh, practical solutions? (8)	❍	❍

What did you find most valuable about the Metaphorming workshop?

How could the workshop be improved?

Finally, tell us about yourself.

Which of the following best describes your profession?

- ❍ science educator (formal or informal) (1)
- ❍ arts educator (formal or informal) (1)
- ❍ education administrator (9)
- ❍ artist (visual or performing arts) (2)
- ❍ scientist, engineer, or mathematician (2)
- ❍ corporate leader (3)
- ❍ policymaker (3)
- ❍ researcher (3)
- ❍ other (8) _____