ARTLAB+ Q?rius

CENTER FOR RESEARCH AND EVALUATION
Lifelong Learning Group

# Teen Art-Science Workshop Series

## *Outcome Evaluation*

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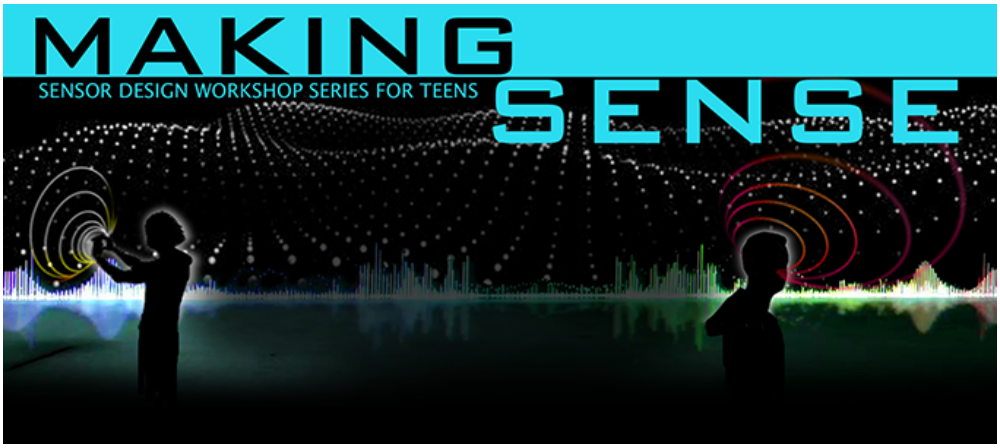
**Prepared by:**
Deborah Wasserman, Ph.D.
Rebecca Nall, B.S., B.A.

**Prepared for:**
The National Museum of Natural History at the Smithsonian Institution

LifelongLearningGroup.org
COSI | 333 West Broad Street | Columbus, Ohio 43215

# Executive Summary




In collaboration with the Hirshhorn Museum and Sculpture Garden's ARTLAB+, the National Museum of Natural History provides workshop opportunities for local youth to find new ways of exploring their world by integrating art and science design thinking skills with innovative technology. Targeting both arts-oriented and science-oriented youth, the program's intended long-term youth-directed outcomes involve integration of both artistic and scientific thinking into careers, career choice, and 20th century skills. This report presents findings from the program evaluation conducted with pre-program and post-program questionnaires completed by 26 of the 29 workshop participants. A followed-up "member check" discussion group, comprised of five volunteer participants, provided rich data into topics about which staff sought additional participant insight. Analyses were conducted for self-identified arts-oriented (n=10), dually oriented (n=8) and science-oriented (n=8) participants.

## Overall Findings

### Q1. Effect on science interest and careers

- All participants increased their interest in science but there was little evidence of effect on career.
- Both arts-oriented and science-oriented participants increased their interest in pursuing science academically.
- Arts-oriented participants both recognized the advantage of science to their artistic pursuits and were more ready to study science academically.

All participants increased their interest in science—significantly so among arts-oriented and science-oriented students. Dually-oriented students changed only moderately but entered and exited the program with highest interest in science.

After the program almost half of the arts-oriented students expressed greater interest in studying science-related topics. Discussion group explanations included experiencing a new sense of attractiveness of science career options; new awareness of creativity involved with science; and a non-threatening environment.

Most of the arts-oriented participants recognized the involvement of either science or technology in their artistic career interests (e.g. photography, animation, music recording).

- Less movement toward studying the arts may have been due to the general challenge of communicating the "how to" of creativity and the workshops' general orientation toward science.

- Although the workshops had little effect on career intentions they had a small effect on science oriented students' belief that their careers would **i**nvolve creative thinking.

## Q2. Effect on 21st Century Skills: Critical Thinking, Problem Solving, and Self-Assessment

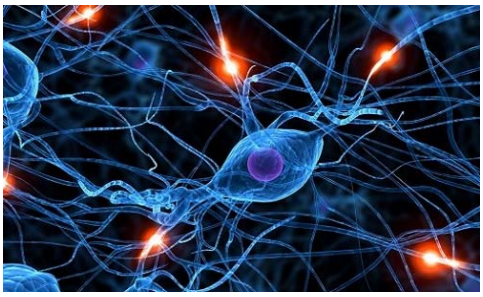
- Immediately after the workshop experience, participants rated workshop influence on their decision making (about school, career, and life) almost at the top, just below hobbies, parents, visual arts, and being outside.

- Participants appeared to have gained a sense of decision-making competence from the combination of this safe environment for learning science and affirmation of their interest in visual arts.

- For more than half of the participants, the art-science workshops functioned as an entrée to Smithsonian Institution experiences.

- These workshops contributed to a broad range of dimensions of critical thinking (analysis, application, synthesis, and evaluation) and contributed most to the area of synthesis, i.e., playing with, arranging, and applying ideas.

### Q3. Connections between the Arts and Science



- These workshops communicated both interdisciplinary (side by side but independent) and substantive (interconnected) integration. Most all participants entered the workshops demonstrating an appreciation for the former; approximately 25% demonstrated an appreciation for both.

- Curiously, after the workshop, arts-oriented and even more so, science-oriented participants saw less opportunity for creative thinking in the scientific process.

- Overall these workshops only minimally affected participants' beliefs about the utility of art or creative thinking for scientists.

- In general, where there were changes in appreciation, interdisciplinary integration helped arts-oriented students become more interested in studying science and science students more appreciative of the arts; substantive integration helped dually oriented participants better understand the role of creativity in the scientific process.

- Some participants altered their ideas about the polarized nature of artists vs. scientists –either in how they used words to define each or the degree to which they incorporated creativity into their definition of science.

### Q4. Workshop effectiveness as recruitment tool for YES! and Q?Crew

The art-science workshops functioned as an effective invitation to the more intensive NMNH youth programs.

## Conclusions and Recommendations

This evaluation of the NMNH 2106 Art Science Workshops produced evidence of both successful outcomes and an important challenge.

### The successes:

**Science for arts-oriented teens**: *"To be an artist, I need science."* By creating a space where arts-oriented students find respect and support for their interests along with a non-threatening environment for asking questions and learning at their own pace, these teens increase their interest and confidence in pursuing science academically.

**Gateway to more intensive NMNH Youth Programs.** Over half of the arts-science workshop participants had not participated in other Smithsonian Programs; moreover equally as many reported that their art-science workshop experience made them more interested in participating in NMNH's volunteer and internship programs.

**21st Century Skills.** The workshops provide participants with a broad range of practice with 21st century skills including analysis, application, synthesis and self-reflection. They particularly contribute to enhancement of the synthesis skills of playing with, arranging, and applying ideas.

## The Challenge

The results also revealed two important challenges with integrating arts and science. First, there was evidence that participants may be experiencing the integration as more interdisciplinary than substantive. As a result, arts –oriented students find a safe and accepting environment for studying science (as mentioned above) but the program has less impact on science-oriented students' understanding of, appreciation for, or experience with incorporating creative thinking into the various steps of the scientific process.

> ***Recommendation: Consider building into the curriculum explicit identification of when and how creative thinking is being applied to various steps of the scientific process.***

Another challenge related to interdisciplinary vs. substantive integration emerges from the finding that, in contrast to dually-oriented participants who significantly increased their recognition of creative thinking in at least two steps of the scientific process, science-oriented participants decreased theirs. One of the discussant's perception that encouraging participants to follow their interests may reinforce existing schemas.

> ***Recommendation: Consider ways to help participants understand their initial orientation schemas and how stretching toward integration might be useful for meeting their goals.***

All in all, considering the successes and challenges of these Art-Science workshops, NMNH and ARTLAB+ can be applauded for providing important science-learning opportunities especially for arts-oriented teens; utilizing the experience to working to integrate science and the arts to help teens enhance 21st century skills, and providing an accessible gateway into more deeply engaging volunteer and internship opportunities. In addition, however, NMNH and ARTLAB+ are forging into important new territory, exploring and discovering the important elements of moving beyond interdisciplinary programming into substantive integration.

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# Introduction

In collaboration with the Hirshhorn Museum and Sculpture Garden's ARTLAB+, the National Museum of Natural History provides workshop opportunities for local youth to find new ways of exploring their world by integrating art and science design thinking skills with innovative technology. Targeting both arts-oriented and science-oriented youth, the program's intended long-term youth-directed outcomes involve integration of both artistic and scientific thinking into careers, career choice, and 20th century skills. As outlined in the program's logic model, one of these outcomes was to increase in the number of teens utilizing art and design thinking and skills in science and science-related careers, and scientific thinking and skills in art and design careers. To achieve this outcome, workshops offered teens programming that combines art, science, and technology with activities such as learning directly from experts in science, using cutting edge technology, and exploring art and design. In addition to outcomes for youth, the program also sought to meet institutional goals involving understanding how to coordinate Smithsonian Institute resources and staff expertise for youth audiences. Program administrators were seeking formative evaluation to help staff more effectively attract teens to the program and to meet program goals in the coming year.

## Focus

This evaluation, a portion of a larger project to evaluate all NMNH youth programs, had a dual focus on understanding (1) art-science programming affects participants' science learning and (2) how the art-science workshop influenced participants' understanding and attitudes toward both science and art.

It is important to note here that, for this study, evaluators brought an understanding of this integration as first of all, valuable and secondly, as occurring at varying levels of sophistication. Integration would occur on a conceptual scale that would range from "siloed" to fully integrated. The evaluators supported these assumptions and further understood them with research literature that helped provide language and theory for understanding both value (Eger, 2011; Root-Bernstein & Root-Bernstein, 2001) and integration (Simon, 1996; Snow, 1961; Zeki, 2001) These sources revealed that integration can range from simple to complex (Radziwell, Benton, & Moellers, 2015; Wilson, 2002): the simplest relationship involves understanding the arts and sciences as complementary, working well alongside each other. Examples include scientist's use of science illustration and graphic design to communicate their findings or artists understanding the science behind their art materials. More complex integration occurs as the silos begin to disappear, say when the scientist uses design skills and even the creative process to "intuit" hypotheses or research design. Ultimately the arts and sciences may be integrated at a neurological level as described by Samir Zeki, the neurologist who identified the three visual centers of the brain and has shown that in many ways, artists function as neurologists (Zeki, 2001). These findings support Simon's (1996) contention that "the aesthetics of natural science and mathematics is at one with the aesthetics of music and painting both inhere in the discovery of a partially concealed pattern." Moreover, the Root-Bernsteins (2001) demonstrated 13 "thinking tools" commonly used by both artists and scientists.

## Evaluation Questions

1. How have the art-science workshops promoted and affected interest in science and science careers?

2. How have the workshops affected critical thinking skills and decision making?

3. In what ways did the workshops affect participants' perceptions of the connections between art and science?

4. In what ways did the workshops affect participants' interest in other longer-term NMNH youth programs?

# Methods

The evaluation took place from June to August 2016. Participants from each of the three week-long 2016 Art-Science workshops responded to pre-program online questionnaires when they arrived on Monday and completed post-program questionnaires on their final programming day at the end of the week. (See Appendix A)

*Table 1. Questionnaire sections for dividing participants into orientation groups and answering evaluation questions*

| | Pre and Post | | | | | | Post Only | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Art-science orientation | Description of artists and scientists | Utility: Aft for scientists; science for artists | Art and the scientific process | Descriptive words | Define Science | Academic interests and Career | Skills | Influence | Science Interest | Interest in NMNH programs? | Additional Thoughts? |
| **Orientation** | ✓ | | | | | | | | | | | |
| **1. How have the art-science workshops promoted and affected interest in science and science careers?** | | | | | | | ✓ | | | ✓ | ✓ | |
| **2. How have the workshops affected critical thinking skills and decision making?** | | | | | | | | ✓ | ✓ | | | |
| **3. In what ways did the workshops affect participants' perceptions of the connections between art and science?** | | ✓ | ✓ | ✓ | | ✓ | | | | | | |
| **4. In what ways did the workshops affect participants' interest in other longer-term NMNH youth programs?** | | | | | | ✓ | | | | | | |

The pre and post survey questionnaires (Appendix A) were comprised of six sections with five additional sections in the post Program questionnaire. Each is listed as a column heading in Table 1 and marked with an "✓" to identify the evaluation question(s) it addressed. More detailed description of the relevant questionnaire items introduce each of the results subsections.

**Member check.** After questionnaire response analysis, program staff reviewed results and identified findings for which they wanted richer detail from program participants. Together with staff, the evaluator constructed questions to probe these identified areas of interest (See Appendix C). Member check responses are reported with the questionnaire analyses they addressed.

# The Sample

## Description of the Workshop Respondents

Altogether, 29 teens participated in the Art-Science workshops. Matched pre-post data were available from approximately 26—depending on the items they chose to skip. Of the respondents with matched pre and post test data, ten were arts-oriented, eight were science-oriented, and eight were equally interested in both disciplines.

Workshop respondents were divided into orientation group based on their response to the statement, "In general, my interests lean . . ." with response choices -2= TOTALLY toward the ARTS, not science; -1= MORE toward the ARTS; 0=EQUALLY toward both; 1= MORE toward SCIENCE than the arts; and 2= TOTALLY toward SCIENCE, not the arts. Across all 26 respondents no one rated themselves in the TOTALLY categories. Ten respondents rated themselves as oriented more toward the arts; eight as dually oriented; and eight as more oriented toward science.

## Member Check Discussion Group Members.

To gather a convenience sample of five workshop participants, staff sent an email message to the entire pool of all workshop participants and selected the first seven who responded. The invitation included an offer of a $30 gift card incentive for those who would participate. Of that group five attended the session and received the gift card.

Of those who participated in the discussion, four had attended the workshop at least twice. All described themselves as either arts-oriented or dually oriented. In the group, all participants described themselves as oriented more toward science.

# Results

## Q1. Effect on Interest in Science and Science-Oriented Careers

### What We Learned

- There was strong evidence that after the workshop, arts-oriented participants both recognized the advantage of science to their artistic pursuits and were more ready to study science academically
- All participants increased their interest in science—significantly so among arts-oriented and science-oriented students. Dually-oriented students changed only moderately but entered and exited the program with highest interest in science.
- After the program almost half of the arts-oriented students expressed greater interest in studying science-related topics. Discussion group explanations included experiencing a new sense of attractiveness of science career options; new awareness of creativity involved with science; and a non-threatening environment.
- Most of the arts-oriented participants recognized the involvement of either science or technology in their artistic career interests (e.g. photography, animation, music recording).
- Less movement toward studying the arts may have been due to the general challenge of communicating the "how to" of creativity and the workshops' general orientation toward science.
- The workshops had little effect on career intentions.

### How We Know

Two areas of inquiry addressed this evaluation question. First participants responded on a Likert scale to a series of items about their interest in science. Second, they answered open ended questions about their academic and career interests.

#### *Interest in Science*

To assess participants' perceived change in general interest in science, participants responded to seven statements such as "I find understanding science and technology to be important" and "I plan on taking more science or technology classes in school/university." Each of these statements were repeated twice, first in in the past tense using the phrase, "before participating in this workshop, I. . . " and then in the present tense with the phrase, "Now I. . . ". Participants rated (on a seven-point

Likert scale, 1 = “strongly disagree” to 7=”strongly agree”) how much they agreed or disagreed with each statement. In total, 26 participants completed the section. Using paired t-tests, for each orientation group, differences between the average pre and post answers were compared to 0 (no change).

Results (illustrated in Figure 1) revealed that dually-oriented and participants entered the program with highest interest in science ($F$=4.912, $df$=2, $p$=.017). Over the course of the program, all participants increased their interest. Arts-oriented participants demonstrating the greatest gain. More specifically, both arts-oriented and science-oriented teens showed significantly increased ($p$<.01) interest in science after the program. Dually-oriented teens’ increased interest was only moderately significant ($p$<.10), but they entered the program with higher interest as well. . The arts-oriented participants demonstrated the largest post-program increase science interest--evidence that the program was effective in engaging teens that were originally not oriented towards science to become more interested in science

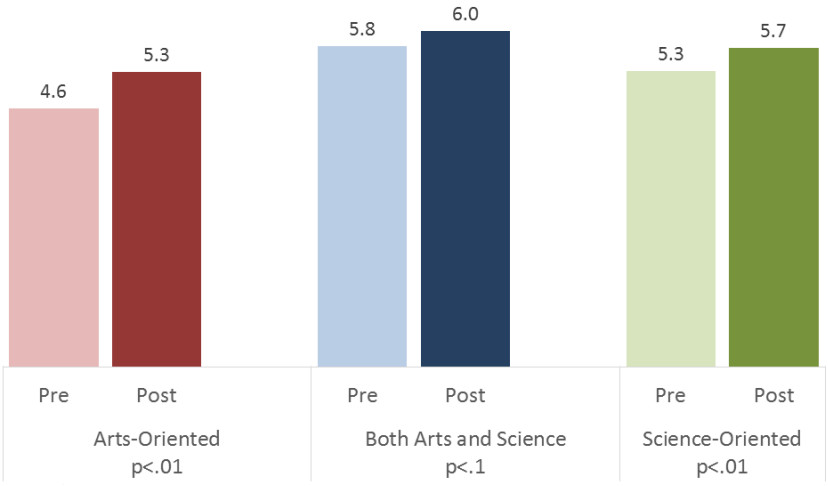


*Figure 1. Arts oriented and Science oriented participants significantly increased their interest in science; dually-oriented participants arrived at the workshop with greatest interest.*

### *Academic and Career Interests*

Both before the program and after, participants responded to open-ended questions asking about topics they were interested in pursuing in school or college and their career interest. After the workshop they responded to these same questions. In relation to the academic subjects they listed, they additionally answered (on a scale of 1 to 5: ranging from “not at all” to “a great deal”), how much they expected these topics to involve their science interest. For their career choice they answered, on the same scale, two additional questions: *How much do you expect this career will involve learning more science*? And *How much do you expect this career will involve thinking like an artist*?

**Program Effect on Academic Plans**

Overall, responses from one third (35%) of the respondents differed after the program. As shown in the pie charts arts-oriented students changed most and of the five who changed, four expressed greater interest in studying science. Of the science oriented students who moved to "undecided," before the workshop one had imagined academically pursuing "*the arts*" and the other, "*business.*" The other moved from "business" to "visual arts and business."

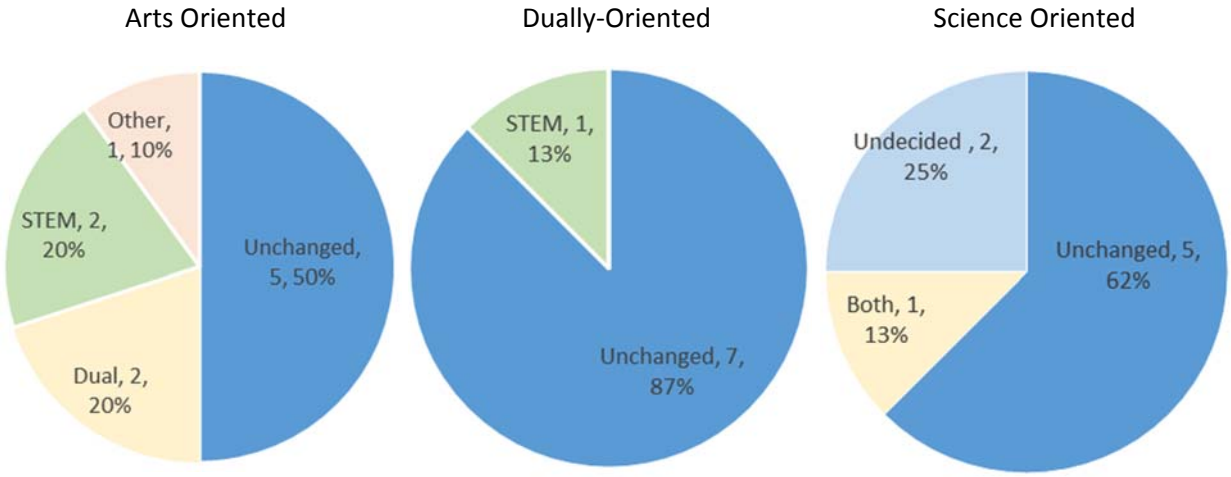


*Figure 2. Effect on Academic Plans*

Discussion group recipients provided more insight into these results in response to the question, "*What about the workshop may have influenced teens' academic plans?"* Feedback addressed both the science-encouraging effects on art-oriented students and the lack of arts/creative thinking effect on science students.

**Discussion group members' comments revealed three themes of ways the workshop may have influenced changes toward science among arts-oriented students: new sense of attractiveness of science career options; new awareness of creativity involved with science; and a non-threatening environment.**

More specifically, in reference to **awareness and attractiveness of science career options**, one discussion participant said, "*For Arts-oriented teens, [the workshop] improved awareness of science career options. It made them seem more interesting and more applicable to real life."*

In reference to **creativity involved with science**, participants said, "*[The workshop helped me see that] science is more than numbers, that science can be creative;" "There were opportunities to be creative (for example, Scratch—you had the ability to make it your own;*" and "*the topics and structure were good for bringing organization to my creative ideas.*"

A number of comments reflected arts-oriented students' sense of relief in finding a **non-threatening environment** where they could pursue their interest in science: These included: "*The structure of the workshop was more 'open' [than typical science classes];*" The teaching style was "*relaxed, not stressful*;" "*It helped me feel comfortable*;" and "*It was about exploration."*

Participants who commented on **why more students moved toward science than toward art** noted both the workshop's subject orientation as being more directed toward science ,("*We saw less of ARTLAB+ than of Q?rius in the program, so it's possible that there was less opportunity for movement toward the arts side*" and the general challenge of instilling appreciation for creativity and the arts (*It's hard to push creativity and the specific skills associated with [arts] than learning information about a teachable topic [in science]*."

Figure 3 illustrates pre to post program changes in how much participants expected their academic studies to include science. Visual inspection shows change for both arts-oriented and science-oriented students- although especially among the small group of seven science-oriented participants, there was not enough statistical power to demonstrate significant difference. Among the arts-oriented students the probability of a difference was moderate greater than 90% chance the two time periods really differed.

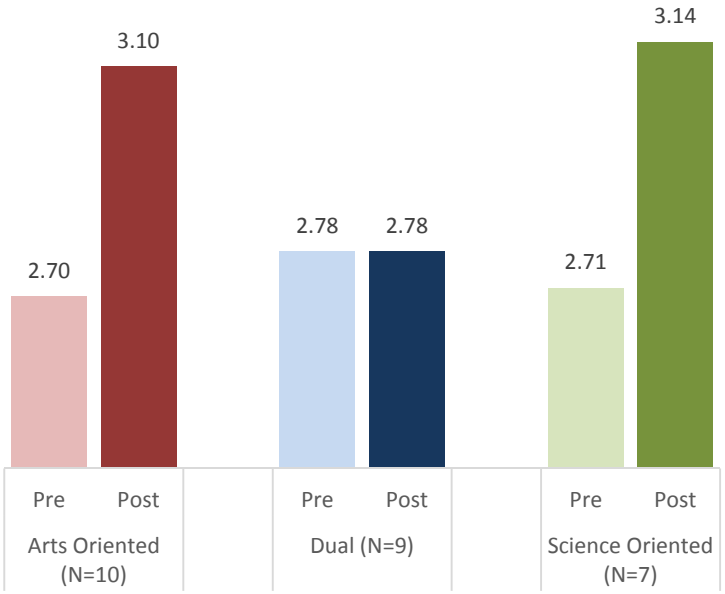


*Figure 3. Arts-oriented and Science-oriented participants increased their academic interest in science*

**Program Effect on Career Plans**

Not surprisingly after a short one-week program, ideas for careers stayed fairly stable. Overall, after the program, approximately 25% (7 of 26) of participants changed how they described their career choice but only three of these respondents expressed interest in careers more related to science. Among Arts-oriented participants, two changed their career paths to be STEM focused (from undecided to "photographer or naturalist;" and from "art" to "dental work." One science-oriented student switched from "entrepreneur" before the program to "scientist of human behavior" after.

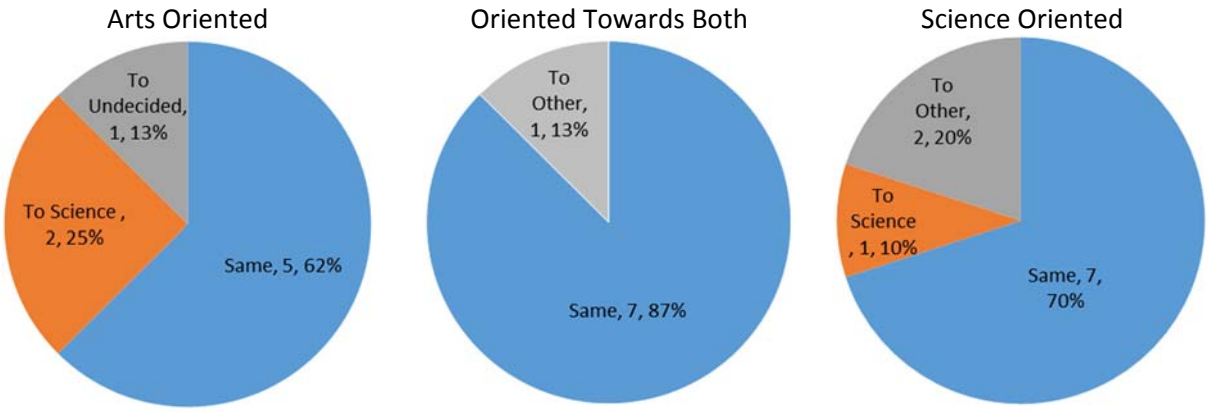


*Figure 4. Program Effect on Career Plans*

**Involvement of Art or Science in a Career Plan**

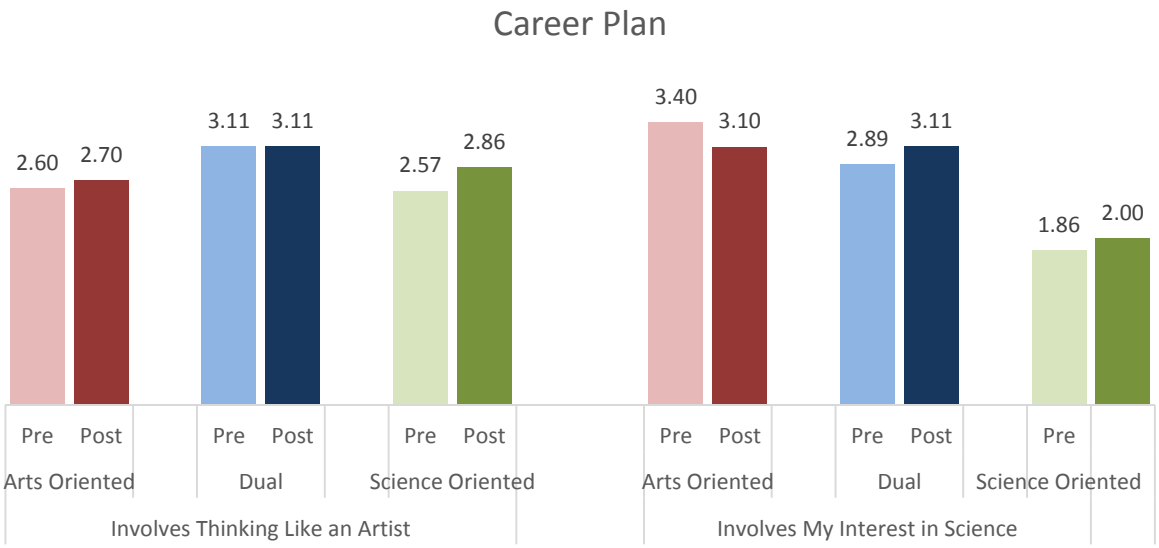


*Figure 5. Average estimate of how much career plans involve thinking like an artist and respondents' interest in science.*

Figure 5 illustrates the average estimate of how much participants believed their career plans would involve thinking like an artist and their interest in science. **The art-science workshop had a small effect (p=.08) on science oriented students' belief that their careers would involve creative thinking.** on and respondents' interest in science Difference between science-oriented students' art vs. science involvement in their career had mostly to do with the fact that the science-oriented students generally listed either not knowing or business (two of these changed to specifying a science career). Of the Arts-oriented students, most imagined themselves in careers

that would require some amount of science or technology (e.g. photographer, animator, recording artist, or psychologist).

## Q2. Effect on 21st Century Skills: Decision Making, Critical Thinking, Problem Solving, and Self-Assessment

### What We Learned

- Immediately after the workshop experience, participants rated workshop influence on decision making (about school, career and life) almost at the top, just below hobbies, parents, visual arts, and being outside.
- Participants appeared to have gained a sense of decision-making competence from this safe environment for learning science combined with affirmation of their interest in visual arts.
- For more than half of the participants, the art-science workshops functioned as an entrée to Smithsonian Institution experiences.
- These workshops contributed to a broad range of dimensions of critical thinking (analysis, application, synthesis, and evaluation) and contributed most to the area of synthesis, i.e., playing with, arranging, and applying ideas.

### How We Know

Two ways of understanding workshop effect on decision making skills contributed to answering this question. The first was to assess the relative influence of the workshop on participants' decisions. The second was to look for changes in how participants understood the value of creative thinking for each aspect of the scientific process.

#### *Influence on Decision Making*

To assess how participants experienced the workshops in relation to "positive influence" on "interests and decisions," teens responded to an array of influences by rating them (on a seven-point scale: 1= "not at all" to 4="somewhat" to 7=a lot) according to how much "each condition positively contributes to where you want to go in the future in terms of school, career, and life." Figure 6 lists each item in order of average influence. Because one-way analysis of variance showed no significant differences between art-science interest groups, the table shows averages across all participants.

Immediately after the workshop experience, participants rated workshop influence almost at the top, just below hobbies, parents, visual arts, and being outside. Among these respondents, all of whom had enough interest in both art and science to attend an art-science workshop, the high influence rating of visual arts along with the relatively equal influence of the workshop may reflect a sense of decision-making competence they experienced from the combination of a safe environment for learning science along with affirmation of their interest in visual arts.

The influence of "other Smithsonian programs" was among the lowest primarily because for most participants, the art-science workshop was their entrée into the Smithsonian experience. Less than half (10) of the 26 participants had experienced any other Smithsonian programs. Of that group, the average influence rating was a 4.0, comparable with the rating of the art-science workshop. **However, for many participants, the art-science workshop functioned as an entrée to the Smithsonian experience.**

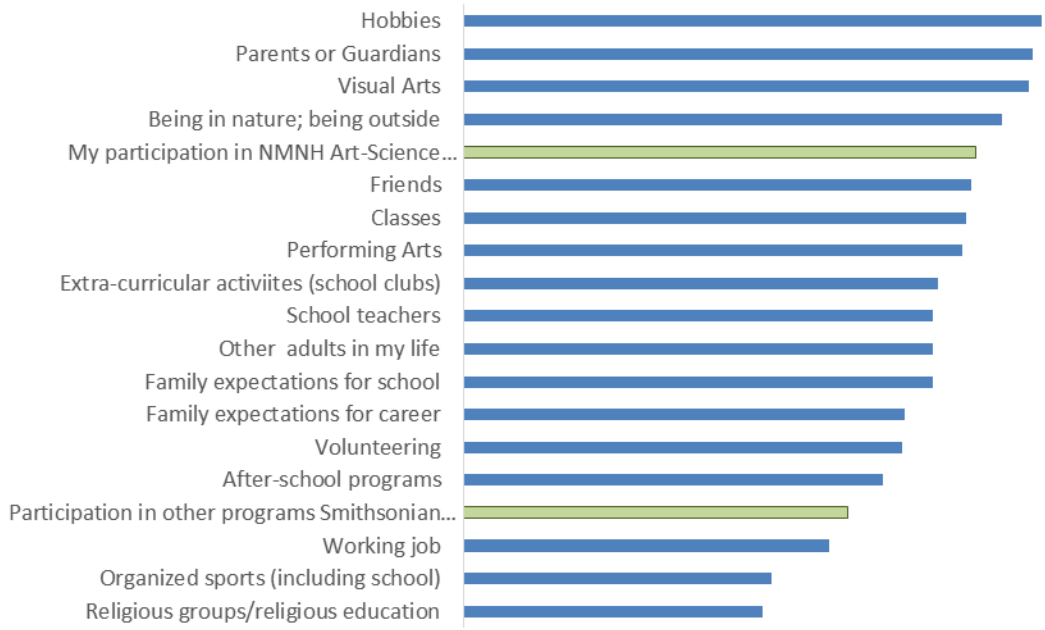


*Figure 6.Relative influence of NMNH Art-Science workshops and other Smithsonian programs on making important decisions.*

Qualitative response to the question, "For what reasons did you rate the influence of your participation in art-science workshops as a [rating value]?" revealed various pathways to influence. Of the 8 participants who rated the workshop influence as "a lot" (the highest rating) themes for the reasons included creativity (*making ideas into reality*), the necessity of science for artists (*to be a good artist, I need science*); general enthusiasm for the program *(cool; informative; fun*), personal direction and the insight that art and science can coexist (*I've always liked both art and science but never really incorporated both of them into one project).* Those who rated the influence as moderate primarily referenced personal direction—i.e., that it opened up potentially interesting career paths, e.g. "*I might look into that*". The full list of comments identified by interest group and influence rating can be found in Appendix B.

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### *Effect on Critical Thinking, Problem Solving, and Self-Assessment Skills*

To measure critical thinking and problem solving, we adapted the Self-Assessment of Critical Thinking scale (Lander, 2016) which is based on 21st century learning outcomes interpreted through Bloom's taxonomy. The adapted scale consisted of fifteen items covering the following skill areas: knowledge; comprehension; application; analysis (finding important points, organizing ideas, comparing and contrasting); synthesis (organizing ideas, using creativity, problem solving); and evaluation (evaluation for a purpose and self-evaluation). Our adaptation additionally included two items (ability to reflect on strengths and weaknesses; confidence to try new things) from the Positive Youth Development Inventory (Koke, Heimlich, Kessler, Ong, & Ancelet, 2007). Participants expressed their perception of program effect on each of the skills listed above by responding to statements that completed the sentence, "Participating in the Making Sense Workshop has . . . ". Each rated item is listed in Figure 7 below.

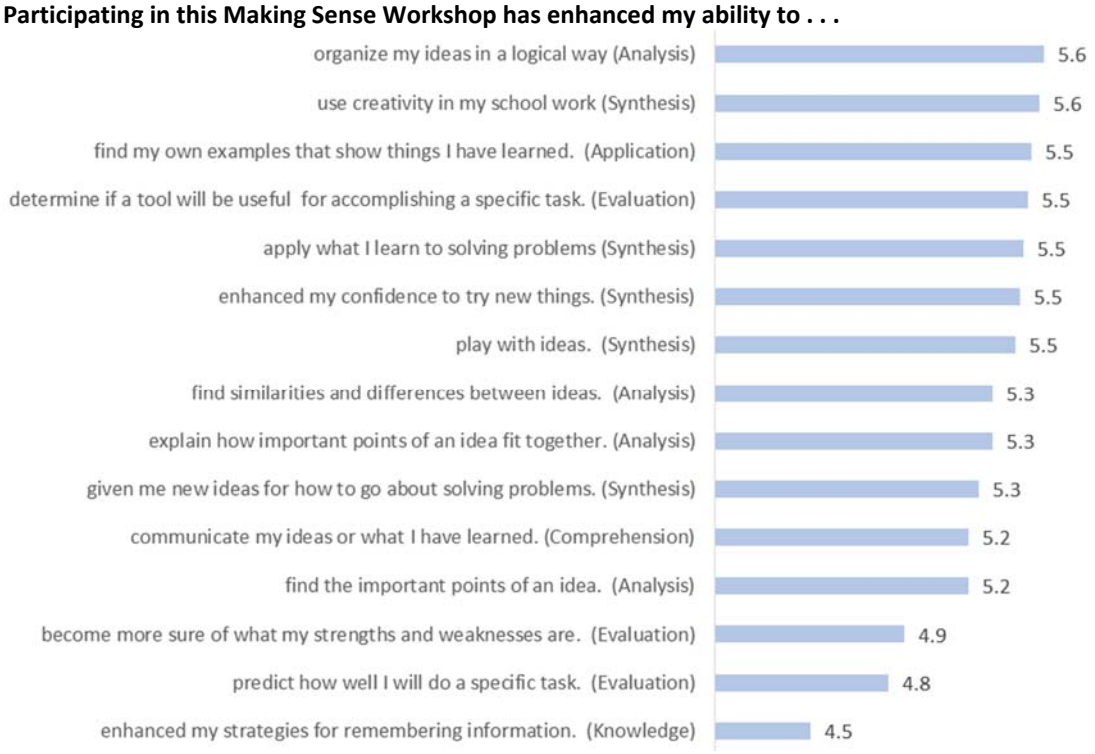



*Figure 7. Average responses representing participant agreement with statements about program effect on critical thinking and problem solving skills.*

Participant responses covered a full range (1 to 7) for each of the scale items. Across each item; standard deviations ranged from 1.2 to 1.6. Averages for each item were all above 4.0, the midpoint (neither agree nor disagree) and ranged between somewhat agree and agree. Responses produced two important observations. First, items rated as most highly contributing to these skills spanned four of the six skill areas involved in this taxonomy. Second, most all but one of the synthesis items were contained in this group (rated at 5.5 or above). **Thus it appears that theses workshops contributed to a broad range of dimensions of critical thinking and problem solving and contributed most to the area of synthesis (i.e., playing with, arranging, and applying ideas).**

## Q3. Workshop Effect on Perceptions of Connections between the Arts and Science

We used this evaluation question to address two needs identified in last year's art-science workshop evaluation. First, because we found that arts-oriented teens are interested in and seeking safe places to learn science, we were interested in how the workshops affected arts-oriented teens' attitudes toward science and integration of science into their arts interests. We also found that science oriented students showed relatively little understanding of how creative thinking interfaces with their interest in science. Thus, in this study we looked for signs of science-oriented students' recognition of scientists as creative thinkers and how creativity affects all aspects of the scientific process.

Four explorations helped us observe participants for these arts and science-based processes. First, participants responded to questions about creative thinking in each of eleven steps in the scientific process. Second, we analyzed changes in how participants applied 41 descriptive words to artists and scientists. Next we compared participants' definitions of science both before and after the workshop to see if after the workshop there was more reference to creative thinking. Finally we compared responses for changes in their perceptions of the usefulness of art to scientists and science to artists.

## What We Learned

- These workshops communicated both interdisciplinary (side by side but independent) and substantive (interconnected) integration. Most all participants entered the workshops demonstrating an appreciation for the former; approximately 25% demonstrated an appreciation for both.
- Curiously, after the workshop, arts-oriented and even more so, science-oriented participants saw less opportunity for creative thinking in the scientific process.
- Overall these workshops only minimally affected participants' beliefs about the utility of art or creative thinking for scientists.
- In general, where there were changes in appreciation, interdisciplinary integration helped arts-oriented students become more interested in studying science and science students more appreciative of the arts; substantive integration helped dually oriented participants better understand the role of creativity in the scientific process.
- Some participants altered their ideas about the polarized nature of artists vs. scientists – either in how they used words to define each or the degree to which they incorporated creativity into their definition of science.

## How We Know

### *Use of Creative Thinking in the Scientific Process*

To assess the workshop's effect on participants' integration of creative thinking into scientific thinking, both before and after the workshop participants answered questions about "thinking like an artist" in each of 11 steps in the scientific process (Bourdeau & Arnold, 2009). Across all the participants, there were no average differences. However, within orientation groups, as illustrated in Figure 8, some significant changes occurred within specific items. Of note is that within the items that changed significantly, **arts-oriented and even more so, science-oriented participants saw less opportunity for creative thinking. Only dually oriented participants saw greater opportunity.** Item details are illustrated in Figure 9.

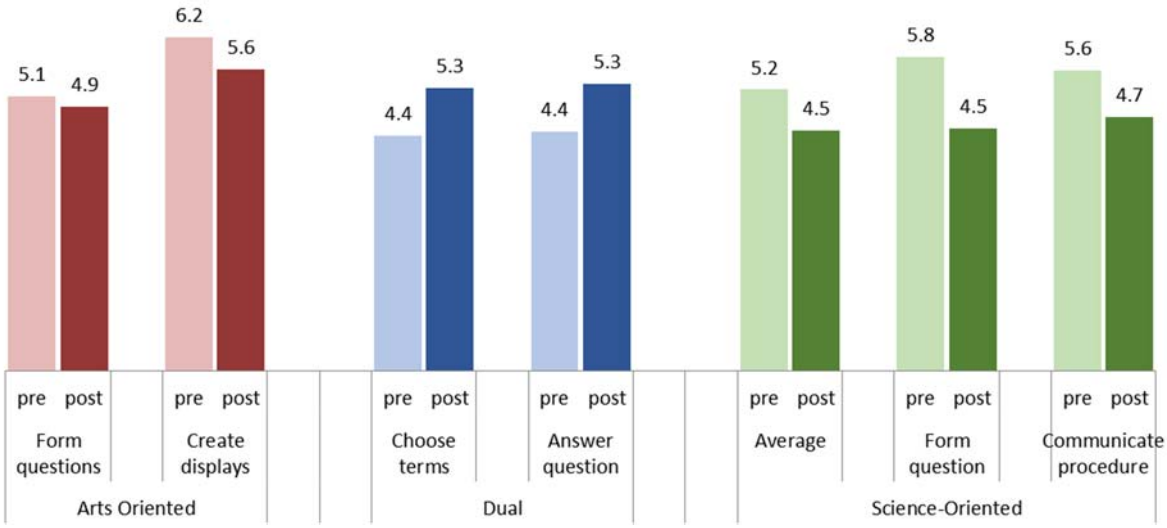
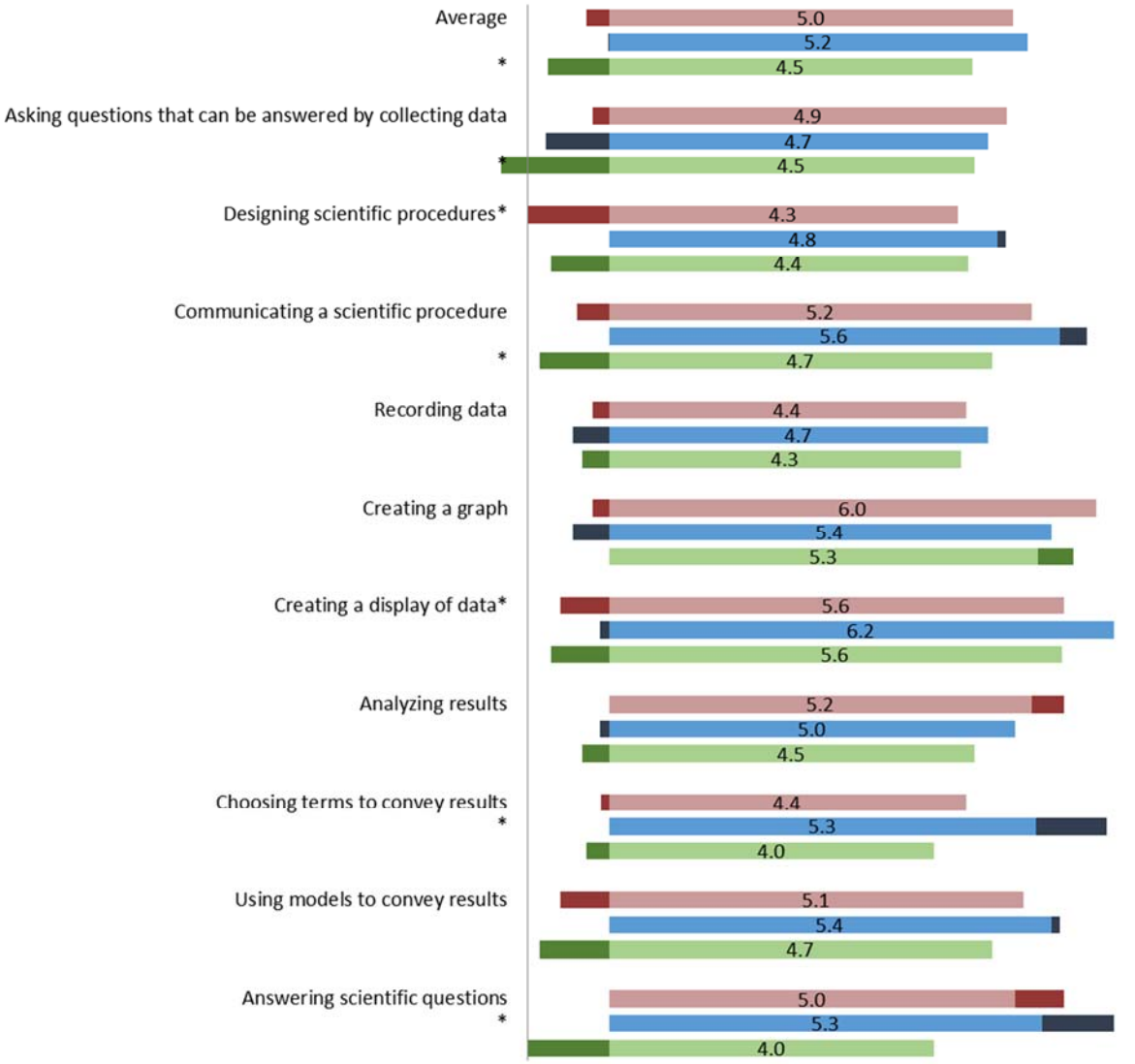



*Figure 8. Significant pre-post changes in participants' perception of the usefulness of "thinking like an artist" in 11 steps of the scientific process: appreciation for creative thinking in science increased only among dually oriented participants.*

To make sense of these findings, the five feedback discussion group members additionally reviewed Figure 9 below and responded to the following three questions:

> *When they saw the phrase, "thinking like an artist" what do you think teens thought it meant?*
>
> *What do you make of this finding both from your own experience and others'? What was it specifically in the workshop that may have changed arts-oriented and science-oriented teens' ideas of how much they could apply arts-like thinking? What makes that different than for dually-oriented teens?*
>
> *It appears that the workshop may have reinforced the notion that art and science are different. Specifically, what in the workshop made it seem this way?*




For each item, average responses from the arts oriented group are shown in red (top); dually oriented are blue (middle); and science-oriented are green (bottom). * Significant changes are marked with an asterisk.

*Figure 9. Detail of average responses for the utility of "thinking like an artist" in eleven steps of the scientific process.*

In contrast to the quantitative findings, these primarily arts-oriented participants all agreed that the workshop made them believe that creative thinking was more useful for scientific processes. They addressed the contrast between themselves and the data findings with explanations that explored the workshop content, the nature of art and science, as well as the data collection process.

Discussion group participants addressed the nature of the workshop content. One identified it as being more about science than art saying, "*It felt like "science with a dash of art. I would like more arts."* Another described the workshop staff's encouragement to *"use the tools to make whatever product the tools inspire"* as a "*flexibility*" that reinforced the arts-oriented, science-oriented, or integrated conceptual schemas with which the participants arrived. This person said:

*It's possible that this flexibility led science-oriented teens to explore science more deeply and arts-oriented teens to explore arts more deeply. I think that for people who are oriented toward both, it's easier to see connections across arts and science and to see pathways for solutions.*

Further discussion highlighted the nature of these independent and integrated schemas. For example, the following comments demonstrated how teens understand the arts and science as being independent:

*Maybe people just didn't think arts applied to science. Scientific method relates to cause and effect; arts processes are broader and more flexible. You have more range in how to solve a problem.*

*Arts people see things as squiggly lines and science people see things as straight lines.*

*Art is more hands-on and is about ideas generated by me (e.g., building something, putting pieces together). Science is more conceptual and is about my figuring out how to understand something (e.g., coding, how to solve a problem and manipulate the pieces).*

On the other hand, as shown in the following comments, they also provided examples of how teens understand the arts and science as integrated:

*Art and science are complementary, like right brain and left brain (e.g., thinking about shapes and putting them together).*

*But, science ALSO requires thinking outside the box, along with structure. You have understand connections, and the character of stuff, like in molecular science.*

Some of these group members also were more specific about how the workshop functioned to integrate the two. As can be heard in the quotes below, one described the workshop's exploratory structure as helping participants experience the creative thinking involved with science. Another described how the specific activity of exposure to animal communication led to discussion and thinking about the nature of creativity.

*The workshop genuinely blended arts and science. It was open exploration, as opposed to something with a defined process and endpoint. And having access to materials that I wouldn't have access to was really helpful in applying arts thinking.*

*I think the workshop tied together both arts and science—they're like long-lost twins. There were bird and wolf talks, and we learned about scent and how animals use it and then it turned into a discussion of creativity, too.*

These two comments illustrate the difference between what some integration theorists have identified as "substantive" and "interdisciplinary" integration (Marshall, 2005). The first case exemplifies substantive integration, describing a connectedness between the subjects, i.e. both art and science involve thinking and assembling processes that simultaneously draw from both disciplines. The second exemplifies interdisciplinary integration whereby separate and discreet disciplines relate to and feed each other. Scholars argue that substantive integration is more valuable and more challenging to create than interdisciplinary integration. This challenge was further illustrated and highlighted by students' comments that reflected their interdisciplinary

understanding of art-science integration whereby they understood the utility of science for enhancing artistic media. For example they said:

> *Arts-oriented people can apply science to arts practice, but workshop activities might have opened new pathways for doing so: The field trips to the hotel/apartment complex and the studio experiences were especially helpful.*
>
> *For people who were both Arts-oriented and Science-oriented, each week was different: sometimes you could see more arts, and sometimes you could see more science. For example, I built a flower that opened up. For the concept, I had to think artistically, but to actually figure out how to build it, it was more like engineering.*

Still, as illustrated by these comments, although interdisciplinary integration fails to instill an understanding of the creative thinking in the scientific process, it does function to invite arts-oriented thinkers to learn more science.

> ***Recommendation: If integration is a goal, help people understand their initial schemas and how stretching them toward integration might be useful.***
>
> ***Recommendation: Be explicit about when creative thinking is being applied to science processes.***

Some discussants considered that the unexpected results that the workshop caused more silo-like thinking among arts-oriented and science-oriented participants may have been because of problems with the reliability of the question or the even the survey in general. As shown in the following quotes, these potential problems involved the wording, "thinking like an artist."

> *Maybe it was a really specific interpretation of the word artist, like if they were thinking about a painter. It may be related to the focus on workshop products, as opposed to art objects.*

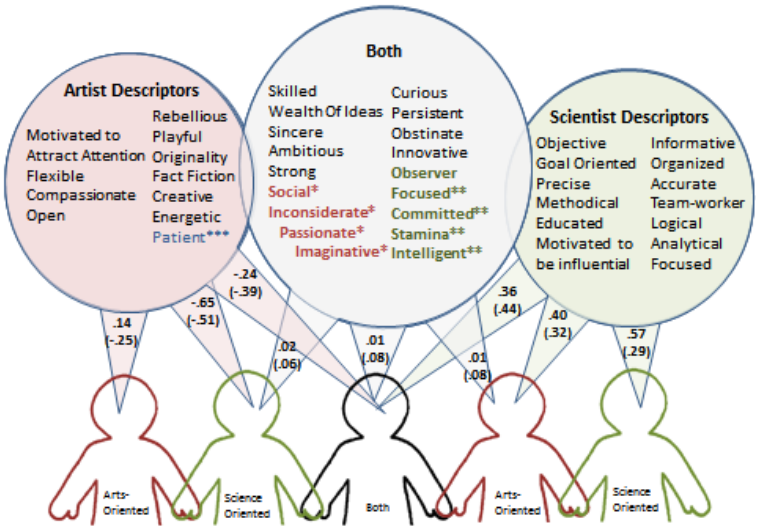
On the other hand one respondent used the phrase generally,

> *"Like an artist" feels very general: thinking outside the box, having to be creative. Covers lots of different arts practices. For example, in theatre, it's thinking about how you present yourself.*

Still another considered that the data collection format in itself was problematic:

> *If people didn't really get the questions and just sort of answered to finish. It felt like a quiz, which was an odd format for the workshop. The pre and post timing felt really weird, too.*
>
> ***Recommendation: Future questionnaires should include a better definition of "thinking like an artist" that involves an explanation of creative thinking, i.e. associating ideas that aren't typically associated*** (Koestler, 1965)**.**

## *Changes in How Participants Used Words to Describe Artists and Scientists*




Before the program, words marked with * in red had been rated as describing artists; **words in green had been rated as describing scientists; *** in blue had been rated as describing both artists and scientists. Pre-program values are followed by (post-program values) in parentheses. There were no significant pre-post or between group differences.

*Figure 10. Post-program association of words oriented towards each group: participants changed m*

The word interpretation section of both the pre and post questionnaire listed 41 words that had been compiled from various internet lists of words to describe both artists and scientists. For each, respondents were asked to assign a value ranging from -3 to +3 (-3 = "Describes artists TOTALLY, not scientists;" -2 = "Describes artists A LOT more than scientists;" -1 = "Describes artists SOMEWHAT more than scientists;" 0 = Describes artists and scientists EQUALLY; 1 = "Describes scientists SOMEWHAT more than artists;" 2= Describes scientists A LOT more than artists; 3= Describes scientists TOTALLY, not artists"). For both pre-program and post-program data, by sorting the words by the average rating for each word across orientation groups we created three words groups: The "describes artists" word group contained words with an average rating less than -.20; the "describes scientists" group contained words with an average rating greater than .20 and words greater than-.20 and less than .20 comprised the "Describes Both" word group. We then compared changes from before to after workshop participation.

From before to after the program there were no significant changes in the amount of value participants assigned to the pre-program descriptor groups or between orientation groups at either time period. However, as shown in Figure 10, eight words moved to describing both artists and scientists, four words ("focused," "intelligent," "stamina," and "committed" moved from the "mostly describing scientists" group and another four ("social," "inconsiderate," "passionate," and "imaginative") from the "mostly describing artists" group. One word, "patient," moved from describing both artists and scientists to mostly describing artists. The after-program rating of these eight words as describing both artists and scientists is evidence that **the workshop had some degree of substantive effect (Marshall, 2005) on helping participants recognize common ground between artists and scientists**.

Detail for each rated word can be found in Appendix B. Table 4.

Overall there was no significant change from in the use of these words from before the program to after (t=1.23, df=24, p=.231).

### *Defining Science*

In order to learn if science became more creative, we looked for signs of creative thinking added to the definition of science after the workshop experience. Of the 26 participants, before the program, no responses included reference to creative thinking. After the program, three references appeared, two from arts-oriented students and one from a science-oriented participant. One art-oriented participant referenced the arts directly: *[no change from before except my definition] would add that science can be mixed in with other fields like arts to make more ideas and opportunities.* The other arts-oriented student wrote the same definition as before the workshop but added, *"the term science can not really be described, but . . . ."* The science-oriented who referenced a more open-ended, creative understanding also wrote the same definition afterward as before, but added, "*but science still can't explain the endless rebirth of life and death."*

### *Appreciation for the Usefulness of Interdisciplinary Learning*

Both before and after the program, 26 participants responded (on a scale ranging from 1 = "Useless" to 5= "Useful") to questions, asking for their opinion on how useful they felt learning about arts would be if they were a professional scientist and how useful learning about science would be if they were a professional artist. Following their assessment of each statement, they provided qualitative explanation of why they answered as they did.

When considering themselves as either scientists or artists, **participant responses, either across or within orientation groups, revealed no significant change from before to after the program.**

In their qualitative responses, participants of all three orientations provided reasons that reflected two types of interdisciplinary (not substantive) integration (Marshall, 2005): (1) use of the arts to communicate scientific findings both graphically and otherwise and (2) being "*well rounded*," i.e. not just scientific. On the other hand participants also demonstrated, even prior to the workshop, appreciation for substantive integration. These reasons included, identifying and solving problems "*differently*;" "*learn how to ask questions*;" "*seek to try new methods*;" "*leading to results they never imagined*;" "*to be inspired*;" "*to find more original hypotheses*;" and "*breakthroughs* [from] *out-of-the-box thinking* [require scientists to] *develop imagination and creative thinking.*" These explanations came from 7 of the 26 pre-program respondents, representing all three orientation groups. After the program, of these seven participants, one provided a more narrow inter-disciplinary explanation; the remaining six remained similarly substantive. Four participants who had provided interdisciplinary responses before the program (three of whom were dually oriented, the other arts oriented) demonstrated substantive responses after. Those new responses were similar to the substantive responses listed above. One new concept that emerged was the idea of how involvement with the arts would help a scientist be "*able to simplify something complex . . . simplifying it to the smallest denominator*." **These responses reflected the no-change finding in the quantitative data, but illuminate ways teens appreciate substantive integration of arts and science as involving creative thinking throughout the scientific process—beyond communicating results and or being "well rounded." .**

## Q4. Workshop effectiveness as recruitment tool for YES! and Q?Crew

### What We Learned

> The art-science workshops functioned as an effective invitation to the more intensive NMNH youth programs.

### How We Know

To find out if the art-science workshops functioned to recruit teens to the more intensive programs, we asked, "To what degree did participating in this workshop make you want to sign up for NMNH Q?Crew or a YES! Internship?" Almost half of the 23 participants respondents who knew about these program opportunities reported being influenced a lot (N=4) or a great deal (N=8). On a Scale of 0 to 5 (0=none; 1=a little; 2=moderate, 3= a lot; 4= a great deal). The average influence was 2.7 with no significant differences between interest groups ($F$=.49, $p$=.62). Three science-oriented participants reported being unaware of these programs.

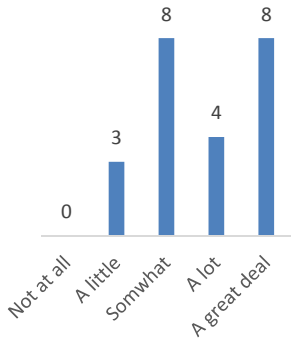



*Figure 11. Almost half the participants became more interested in other NMNH youth programs.*

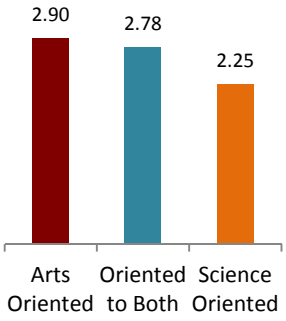



*Figure 12. Program Effect on Interest in Joining YES! or Q?Crew*

## Conclusions and Recommendations

This evaluation of the NMNH 2106 Art Science Workshops produced evidence of both successful outcomes and an important challenge.

### The successes:

**Science for arts-oriented teens**: *"To be an artist, I need science."* By creating a space where arts-oriented students find respect and support for their interests along with a non-threatening environment for asking questions and learning at their own pace, these teens increase their interest and confidence in pursuing science academically.

**Gateway to more intensive NMNH Youth Programs.** Over half of the arts-science workshop participants had not participated in other Smithsonian Programs; moreover equally as many reported that their art-science workshop experience made them more interested in participating in NMNH's volunteer and internship programs.

**21st Century Skills.** The workshops provide participants with a broad range of practice with 21st century skills including analysis, application, synthesis and self-reflection. They particularly contribute to enhancement of the synthesis skills of playing with, arranging, and applying ideas.

## The Challenge

The results also revealed two important challenges with integrating arts and science. First, there was evidence that participants may be experiencing the integration as more interdisciplinary than substantive. As a result, arts –oriented students find a safe and accepting environment for studying science (as mentioned above) but the program has less impact on science-oriented students' understanding of, appreciation for, or experience with incorporating creative thinking into the various steps of the scientific process.

> ***Recommendation: Consider building into the curriculum explicit identification of when and how creative thinking is being applied to various steps of the scientific process.***

Another challenge related to interdisciplinary vs. substantive integration emerges from the finding that, in contrast to dually-oriented participants who significantly increased their recognition of creative thinking in at least two steps of the scientific process, science-oriented participants decreased theirs. One of the discussant perception that encouraging participants to follow their interests may reinforce existing schemas.

> ***Recommendation: Consider ways to help participants understand their initial orientation schemas and how stretching toward integration might be useful for meeting their goals.***

All in all, considering the successes and challenges of these Art-Science workshops, , NMNH and ARTLAB+ can be applauded for providing important science-learning opportunities especially for arts-oriented teens; utilizing the experience to working to integrate science and the arts to help teens enhance 21st century skills, and providing an accessible gateway into more deeply engaging volunteer and internship opportunities. In addition, however, NMNH and ARTLAB+ are forging into important new territory, exploring and discovering the important elements of moving beyond interdisciplinary programming into substantive integration.

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# Appendix A Instruments

# ArtScience Pre-Workshop Survey Questionnaire

Default Question Block

**Welcome to the NMNH Making Sense Art-Science Workshop!**

Before you launch into this exciting week of discovery, we'd like to know a bit about who you are and what you think about science, art, and their relationship to each other. This questionnaire will help us get to know you better, learn how we can meet your needs and how we might make future workshops work well for teens.

**For a detailed description of the questionnaire and your participation, click on this link:** http://goo.gl/tOz5S6. Please read it over to help you decide if you would like to participate in this study. If you agree to participate, you will answer some questions now and then some more at the end of the workshop. This pre-workshop questionnaire should take you about 10 minutes to complete.

We do not anticipate any risks to you by participating in this study. The only anticipated benefits are that your feedback may help strengthen NMNH youth programs in the future. Your responses will be anonymous – not linked to you. No personally identifying information (like your name, your address, your school) will be collected.

**Completing this survey is completely up to you, and you can choose not to answer these questions or to stop at any time without any consequences.** If you have questions about this study or would like a copy of this page, please contact the director of the evaluation:

Deborah Wasserman, Ph.D.; Research Associate; Lifelong Learning Group: dwasserman@cosi.org or phone 614-629-3123.

If you have any questions about your rights or concerns that you can't discuss with the investigator, you may call the institutional review board: E&I Review, phone: (816-421-0008).

**By clicking "Next Page" below, I indicate that I have read the above information, had the chance to ask questions and receive answers, and I consent to take part in the study.**

To start, we'd like you to learn about your interests and how you like to spend your time. Do you lean more toward science? Do you lean more toward the arts? (By the word "arts," we include performing, visual, and/or literary arts). Are you equally interested in the arts and the sciences? **For each activity listed below, tell us about your interests by completing the sentence:**

**My interests lean . . .**

| | TOTALLY toward the ARTS, not science | MORE toward the ARTS | I am equally interested in both art and science: Equally toward both | MORE toward SCIENCE than the arts | TOTALLY toward SCIENCE, not the arts |
|---|---|---|---|---|---|
| What I choose to read | ○ | ○ | ○ | ○ | ○ |
| How I choose to spend my free time | ○ | ○ | ○ | ○ | ○ |
| How I choose my activities | ○ | ○ | ○ | ○ | ○ |
| How I choose topics for projects at school | ○ | ○ | ○ | ○ | ○ |
| In general, my interests lean . . . | ○ | ○ | ○ | ○ | ○ |

Have you participated in an Art and Science workshop or course previously?

yes

no

Please list five words or phrases that describe the most interesting/attractive aspects of professional artists (including visual, performing, and/or literary artists).

The most interesting or attractive qualities of professional artists are:

1. 
2. 

The most interesting or attractive qualities of professional artists are:

3.
4.
5.

Please list five words or phrases that describe the most interesting/attractive aspects of scientists.

The most interesting or attractive qualities of scientists are:

1.
2.
3.
4.
5.

If you were a professional artist, how useful do you think it would be to your career to learn about science?

Useless Somewhat useless Neutral Somewhat useful Useful

If you were a professional scientist, how useful do you think it would be to your career to learn about the arts?

Useless Somewhat Useless Neutral Somewhat useful Useful

The statements below ask you to think about the science process and the utility of thinking like an artist (that is, a painter, musician, actor, sculptor, writer, etc.). For each, please mark how much you agree or disagree with each statement.

**Thinking like an artist is *very* useful for . . .**

| | Strongly agree | Agree | Somewhat agree | Neither agree nor disagree | Somewhat disagree | Disagree | Strongly disagree |
|---|---|---|---|---|---|---|---|
| 1. . . . forming scientific questions. | O | O | O | O | O | O | O |
| 2. . . . asking questions that can be answered by collecting data. | O | O | O | O | O | O | O |
| 3. . . . designing scientific procedures to answer a question. | O | O | O | O | O | O | O |
| 4. . . . communicating a scientific procedure to others. | O | O | O | O | O | O | O |
| 5. . . . recording data accurately. | O | O | O | O | O | O | O |
| 6. . . . creating a graph for presentation to others. | O | O | O | O | O | O | O |
| 7. . . . creating a display to communicate scientific data and observations. | O | O | O | O | O | O | O |
| 8. . . . analyzing the results of a scientific investigation. | O | O | O | O | O | O | O |
| 9. . . . choosing and using science terms to share scientific results. | O | O | O | O | O | O | O |
| 10. . . . for using scientific models to explain results. | O | O | O | O | O | O | O |
| 11. . . . for answering a scientific question. | O | O | O | O | O | O | O |

Imagine yourself defining science to a sixth grader. Please write what you would say:

Please list up to three reasons why artists might want to learn more about science.

Please list up to three reasons why scientists might want to learn more about the arts.

Please look at the words in the list below and make a selection based on whether you think each describes both artists and scientists equally (middle column) or if it applies more to artists or more to scientists.

| | Describes **artists** TOTALLY, not scientists | Describes **artists** A LOT more than scientists | Describes **artists** SOMEWHAT more than scientists | Describes artists and scientists **EQUALLY** | Describes **scientists** SOMEWHAT more than artists | Describes **scientists** A LOT more than artists | Descri **scient** TOTAl not art |
|---|---|---|---|---|---|---|---|
| Educated | ○ | ○ | ○ | ○ | ○ | ○ | ○ |

| | Describes **artists** TOTALLY, not scientists | Describes **artists** A LOT more than scientists | Describes **artists** SOMEWHAT more than scientists | Describes artists and scientists **EQUALLY** | Describes **scientists** SOMEWHAT more than artists | Describes **scientists** A LOT more than artists | Descri **scient** TOTAl not art |
|---|---|---|---|---|---|---|---|
| Intelligent | ○ | ○ | ○ | ○ | ○ | ○ | ○ |
| Skilled | ○ | ○ | ○ | ○ | ○ | ○ | ○ |
| Logical | ○ | ○ | ○ | ○ | ○ | ○ | ○ |
| Creative | ○ | ○ | ○ | ○ | ○ | ○ | ○ |
| Curious | ○ | ○ | ○ | ○ | ○ | ○ | ○ |
| Imaginative | ○ | ○ | ○ | ○ | ○ | ○ | ○ |

| | Describes **artists** TOTALLY, not scientists | Describes **artists** A LOT more than scientists | Describes **artists** SOMEWHAT more than scientists | Describes artists and scientists **EQUALLY** | Describes **scientists** SOMEWHAT more than artists | Describes **scientists** A LOT more than artists | Descri **scient** TOTAl not art |
|---|---|---|---|---|---|---|---|
| Playful | ○ | ○ | ○ | ○ | ○ | ○ | ○ |
| Has ability to slide between fact and fiction | ○ | ○ | ○ | ○ | ○ | ○ | ○ |
| Innovative | ○ | ○ | ○ | ○ | ○ | ○ | ○ |
| Flexible | ○ | ○ | ○ | ○ | ○ | ○ | ○ |
| Goal oriented | ○ | ○ | ○ | ○ | ○ | ○ | ○ |
| Ambitious | ○ | ○ | ○ | ○ | ○ | ○ | ○ |
| Motivated by a need to be influential | ○ | ○ | ○ | ○ | ○ | ○ | ○ |

| | Describes **artists** TOTALLY, not scientists | Describes **artists** A LOT more than scientists | Describes **artists** SOMEWHAT more than scientists | Describes artists and scientists **EQUALLY** | Describes **scientists** SOMEWHAT more than artists | Describes **scientists** A LOT more than artists | Descri **scient** TOTAl not art |
|---|---|---|---|---|---|---|---|
| Motivated by a need to attract attention | ○ | ○ | ○ | ○ | ○ | ○ | ○ |


| | Describes artists TOTALLY, not scientists | Describes artists A LOT more than scientists | Describes artists SOMEWHAT more than scientists | Describes artists and scientists EQUALLY | Describes scientists SOMEWHAT more than artists | Describes scientists A LOT more than artists | Describes scientists TOTALLY, not artists |
|---|---|---|---|---|---|---|---|
| Has a need for originality | ○ | ○ | ○ | ○ | ○ | ○ | ○ |
| Inconsiderate | ○ | ○ | ○ | ○ | ○ | ○ | ○ |
| Obstinate | ○ | ○ | ○ | ○ | ○ | ○ | ○ |
| Accurate | ○ | ○ | ○ | ○ | ○ | ○ | ○ |
| Analytical | ○ | ○ | ○ | ○ | ○ | ○ | ○ |
| Focused | ○ | ○ | ○ | ○ | ○ | ○ | ○ |
| Methodical | ○ | ○ | ○ | ○ | ○ | ○ | ○ |
| Objective | ○ | ○ | ○ | ○ | ○ | ○ | ○ |
| Observer | ○ | ○ | ○ | ○ | ○ | ○ | ○ |
| Organized | ○ | ○ | ○ | ○ | ○ | ○ | ○ |
| Precise | ○ | ○ | ○ | ○ | ○ | ○ | ○ |
| Team-worker | ○ | ○ | ○ | ○ | ○ | ○ | ○ |
| Rebellious | ○ | ○ | ○ | ○ | ○ | ○ | ○ |
| Compassionate | ○ | ○ | ○ | ○ | ○ | ○ | ○ |
| Passionate | ○ | ○ | ○ | ○ | ○ | ○ | ○ |
| Social | ○ | ○ | ○ | ○ | ○ | ○ | ○ |
| Sincere | ○ | ○ | ○ | ○ | ○ | ○ | ○ |
| Informative | ○ | ○ | ○ | ○ | ○ | ○ | ○ |
| Energetic | ○ | ○ | ○ | ○ | ○ | ○ | ○ |
| Open | ○ | ○ | ○ | ○ | ○ | ○ | ○ |
| Patient | ○ | ○ | ○ | ○ | ○ | ○ | ○ |


| | Describes artists TOTALLY, not scientists | Describes artists A LOT more than scientists | Describes artists SOMEWHAT more than scientists | Describes artists and scientists EQUALLY | Describes scientists SOMEWHAT more than artists | Describes scientists A LOT more than artists | Describes scientists TOTALLY, not artists |
|---|---|---|---|---|---|---|---|
| Persistent | ○ | ○ | ○ | ○ | ○ | ○ | ○ |
| Strong | ○ | ○ | ○ | ○ | ○ | ○ | ○ |
| Has a wealth of ideas | ○ | ○ | ○ | ○ | ○ | ○ | ○ |
| Has ability to be committed | ○ | ○ | ○ | ○ | ○ | ○ | ○ |
| Has the stamina to tackle difficult issues | ○ | ○ | ○ | ○ | ○ | ○ | ○ |

Now some questions just about you!

Thinking about the future, are you planning to go to college?

yes

No

What academic subjects do you think you might pursue in college?

How much do you expect these subjects will involve your science interest?

A great deal

A lot

A moderate amount

A little
None at all

Right now, if you had to choose, what do you expect your career will be?

How much do you expect this career will involve learning more science?

A great deal
A lot
A moderate amount
A little
None at all

How much do you expect this career will involve thinking like an artist?

A great deal
A lot
A moderate amount
A little
None at all

Thanks so much for participating in our study! We really appreciate your time. Teens in future workshops also appreciate your input!

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# ArtScience Post-Workshop Survey Questionnaire

**Default Question Block**

**Congratulations for completing the NMNH Making Sense Art-Science Workshop!**

Before you go, we'd like to know a bit your experience in the workshop and how it affected you. Your responses will help us understand the NMNH Art-Scince workshop experience for teens, what works, and how we can improve it. If you agree to participate, you will complete the following series of questions about your experience and how has affected you and your thoughts. Thanks so much for providing your feedback!

**For a detailed description of the questionnaire and your participation, click on this link:** info . Please read it over to help you decide if you would like to participate in this study. If you agree to participate, you will answer this after-workshop questionnaire. Completing it will take about 45 minutes. **You'll notice that many of the questions are same as the ones you answered at the beginning of the week. That is because we'd like to know how the workshop may have affected how yo think about things.**

In appreciation for your time and thoughts, we will send you a $10 gift card within a few days after you complete the survey.

We do not anticipate any risks to you by participating in this study. The only anticipated benefits are that your feedback may help strengthen NMNH youth programs in the future. Your responses will be anonymous – not linked to you. No personally identifying information (like your name, your address, your school) will be collected.

**Completing this survey is completely up to you, and you can choose not to answer these questions or to stop at any time without any consequences.** If you have questions about this study or would like a copy of this page, please contact the director of the evaluation:

Deborah Wasserman, Ph.D.; Research Associate; Lifelong Learning Group: dwasserman@cosi.org or phone 614-629-3123.

If you have any questions about your rights or concerns that you can't discuss with the investigator, you may call the institutional review board: E&I Review, phone: (816-421-0008).

**By clicking "Next Page" below, I indicate that I have read the above information, had the chance to ask questions and receive answers, and I consent to take part in the study.**

This first set of questions is about you and your interests.

First we'd like you to think of the many conditions that ***positively*** influence your interests and decisions. Look across the list below. How much does each condition positively contribute to where you want to go in the future in terms of school, career, and life.

For each condition, please rate from 1 to 7 if it has influenced you 1= "not at all", 4= "somewhat," or 7 = "a lot" or anywhere in between.

| | Positively influences my interests and decisions . . . | | | | | | |
|---|---|---|---|---|---|---|---|
| | Not at all | 2 | 3 | Somewhat | 5 | 6 | A lot |
| Parents/guardians | O | O | O | O | O | O | O |
| Friends | O | O | O | O | O | O | O |
| School classes | O | O | O | O | O | O | O |
| School teachers | O | O | O | O | O | O | O |
| Religious groups/religious education | O | O | O | O | O | O | O |
| Visual arts | O | O | O | O | O | O | O |
| Performing arts | O | O | O | O | O | O | O |
| | Not at all | 2 | 3 | Somewhat | 5 | 6 | A lot |
| After-school programs | O | O | O | O | O | O | O |
| Organized sports (including school) | O | O | O | O | O | O | O |
| Hobbies | O | O | O | O | O | O | O |
| Being in nature/being outside | O | O | O | O | O | O | O |
| Work/my job | O | O | O | O | O | O | O |

| | Not at all | 2 | 3 | Somewhat | 5 | 6 | A lot |
|---|---|---|---|---|---|---|---|
| Extra-curricular activities (school clubs) | O | O | O | O | O | O | O |
| Volunteering | O | O | O | O | O | O | O |
| Other adults in my life | O | O | O | O | O | O | O |
| Family expectations for school | O | O | O | O | O | O | O |
| Family expectations for career | O | O | O | O | O | O | O |
| My participation in NMNH Art-Science workshops | O | O | O | O | O | O | O |
| My participation in other programs sponsored by the Smithsonian Institution | O | O | O | O | O | O | O |

For what reasons did you rate the influence of your participation in art-science workshops as ${q://QID59/SelectedAnswerRecode/21} points out of a possible 7 (a lot) ?

For what reasons did you rate the influence of your participation in other Smithsonian programs as ${q://QID59/SelectedAnswerRecode/23} points out of a possible 7 (a lot)?

The next statements are about your interest in science and technology before the workshop and now. For each of the qualities listed, please tell us how much you agree or disagree that the statement reflects you.

| | Strongly disagree | Disagree | Somewhat disagree | Neither agree nor disagree | Somewhat agree | Agree | Strongly agree |
|---|---|---|---|---|---|---|---|
| Before participating in this workshop I planned on taking more science or technology classes in school/university (while in school). | O | O | O | O | O | O | O |
| Now I plan on taking more science or technology classes in school/university (while in school). | O | O | O | O | O | O | O |
| Before this workshop, I always wanted to learn new things about science and technology. | O | O | O | O | O | O | O |
| Now, I always want to learn new things about science and technology. | O | O | O | O | O | O | O |
| Before this workshop, I found understanding science and technology to be important. | O | O | O | O | O | O | O |
| Now, I find understanding science and technology to be important. | O | O | O | O | O | O | O |
| Before this workshop I found being involved in scientific activity to be important. | O | O | O | O | O | O | O |
| Now I find being involved in scientific activity to be important. | O | O | O | O | O | O | O |

| | Strongly disagree | Disagree | Somewhat disagree | Neither agree nor disagree | Somewhat agree | Agree | Strongly agree |
|---|---|---|---|---|---|---|---|
| Before this workshop I imagined myself in a career or job that uses math. | ○ | ○ | ○ | ○ | ○ | ○ | ○ |
| **Now** I imagine myself in a career or job that uses math. | ○ | ○ | ○ | ○ | ○ | ○ | ○ |
| Before this workshop, I found science to be useful in helping to solve the problems of everyday life. | ○ | ○ | ○ | ○ | ○ | ○ | ○ |
| **Now**, I find science to be useful in helping to solve the problems of everyday life. | ○ | ○ | ○ | ○ | ○ | ○ | ○ |
| Before this workshop, I believed that most people should have a basic understanding of scientific principles. | ○ | ○ | ○ | ○ | ○ | ○ | ○ |
| **Now**, I believe that most people should have a basic understanding of scientific principles. | ○ | ○ | ○ | ○ | ○ | ○ | ○ |

Do you plan to go to college?

yes

no

What academic subjects do you think you might pursue in college?

How much do you expect these subjects to involve your science interest?

A great deal

A lot

A moderate amount

A little

None at all

Right now, if you had to choose, what do you expect your career will be?

How much do you expect this career will involve learning more science?

A great deal

A lot

A moderate amount

A little

None at all

How much do you expect this career will involve thinking like an artist?

A great deal

A lot

A moderate amount

A little

None at all

To what degree did participating in this workshop make you want to sign up for NMNH Q?Crew or a YES! intership?

A great deal

A lot

A moderate amount

A little

None at all

I've never heard of these programs

This next set of questions is about your thoughts now compared to before the workshop. You'll recognize the questions from the questionnaire you completed on Monday. If the workshop did nothing to change the way you think, feel free to write "no change."

**Block 1**

If you were a professional artist, how useful do you think it would be to your career to learn about science?

Useless | Somewhat useless | Neutral | Somewhat useful | Useful

If you were a professional scientist, how useful do you think it would be to your career to learn about the arts?

Useless | Somewhat Useless | Neutral | Somewhat useful | Useful

Please list up to three reasons why scientists might want to learn more about the arts.

Please list up to three reasons why scientists might want to learn more about the arts.

Please look at the words in the list below and make a selection based on whether you think each describes both artists and scientists equally (middle column) or if it applies more to artists or more to scientists.

| | Describes **artists** TOTALLY, not scientists | Describes **artists** A LOT more than scientists | Describes **artists** SOMEWHAT more than scientists | Describes artists and scientists **EQUALLY** | Describes **scientists** SOMEWHAT more than artists | Describes **scientists** A LOT more than artists | Descri **scient** TOTAl not art |
|---|---|---|---|---|---|---|---|
| Educated | ○ | ○ | ○ | ○ | ○ | ○ | ○ |
| Intelligent | ○ | ○ | ○ | ○ | ○ | ○ | ○ |
| Skilled | ○ | ○ | ○ | ○ | ○ | ○ | ○ |
| Logical | ○ | ○ | ○ | ○ | ○ | ○ | ○ |
| Creative | ○ | ○ | ○ | ○ | ○ | ○ | ○ |
| Curious | ○ | ○ | ○ | ○ | ○ | ○ | ○ |
| Imaginative | ○ | ○ | ○ | ○ | ○ | ○ | ○ |

| | Describes **artists** TOTALLY, not scientists | Describes **artists** A LOT more than scientists | Describes **artists** SOMEWHAT more than scientists | Describes artists and scientists **EQUALLY** | Describes **scientists** SOMEWHAT more than artists | Describes **scientists** A LOT more than artists | Descri **scient** TOTAl not art |
|---|---|---|---|---|---|---|---|
| Playful | ○ | ○ | ○ | ○ | ○ | ○ | ○ |
| Has ability to slide between fact and fiction | ○ | ○ | ○ | ○ | ○ | ○ | ○ |
| Innovative | ○ | ○ | ○ | ○ | ○ | ○ | ○ |
| Flexible | ○ | ○ | ○ | ○ | ○ | ○ | ○ |
| Goal oriented | ○ | ○ | ○ | ○ | ○ | ○ | ○ |
| Ambitious | ○ | ○ | ○ | ○ | ○ | ○ | ○ |
| Motivated by a need to be influential | ○ | ○ | ○ | ○ | ○ | ○ | ○ |

| Describes | Describes **artists** | Describes | | Describes | Describes | |
|---|---|---|---|---|---|---|

v

| | artists TOTALLY, not scientists | A LOT more than scientists | artists SOMEWHAT more than scientists | Describes artists and scientists EQUALLY | scientists SOMEWHAT more than artists | scientists A LOT more than artists | Descri scient TOTAl not art |
|---|---|---|---|---|---|---|---|
| Motivated by a need to attract attention | ○ | ○ | ○ | ○ | ○ | ○ | ○ |
| Has a need for originality | ○ | ○ | ○ | ○ | ○ | ○ | ○ |
| Inconsiderate | ○ | ○ | ○ | ○ | ○ | ○ | ○ |
| Obstinate | ○ | ○ | ○ | ○ | ○ | ○ | ○ |
| Accurate | ○ | ○ | ○ | ○ | ○ | ○ | ○ |
| Analytical | ○ | ○ | ○ | ○ | ○ | ○ | ○ |
| Focused | ○ | ○ | ○ | ○ | ○ | ○ | ○ |

| | Describes artists TOTALLY, not scientists | Describes artists A LOT more than scientists | Describes artists SOMEWHAT more than scientists | Describes artists and scientists EQUALLY | Describes scientists SOMEWHAT more than artists | Describes scientists A LOT more than artists | Descri scient TOTAl not art |
|---|---|---|---|---|---|---|---|
| Methodical | ○ | ○ | ○ | ○ | ○ | ○ | ○ |
| Objective | ○ | ○ | ○ | ○ | ○ | ○ | ○ |
| Observer | ○ | ○ | ○ | ○ | ○ | ○ | ○ |
| Organized | ○ | ○ | ○ | ○ | ○ | ○ | ○ |
| Precise | ○ | ○ | ○ | ○ | ○ | ○ | ○ |
| Team-worker | ○ | ○ | ○ | ○ | ○ | ○ | ○ |
| Rebellious | ○ | ○ | ○ | ○ | ○ | ○ | ○ |

| | Describes artists TOTALLY, not scientists | Describes artists A LOT more than scientists | Describes artists SOMEWHAT more than scientists | Describes artists and scientists EQUALLY | Describes scientists SOMEWHAT more than artists | Describes scientists A LOT more than artists | Descri scient TOTAl not art |
|---|---|---|---|---|---|---|---|
| Compassionate | ○ | ○ | ○ | ○ | ○ | ○ | ○ |
| Passionate | ○ | ○ | ○ | ○ | ○ | ○ | ○ |
| Social | ○ | ○ | ○ | ○ | ○ | ○ | ○ |
| Sincere | ○ | ○ | ○ | ○ | ○ | ○ | ○ |
| Informative | ○ | ○ | ○ | ○ | ○ | ○ | ○ |
| Energetic | ○ | ○ | ○ | ○ | ○ | ○ | ○ |
| Open | ○ | ○ | ○ | ○ | ○ | ○ | ○ |

Describes

| | Describes artists TOTALLY, not scientists | artists A LOT more than scientists | Describes artists SOMEWHAT more than scientists | Describes artists and scientists EQUALLY | Describes scientists SOMEWHAT more than artists | Describes scientists A LOT more than artists | Descri scient TOTAl not art |
|---|---|---|---|---|---|---|---|
| Patient | ○ | ○ | ○ | ○ | ○ | ○ | ○ |
| Persistent | ○ | ○ | ○ | ○ | ○ | ○ | ○ |
| Strong | ○ | ○ | ○ | ○ | ○ | ○ | ○ |
| Has a wealth of ideas | ○ | ○ | ○ | ○ | ○ | ○ | ○ |
| Has ability to be committed | ○ | ○ | ○ | ○ | ○ | ○ | ○ |
| Has the stamina to tackle difficult issues | ○ | ○ | ○ | ○ | ○ | ○ | ○ |

The statements below ask you to think about the science process and the utility of thinking like an artist (that is, a painter, musician, actor, sculptor, writer, etc.). For each, please mark how much you agree or disagree with each statement.

**Thinking like an artist is *very* useful for . . .**

| | Strongly disagree | Disgree | Somewhat disagree | Neither agree nor disagree | Somewhat agree | Agree | Strongly Agree |
|---|---|---|---|---|---|---|---|
| 1. . . . forming scientific questions. | ○ | ○ | ○ | ○ | ○ | ○ | ○ |
| 2. . . . asking questions that can be answered by collecting data. | ○ | ○ | ○ | ○ | ○ | ○ | ○ |
| 3. . . . designing scientific procedures to answer a question. | ○ | ○ | ○ | ○ | ○ | ○ | ○ |
| 4. . . . communicating a scientific procedure to others. | ○ | ○ | ○ | ○ | ○ | ○ | ○ |
| 5. . . . recording data accurately. | ○ | ○ | ○ | ○ | ○ | ○ | ○ |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| 6. . . . creating a graph for presentation to others. | O | O | O | O | O | O | O |
| 7. . . . creating a display to communicate scientific data and observations. | O | O | O | O | O | O | O |
| 8. . . . analyzing the results of a scientific investigation. | O | O | O | O | O | O | O |
| 9. . . . choosing and using science terms to share scientific results. | O | O | O | O | O | O | O |
| 10. . . . for using scientific models to explain results. | O | O | O | O | O | O | O |
| 11. . . . for answering a scientific question. | O | O | O | O | O | O | O |

Imagine yourself defining science to a sixth grader. Please write what you would say:

This is the last section! These next statements are about ways the Making Sense Workshop may have affected you. Please tell us how much you agree or disagree that teh statement reflects you.

**Participating in this Making Sense Workshop has . . .**

| | Strongly disagree | Disgree | Somewhat disagree | Neither agree nor disagree | Somewhat agree | Agree | Strongly Agree |
|---|---|---|---|---|---|---|---|
| . . . enhanced my strategies for remembering information. | O | O | O | O | O | O | O |
| . . . enhanced my ability to communicate my ideas or what I have learned. | O | O | O | O | O | O | O |
| . . . enhanced my ability to find my own examples that show things I have learned. | O | O | O | O | O | O | O |
| . . . enhanced my ability to find the important points of an idea. | O | O | O | O | O | O | O |
| . . . enhanced my ability to explain how import points of an idea fit together. | O | O | O | O | O | O | O |

| | Strongly disagree | Disgree | Somewhat disagree | Neither agree nor disagree | Somewhat agree | Agree | Strongly Agree |
|---|---|---|---|---|---|---|---|
| . . . enhanced my ability to find similarities and differences between ideas. | O | O | O | O | O | O | O |
| . . . enhanced my ability to play with ideas. | O | O | O | O | O | O | O |
| . . . enhanced by ability to organize my ideas in a logical way | O | O | O | O | O | O | O |
| . . . enhanced my ability to use creativity in my school work | O | O | O | O | O | O | O |
| . . . enhanced my ability to apply what I learn to solving problems | O | O | O | O | O | O | O |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| . . . given me new ideas for how to go about solving problems. | ○ | ○ | ○ | ○ | ○ | ○ | ○ |
| . . . enhanced my ability to determine if a tool will be useful for accomplishing a specific task. | ○ | ○ | ○ | ○ | ○ | ○ | ○ |
| . . . enhanced my ability to predict how well I will do a specific task. | ○ | ○ | ○ | ○ | ○ | ○ | ○ |
| . . . become more sure of what my strengths and weaknesses are. [from pyd inventory-project TRUE] | ○ | ○ | ○ | ○ | ○ | ○ | ○ |
| . . . enhanced my confidence to try new things. | ○ | ○ | ○ | ○ | ○ | ○ | ○ |

Please tell us any additional thoughts you want us to know about you, your Making Sense experience, or how to make the workshop better for other teens.

Thanks so much for participating in our study! We really appreciate your time. Teens in future workshops also appreciate your input!

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# Appendix B. Data Detail

## Detail of reasons for Art-Science workshop influence rankings

| order | Group | Reason | Rating | Theme 1 |
|---|---|---|---|---|
| **1** | 0 | creativeness, making ideas into reality, | 6 | Creativity |
| **2** | -1 | It helped me realize that to be a good artist, I need science. | 6 | artist needs science |
| **5** | -1 | This definitely influences my life because it is something I am passionate about, is something I would love to explore as a career, and has great uses in society. | 6 | personal and social-impact direction |
| **14** | 0 | Because is was a cool program | 6 | general satisfaction |
| **20** | 1 | It was very informative/fun. | 6 | general satisfaction |
| **21** | 0 | I have to do art. | 6 | Creativity |
| **25** | 0 | It shows me different ways in which you can put the two together. Ive always liked both art and science but never really incorporated both of them innto one project | 6 | art-science "co-exist" |
| **26** | -1 | Because it helped me figure out what I wanted to do in life. | 6 | personal direction |
| **10** | 1 | I rated it as 5 points because it somewhat influenced me but not fully | 5 | amount |
| **16** | -1 | we did a lot of stuff and it was fun but it kind got boring in the middle because we did a lot of sewing. | 5 | amount |
| **18** | 0 | The workshops showed me how to combine new technology and LEDs and other lights and art to make something really cool. It also taught me new codes and uses for those codes. | 5 | art and science skill that could be combined |
| **4** | -1 | I am very interested in both art and science, and these workshops show that they can coexist | 4 | art-science "co-exist" |
| **7** | -1 | Although I have been influenced by Art-Science workshops, I did not feel as though they had influenced me to the same level as other things on that survey. | 4 | amount |
| **8** | 1 | I haven't participated in a lot of them. | 4 | amount |
| **9** | 0 | I love doing these workshops and I learn a lot and am exposed to new things that are really awesome. | 4 | personal learning |

| | | | | |
|---|---|---|---|---|
| **17** | 1 | i learned a lot and had fun and i got a bit influenced | 4 | personal learning and fun |
| **23** | 1 | I have only done a few other similar workshops. My robotics team at school was the thing that mostly influenced to attend this workshop. | 4 | school influenced workshop (robotics) |
| **6** | -1 | I felt that it was necessary and correct. | 3 | personal and social-impact objectives |
| **11** | 1 | It was very fun and I had a good time, but I don't think I would do sensors and circuitry as my job. I would do it as a hobbie though | 3 | personal direction |
| **12** | 0 | They introduce me to interesting activities and career paths. I am not sure if I will pursue that path, but it has gotten me kind of interested. | 3 | personal direction |
| **15** | 1 | I was very helpful but i was tired and had a hard time focusing. | 3 | amount |
| **22** | -1 | I would like to have a career in art or science and this workshop made me think more about how the two relate | 3 | personal direction and coexist |
| **24** | -1 | While this camp has given me a bigger outlook, it hasn't completely changed my interests or opinions. It did get me more interested in programming, so I might look into that. | 3 | personal direction |
| **13** | 0 | TO my knowledge, the Smithsonian is not really influential in the Science-Art-Technology world, despite having an over-abundance of resources and funds. | 2 | personal direction |
| **19** | 1 | I've only ever participated in one art-science workshop. | 1 | amount |
| **3** | -1 | Help me grow as a person | 0 | Personal development |

## Detail of reasons for Smithsonian Institution Influence ratings.

| | Code | Smithsonian Experience? | Positive? | rating |
|---|---|---|---|---|
| when I first saw the Q?rius collection I decided I wanted to do something to do with biology. | 1 | 1 | 1 | 3 |
| The Smithsonian helps me learn different things | 2 | 1 | 1 | 6 |
| It help me learn | 3 | 1 | 1 | 1 |
| The other programs were not as involving or similar to my interests. | 4 | | +1 | 2 |
| Many Smithsonian programs provide positive experiences that can add to my personal life. | 5 | | 1 | 4 |
| because making sense is the first Smithsonian program I've done. | 6 | | 99 | 0 |
| Although I have been influenced by other Smithsonian programs, I did not feel as though they had influenced me to the same level as other things on that survey. | 7 | | 1 | 4 |
| I rated it a 5. | 8 | | 99 | 3 |
| | 9 | | 99 | 4 |
| Because I'm not really involved with any other smithsonian programs so they don't really influence me | 10 | | 99 | 3 |
| This is the first Smithsonian program I've been to. | 11 | | 99 | 2 |
| I have not gone to any other Smithsonian programs, but they will probably influence me the same as this, because they show me to career paths which I may or may not be interested in. | 12 | | 99 | 3 |
| Although the Smithsonian has a positive influence on America's expectation of museums, I feel the Smithsonian is still using old-school methods that are not engaging to the newer, more technologically advanced generations. | 13 | | 0 | 3 |
| Because this is the only program that I've ever done | 14 | | 99 | 4 |
| i have not been in other programs. | 15 | | 99 | 3 |
| I have not been to other camps. | 16 | | 99 | 0 |
| i have done no other programs | 17 | | 99 | 2 |
| The Smithsonian classes were fun because I got to get hands-on experience with lots of interesting things I don't have at home, like bones or ancient jewelry. I also thought the way they were taught was good. | 18 | | 1 | 5 |
| I haven't participated officially in any other Smithsonian programs. | 19 | | 99 | 0 |

| | | | | |
|---|---|---|---|---|
| **I didn't.** | 20 | | 99 | 5 |
| **I do science.** | 21 | | 1 | 6 |
| **Haven't done any others** | 22 | | 99 | 0 |
| **The only other time I have heard about Smithsonian programs is when my sister went to art lab and liked it. So, it did have some influence on me but not a lot since it wasn't the same program and I didn't experience it myself.** | 23 | | 99 | 3 |
| **I haven't participated in any other Smithsonian programs. Sorry.** | 24 | | 99 | 3 |
| | 25 | | 99 | 6 |
| **Because I helped me learn about new things like other parts of science and math.** | 26 | | 1 | 6 |

## Detail of Influence on Decision Making

| | Arts Oriented (n=10) | Oriented to Both (n=8) | Science Oriented (n=8) |
|---|---|---|---|
| **Parents/Guardians** | 4.56 | 4.56 | 4.81 |
| **Friends** | 4.20 | 4.08 | 4.31 |
| **School Classes** | 4.00 | 4.12 | 3.94 |
| **School Teachers** | 3.72 | 3.72 | 3.69 |
| **Religions Group Education** | 2.48 | 2.32 | 1.75 |
| **Visual Arts** | 4.52 | 4.64 | 4.31 |
| **Performance Arts** | 3.96 | 4.04 | 3.44 |
| **After School Programs** | 3.54 | 3.33 | 2.93 |
| **Sports** | 2.61 | 2.52 | 2.64 |
| **Hobbies** | 4.63 | 4.63 | 4.53 |
| **Nature** | 4.29 | 4.29 | 4.20 |
| **Work** | 3.08 | 2.83 | 2.80 |
| **Clubs** | 4.0 | 3.75 | 3.60 |
| **Volunteer Work** | 3.63 | 3.46 | 3.53 |
| **Other Adults (non-parents)** | 3.72 | 3.76 | 3.75 |
| **Family Expectations of School** | 3.92 | 3.75 | 3.83 |
| **Family Expectations of Career** | 3.68 | 3.52 | 3.69 |
| **NMNH** | 4.08 | 4.08 | 4.00 |
| **Other Smithsonian Programs** | 3.12 | 3.00 | 2.88 |

*Table 2. Evidence of workshop effect on participants' perception of how useful it is to scientists to learn about the arts to scientists. (Arts for Science)*

| Orien-tation | Pre | Post | Pre-program understanding | Post-program additions |
|---|---|---|---|---|
| Science | 4 | 4 | Scientists can learn to be more creative. | Scientists can use it to be more creative. |
| Science | 4 | 4 | to be more creative with experiments [creative thinking] | creativity -thinking outside the box -Imaginative |
| Science | 3 | 3 | For thinking outside the box, sketching up concept art and other things I can't think of ay the moment [art to explain science] | Anatomy of the human body for drawing people<br><br>[art to explain science. |
| Science | 5 | 3 | 1. Art can help scientists become more creative. 2. Creativity can lead scientists to results they never imagined. 3. Art can help scientists express their results. Explains Creative thinking | Scientists can be more creative with art and it can help them plan and demonstrate their work and results in an understandable and creative way. |
| Science | 3 | 4 | to be inspired. to be more creative. to have fun creative thinking | to be more open minded. to be inspired. to learn new things |
| Science | 5 | 5 | 1. to visualize ideas 2. to communicate ideas 3. to display ideas explain | to visualize ideas to express ideas to display ideas |
| Science | 2 | 4 | Art is very creative and abstract. Breakthroughs in science come from out of the box thinking. So scientists need to develop imagination and creativity. | no change |
| Both | 5 | 5 | they could learn that a lot of the arts are actually science, and they could learn more stuff that could help them with their career. | thinking like an artist, looking at a problem from all angles |
| Both | 4 | 5 | In fields such as engineering, an artistic mind is very important. | Thinking like an artist helps a lot with things such as engineering |
| Both | 4 | 4 | 1. To understand what appeals to people 2. To learn about the mindset of modern people who appreciate art. 3. To find something to love and admire, but not specifically study | 1. It can help them understand things less explained by science 2. It allows them to think about other things besides science 3. It broadens their knowledge, tests their mind to understand slightly abstract things. |
| Both | 5 | 5 | 1. To also be 360 2. Loosen up 3. Be able to formulate and teach ideas without being such a stickler | To understand conceptual, more methodical terms, I feel you should be able to: 1.) Express your views broadly, being able to tailor your ideals & theories to a larger, diverse demographics 2.) Visually express your ideas, clearly, using color theory, value, depth, and an infinite of other artistic applications 3.) Being able to simplify something complex, at prestigious animation art schools, they teach animation students, you can make anything overly complex, but only the best can learn a complex idea and simplify it the smallest denominator. |
| Both | 5 | 3 | They look at problems differently They put a more artist side to their work | No change |
| Both | 4 | 4 | 1. If scientists need to draw a picture of something they are studying, they need to know how to draw. 2. Artists are creative, and sometimes scientists need to as well if they are having a hard time figuring out a problem 3. Artists are open-minded ad scientists need to as well if they are studying something, they do not like, or studying something that does not have much interesting stuff about it. | 1. Artists are more open-minded than scientists and sometimes scientists need to open up a little bit. 2. Artists are more creative than scientists and scientists need to be more creative sometimes. 3. Artists see the world how it can be, while scientists only see the world how it is. |

| | | | | |
|---|---|---|---|---|
| Both | 3 | 5 | They focus on planets. | Artists do makings. |
| Both | 5 | 5 | being able to draw scientific models | To make visually attractive graphic design. To collect different types of data in an organized fashion. |
| Arts | 3 | 3 | to make presentations to make graphs to be well rounded | to make graphs to make good presentations to be a well rounded person |
| Arts | 4 | 4 | it is fun to make graphs to be well rounded | Science is cool Investigatory To be a well rounded person |
| Arts | 3 | 5 | It would help them effectively communicate their ideas to other people | No change |
| Arts | 4 | 4 | 1. To find new ways to express their information | to express their ideas creatively to find creative solutions to logical problems to engage their audiences in creative ways |
| Arts | 4 | 5 | in order to solve a question or make one, scientist must be creative. The arts help them discover and answer the questions. It makes the process of discovering easier. | help them think outside the box, develop new ways of finding things out, be creative |
| Arts | 4 | 4 | 1. To learn how to ask questions 2. To learn how to present findings 3. Finding new methods? | No change |
| Arts | 5 | 4 | 1. They may want to make a cool project or diagram using art 2. For visual displays | To make diagrams To make models |
| Arts | 4 | 5 | Scientists might want to learn more about the arts because thinking like an artist could lead the scientist to find more creative and original hypotheses and methods of experimentation. | Because scientific data can be represented in interesting and effective ways through art. |
| Arts | 3 | 2 | 1. It can help them find new and innovative ways to present their data. 2. It can help them find new ways to spread their message and tell the public about their research. | no change |
| Arts | 2 | 3 | 1. They can make a creative data charts. 2. They make different datasets. 3. Scientists can make models of there presentation. | No change |

## Detail of changes in perception of interdisciplinary utility

*Table 3. Retrospective perception of changes in participants' understanding of the utility of the arts to scientists and science to artists (n=25)*

| Interest Group | | Count of improved scores | Before | After | Change | Paired t-test |
|---|---|---|---|---|---|---|
| Arts | If you were a professional scientist, how useful do you think it would be to your career to learn about art? | 2 | 3.60 | 3.90 | 0.30 | -1.0 |
| | If you were a professional artist, how useful do you think it would be to your career to learn about science? | 5 | 4.20 | 4.30 | 0.10 | -0.56 |
| Both | If you were a professional scientist, how useful do you think it would be to your career to learn about art? | | 4.38 | 4.50 | 0.12 | -0.31 |
| | If you were a professional artist, how useful do you think it would be to your career to learn about science? | | 4.38 | 4.38 | 0.0 | 0.0 |
| Science | If you were a professional scientist, how useful do you think it would be to your career to learn about art? | | 3.71 | 3.86 | 0.15 | -0.31 |
| | If you were a professional artist, how useful do you think it would be to your career to learn about science? | | 4.0 | 4.29 | 0.29 | -1.0 |

## Detail of rating of words as describing Artists and Scientists

*Table 4. Pre - Words used differently, based on orientation, to describe Artists; Scientists, or both (negative numbers describe artists).*

| | | Orientation toward | | Whole Group |
|---|---|---|---|---|
| **Values** | **The Arts** | **Equally** | **Science** | |
| **Rebellious** | **-0.70 (1.06)** | **-1.00 (0.93)** | **-0.86 (0.69)** | -0.84 (0.90) |
| **Playful** | **-0.78 (0.83)** | **-0.50 (1.31)** | **-1.14 (0.69)** | **-0.79 (0.98)** |
| Determine Fact versus Fiction | -1.00 (1.05) | -0.63 (1.06) | -0.14 (1.35) | -0.64 (1.15) |
| Creative | -0.22 (0.44) | -1.00 (0.76) | -0.75 (1.04) | -0.64 (0.81) |
| Motivated to Attract Attention | -0.50 (0.97) | -0.63 (0.92) | -0.63 (0.92) | -0.58 (0.90) |
| Energetic | -0.22 (0.44) | -0.75 (0.71) | -0.86 (0.69) | -0.58 (0.65) |
| **Imaginative** | **-0.30 (0.48)** | **-0.38 (0.74)** | **-0.63 (0.74)** | **-0.42 (0.64)** |
| **Flexible** | **-0.10 (0.74)** | **-0.50 (1.07)** | **-0.43 (0.53)** | **-0.32 (0.80)** |
| Compassionate | -0.44 (0.88) | -0.50 (0.76) | 0.14 (0.38) | -0.29 (0.75) |
| **Open** | -0.40 (1.07) | **-0.63 (0.92)** | **0.29 (0.95)** | -0.28 (1.02) |
| Social | -0.10 (0.32) | -0.25 (1.04) | -0.14 (1.69) | -0.16 (0.69) |
| **Skilled** | **0.00 (0.00)** | **-0.14 (0.38)** | **-0.13 (0.35)** | **-0.08 (0.28)** |
| Sincere | -0.20 (0.42) | 0.13 (0.83) | 0.00 (0.58) | -0.04 (0.61) |
| Passionate | **-0.10 (0.32)** | **-0.38 (0.74)** | **0.00 (0.58)** | -0.16 (0.55) |
| **Ambitious** | **0.10 (0.32)** | **0.13 (0.35)** | **-0.43 (0.53)** | **-0.04 (0.45)** |
| **Wealth of Ideas** | 0.00 (0.00) | **0.00 (0.53)** | **-0.14 (0.38)** | -0.04 (0.35) |
| Strong | 0.00 (0.00) | 0.00 (0.00) | 0.00 (0.58) | 0.00 (0.29) |
| **Innovative** | **0.00 (0.47)** | **0.00 (0.53)** | **0.00 (0.00)** | **0.00 (0.41)** |
| Curious | 0.00 (0.00) | 0.13 (1.25) | 0.00 (0.00) | 0.04 (0.66) |
| **Patient** | 0.20 (0.42) | **-0.13 (0.35)** | **0.00 (1.00)** | 0.04 (0.61) |
| Persistent | 0.00 (0.00) | 0.13 (0.35) | 0.14 (0.38) | 0.08 (0.28) |
| Committed | 0.00 (0.00) | **0.38 (0.52)** | **0.00 (0.00)** | 0.12 (0.33) |
| Obstinate | 0.20 (0.63) | 0.13 (0.99) | 0.13 (0.64) | 0.15 (0.73) |
| **Motivated for Influence** | **0.00 (0.00)** | **0.38 (1.19)** | **0.14 (1.07)** | **0.16 (0.85)** |
| **Focused** | **0.30 (0.67)** | **0.25 (0.46)** | **0.00 (0.00)** | **0.19 (0.49)** |
| **Intelligent** | **0.00 (0.00)** | **0.38 (0.74)** | **0.25 (0.46)** | **0.19 (0.49)** |
| **Focused** | **0.30 (0.67)** | **0.25 (0.46)** | **0.00 (0.00)** | **0.19 (0.49)** |
| **Stamina** | 0.10 (0.32) | **0.38 (0.52)** | **0.29 (0.49)** | 0.24 (0.44) |
| **Observer** | **0.20 (0.42)** | **0.38 (0.92)** | **0.14 (0.90)** | **0.24 (0.72)** |
| **Objective** | **0.30 (1.06)** | **0.25 (0.89)** | **0.14 (0.38)** | **0.24 (0.83)** |
| **Goal Orientation** | **0.30 (0.67)** | **0.38 (0.92)** | **0.57 (0.79)** | **0.40 (0.76)** |
| **Precise** | **0.20 (0.79)** | **1.00 (0.76)** | **0.14 (0.38)** | 0.44 (0.77) |
| **Methodical** | **0.50 (0.71)** | **0.25 (0.71)** | **0.71 (0.49)** | **0.48 (0.65)** |
| **Educated** | **0.00 (0.00)** | **0.88 (0.83)** | **0.75 (0.71)** | **0.50 (0.71)** |
| Informative | 0.40 (0.70) | 0.50 (0.53) | 0.86 (0.69) | 0.56 (0.65) |
| Organized | 0.40 (0.52) | 0.63 (0.74) | 0.71 (0.49) | 0.56 (0.58) |
| Accurate | 0.60 (0.97) | 0.71 (0.76) | 0.63 (0.52) | 0.64 (0.76) |
| Team Worker | 0.10 (0.57) | 1.25 (0.89) | 1.0 (0.82) | 0.72 (0.89) |
| **Logical** | **0.80 (0.79)** | **1.00 (1.07)** | **1.00 (1.07)** | **0.92 (0.93)** |
| Analytical | 0.60 (1.07) | 1.50 (0.93) | 1.00 (0.76) | 1.00 (0.98) |

* Averages that differed significantly (F-test probability less than .1) between groups appear in **bold** (see Appendix --- for detail).

*Table 5. Post- Words used differently, based on orientation, to describe Artists; Scientists, or both (negative numbers describe artists).*

| | | Orientation toward | | Whole Group |
|---|---|---|---|---|
| **Values** | **The Arts** | **Equally** | **Science** | |
| **Rebellious** | **-0.70 (0.67)** | **-1.00 (1.20)** | **-1.14 (1.07)** | -0.92 (0.95) |
| **Playful** | **-0.50 (1.08)** | **-0.63 (1.06)** | **-1.43 (0.53)** | **-0.80 (1.00)** |
| Creative | -0.90 (0.57) | -0.63 (0.92) | -0.71 (0.95) | -0.76 (0.78) |
| Energetic | -0.50 (0.71) | -0.38 (0.74) | -0.71 (0.76) | -0.52 (0.71) |
| Determine Fact versus Fiction | -0.40 (1.07) | -0.50 (1.07) | -0.57 (1.13) | -0.48 (1.05) |
| Motivated to Attract Attention | -0.30 (0.48) | -0.38 (0.92) | -0.71 (0.76) | -0.44 (0.71) |
| **Open** | 0.00 (0.94) | **-0.50 (0.76)** | **-0.43 (0.53)** | -0.28 (0.79) |
| **Patient** | -0.20 (0.79) | **-0.13 (0.83)** | **-0.29 (0.49)** | -0.20 (0.71) |
| **Flexible** | **0.00 (0.47)** | **-0.38 (0.74)** | **-0.57 (0.53)** | **-0.28 (0.61)** |
| Compassionate | -0.10 (0.32) | -0.13 (0.35) | -0.43 (0.53) | -0.20 (0.41) |
| Passionate | **-0.10 (0.32)** | **-0.13 (0.35)** | **-0.14 (0.38)** | -0.12 (0.33) |
| **Imaginative** | **0.20 (1.03)** | **-0.38 (0.74)** | **-0.14 (0.38)** | **-0.08 (0.81)** |
| Persistent | -0.10 (0.74) | -0.13 (0.35) | 0.00 (0.00) | -0.08 (0.49) |
| **Skilled** | **0.10 (1.10)** | **-0.13 (0.35)** | **-0.17 (0.41)** | **-0.04 (0.75)** |
| Sincere | -0.20 (0.42) | -0.13 (0.35) | 0.29 (0.49) | -0.04 (0.45) |
| **Focused** | **0.00 (0.47)** | **0.00 (0.00)** | **0.00 (0.00)** | **0.00 (0.29)** |
| **Ambitious** | **0.20 (0.79)** | **-0.25 (0.89)** | **0.00 (0.00)** | **0.00 (0.71)** |
| **Observer** | **-0.20 (0.79)** | **0.38 (0.74)** | **-0.14 (0.69)** | **0.00 (0.76)** |
| Committed | 0.20 (0.63) | **-0.13 (0.35)** | **0.00 (0.00)** | 0.04 (0.45) |
| Social | 0.00 (0.00) | 0.25 (0.89) | -0.14 (0.38) | 0.04 (0.54) |
| **Wealth of Ideas** | 0.20 (0.63) | **-0.13 (0.64)** | **0.00 (0.00)** | 0.04 (0.54) |
| Obstinate | 0.20 (0.42) | -0.13 (0.83) | 0.14 (0.38) | 0.08 (0.57) |
| Strong | 0.30 (0.95) | 0.13 (0.35) | 0.00 (0.58) | 0.16 (0.62) |
| **Innovative** | **-0.10 (0.32)** | **0.25 (0.89)** | **0.43 (0.53)** | **0.16 (0.62)** |
| **Stamina** | 0.30 (0.67) | **0.13 (0.83)** | **0.00 (0.00)** | 0.16 (0.62) |
| **Intelligent** | **0.10 (0.32)** | **0.43 (1.13)** | **0.00 (0.00)** | **0.17 (0.64)** |
| **Motivated for Influence** | **0.10 (0.57)** | **0.50 (0.76)** | **0.00 (0.58)** | **0.20 (0.65)** |
| **Precise** | **0.10 (0.57)** | **0.50 (0.93)** | **0.14 (0.38)** | 0.24 (0.66) |
| **Educated** | **0.20 (0.63)** | **0.38 (0.74)** | **0.43 (0.53)** | **0.32 (0.63)** |
| **Objective** | **0.30 (0.82)** | **0.50 (1.31)** | **0.29 (0.49)** | **0.36 (0.91)** |
| Curious | 0.40 (0.97) | 0.63 (0.74) | 0.14 (0.38) | 0.40 (0.76) |
| Team Worker | 0.30 (0.48) | 0.63 (0.92) | 0.29 (0.95) | 0.40 (0.76) |
| **Methodical** | **0.40 (0.52)** | **0.38 (1.51)** | **0.43 (0.79)** | **0.40 (0.96)** |
| **Goal Orientation** | **0.60 (0.84)** | **0.38 (0.74)** | **0.43 (0.53)** | **0.48 (0.71)** |
| Informative | 0.40 (0.84) | 0.38 (0.74) | 0.71 (0.49) | 0.48 (0.71) |
| Organized | 0.80 (0.79) | 0.75 (0.89) | 0.29 (0.49) | 0.64 (0.76) |
| **Logical** | **0.70 (0.95)** | **0.63 (1.51)** | **0.71 (0.76)** | **0.68 (1.07)** |
| Accurate | 0.80 (0.79) | 0.75 (1.04) | 0.57 (0.79) | 0.72 (0.84) |
| Analytical | 0.40 (0.52) | 1.00 (1.31) | 0.86 (0.69) | 0.72 (0.89) |

## Detail of Qualitative reasons for the utility of the arts for Scientists

| substantive pre | group | pre | post | | Sub pos |
|---|---|---|---|---|---|
| | 0 | they could learn that a lot of the arts are actually science, and they could learn more stuff that could help them with their career. | thinking like an artist, looking at a problem from all angles | broader | x |
| | -1 | to make presentations to make graphs to be well rounded | to make graphs to make good presentations to be a well rounded person | same | |
| | -1 | it is fun to make graphs to be well rounded | Science is cool Investigatory To be a well rounded person | | |
| | -1 | It would help them effectively communicate their ideas to other people | No change | | |
| | -1 | 1. To find new ways to express their information | to express their ideas creatively to find creative solutions to logical problems to engage their audiences in creative ways | broader | x |
| x | -1 | in order to **solve a question or make one, scientist must be creative**. The arts help them discover and answer the questions. It makes the process of discovering easier. | help them think outside the box, develop new ways of finding things out, be creative | same | |
| | -1 | 1. To learn how to ask questions 2. To learn how to present findings 3. Finding new methods? | No change | same | |
| x | 1 | Scientists can learn to be more creative. | Scientists can use it to be more creative. | same | |
| | 0 | In fields such as engineering, an artistic mind is very important. | Thinking like an artist helps a lot with things such as engineering | same | |
| | 1 | to be more creative with experiments | #NAME? | | |
| | 1 | For thinking outside the box, sketching up concept art and other things I can't think of ay the moment | Anatomy of the human body for drawing people. | | |
| | 0 | 1. To understand what appeals to people 2. To learn about the mindset of modern people who appreciate | 1. It can help them understand things less explained by science 2. It allows them to think about other things besides science 3. It broadens their knowledge, | same | |

| | | | | |
|---|---|---|---|---|
| | | art. 3. To find something to love and admire, but not specifically study | tests their mind to understand slightly abstract things. | |
| | 0 | 1. To also be 360 2. Loosen up 3. Be able to formulate and teach ideas without being such a stickler | To understand conceptual, more methodical terms, I feel you should be able to: 1.) Express your views broadly, being able to tailor your ideals & theories to a larger, diverse demographics 2.) Visually express your ideas, clearly, using color theory, valu, depth, and an infinite of other artistic applications 3.) Being able to simplify something complex, at prestigious animation art schools, they teach animation students, you can make anything overly complex, but only the best can learn a complex idea andsimplify it the smallest denominator. | broad er x |
| x | 0 | They look at problems differently They put a more artist side to their work | No change | same |
| x | 1 | 1. Art can help scientists become more creative. 2. Creativity can lead scientists to results they never imagined. 3. Art can help scientists express their results. | Scientists can be more creative with art and it can help them plan and demonstrate their work and results in an understandable and creative way. | same |
| | -1 | 1. They may want to make a cool project or diagram using art 2. For visual displays | To make diagrams To make models | same |
| x | 1 | to be inspired. to be more creative. to have fun | to be more open minded. to be inspired. to learn new things | same |
| | 0 | 1. If scientists need to draw a picture of something they are studying, they need to know how to draw. 2. Artists are creative, and sometimes scientists need to as well if they are having a hard time figuring out a problem 3. Artists are open-minded ad scientists need to as well if they are studying something, they do not like, or studying something that does not have much interesting stuff about it. | 1. Artists are more open-minded than scientists and tysometimes scientists need to open up a little bit. 2. Artists are more creative than scientists and scientists need to be more creative sometimes. 3. Artists see the world how it can be, while scientistsonly see the world how it is. | |

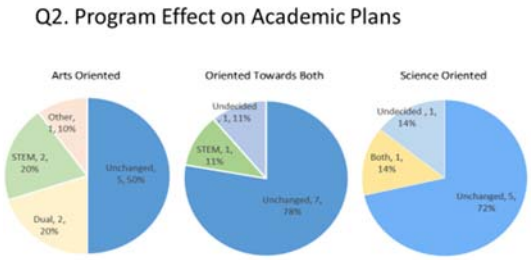
| | | | | | |
|---|---|---|---|---|---|
| | 1 | | | | |
| | 1 | 1. to visualize ideas 2. to communicate ideas 3. to display ideas | to visualize ideas to express ideas to display ideas | same | |
| | 0 | They focus on planets. | Artists do makings. | | |
| x | -1 | Scientists might want to learn more about the arts because thinking like an artist could lead the scientist to find more creative and original hypotheses and methods of experimentation. | Because scientific data can be represented in interesting and effective ways through art. | more narrow | |
| x | 1 | Art is very creative and abstract. Breakthroughs in science come from out of the box thinking. So scientists need to develop imagination and creativity. | no change | same | |
| | -1 | 1. It can help them find new and innovative ways to present their data. 2. It can help them find new ways to spread their message and tell the public about their research. | no change | same | |
| | 0 | being able to draw scientific models | To make visually attractive graphic design. To collect different types of data in an organized fashion. | | x |
| | -1 | 1. They can make a creative data charts. 2. They make different datasets. 3. Scientists can make models of there presentation. | No change | same | |

# Appendix C. Member Check Discussion Questions

## Q1. Orientation Group (no handout)

*How do you identify yourself?- Arts-oriented? Arts and Science oriented? Science oriented? What makes you answer this way?*

## Q2. Workshop Effect on Academic Plans

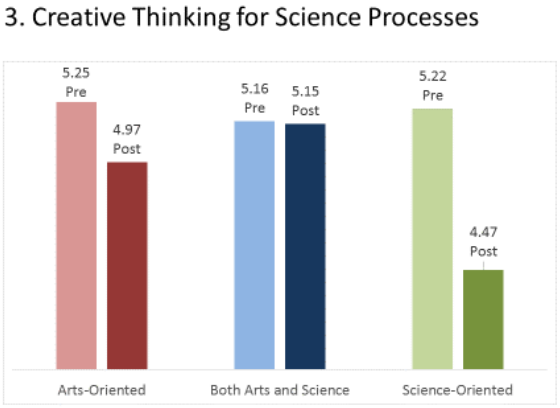



Both before and after the workshop, teens responded to open-ended questions asking about topics they were interested in pursuing in college (100% of respondents said they planned to attend college). After the workshop, half of the arts-oriented participants had changed how they described their plans. Only 25% of the other teens changed their plans.

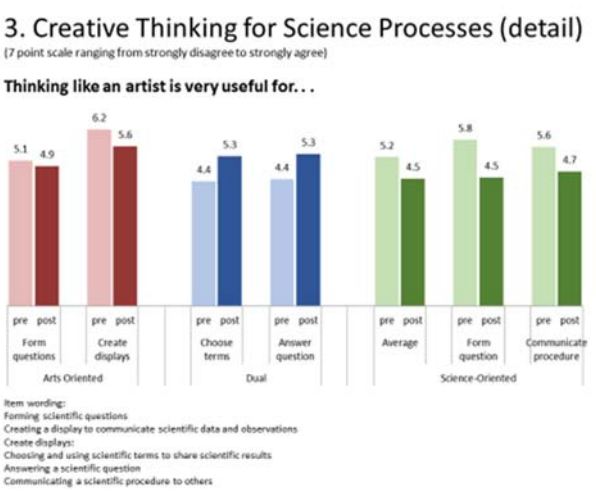
*What do you make of this finding both from your own experience and others'? What about the workshop may have influenced teens' academic plans?*

## Q3a-3c. Creative Thinking in the Scientific Process

To assess the workshop's effect on participants' integration of creative thinking into the scientific thinking, both before and after the workshop experience participants answered questions about "thinking like an artist" in each of 11 steps in the scientific process (Bourdeau & Arnold, 2009). Across all the participants, there were no average differences. However, within orientation groups, as illustrated the detail figure on the next page, some significant changes occurred within specific items. Of note is that within the items that changed significantly, **arts-oriented and even more so, science-oriented participants saw less opportunity for creative thinking. Only dually oriented participants saw greater opportunity.**




3a. When they saw the phrase, "thinking like an artist" what do you think teens thought it meant?




*3b. What do you make of this finding both from your own experience and others'? What was it specifically in the workshop that may have changed arts-oriented and science-oriented teens' ideas of how much they could apply arts-like thinking. What makes that different than for dually-oriented teens?*

*3c. It appears that the workshop may have reinforced the notion that art and science are different. Specifically, what in the workshop made it seem this way?*