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Baseline Attitudes and Impacts of Informal Science Education Lectures on Content Knowledge and Value of Science Among Incarcerated Populations

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Abstract

Many public audiences lack access to traditional science education. We examined baseline perceptions and the impacts of science lectures on incarcerated adults in two correctional institutions. Although incarcerated populations are often characterized as having poor educational backgrounds, being disinterested in learning, and having few tools to seek science education, our incarcerated audiences were interested in, capable of, and desirous of science education. We found positive baseline attitudes about science and a significant positive effect of science lectures on content knowledge, attitudes, and behavioral intentions related to science, suggesting that informal science lectures may be an appropriate portal to science education for this population.

Keywords

informal science education, science attitudes and perceptions, science content knowledge, incarceration, science literacy

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Extensive data summaries and statistical details are available from the authors.

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Introduction

A substantial challenge for scientists and science educators is to engage those who come from nonacademic backgrounds (Holdren, 2008; Leshner, 2007). Scientists tend to develop their questions and disseminate their work with people of similar cultures and education, and who hold similar values and share common vocabularies. However, broadening participation of those who have been traditionally underrepresented in science fields can foster a diversity of thinking, problem solving, and ways of knowing that can serve as a critical driver of excellence in research and innovation in scientific disciplines (Committee on Equal Opportunities in Science and Engineering, 2013; Guterl, 2014; National Academy of Sciences, 2011; Phillips, 2014; President's Council of Advisors on Science and Technology, 2012). Similarly, public engagement in science is important for expanding the scientifically literate populace, facilitating individuals to make decisions on issues of personal health and public policy as informed, independent thinkers, and to decrease the presently large gap in science understanding and trust between the scientific community and the public (Miller, 2004, 2013; Pew Research Center, 2015b). The increasing importance of broadening participation and public engagement in science has led to the designation of these practices as major investment priorities for the National Science Foundation (National Science Foundation, 2015) and other STEM research and education agencies (e.g., National Aeronautics and Space Administration, 2015).

Although greater support for public engagement in science has led to an increase in the number of programs and communities reached (e.g., Bauer & Jensen, 2011), there remain many communities for which pubic engagement is limited or absent. One such audience with virtually no access to formal (K-16) science education or informal science education (ISE) venues (e.g., educational institutions, museums, zoos) are the 2.3 million incarcerated people in the United States (Carson, 2015; Kirk, 2015; Minton & Zeng, 2015). More than 600,000 inmates are released from federal and state prisons each year (Carson & Golinelli, 2013). Recidivism rates (52% return to prison within 3 years; Durose, Cooper, & Snyder, 2014) are essentially unchanged over the past decade despite unprecedented spending on incarceration and other strategies aimed at criminal deterrence.

In addition to the general benefits of public engagement in science, educational engagement is particularly important to the incarcerated because of the direct impact it has on their future success. A meta-analysis commissioned by the Bureau of Justice Administration (Davis, Bozick, Steele, Saunders, & Miles, 2013) that included adult basic education, high school, GED, postsecondary education, and vocational training programs showed strong positive outcomes following exposure of inmates to corrections education of any type. Such exposure reduced the probability of recidivism by 13% and increased the probability of postrelease employment by 13% (Davis et al., 2013). Similarly, formal prison education programs (e.g., Bard College's Bard Prison Initiative, Washington State's College in Prisons Program) have documented that higher education behind bars decreases recidivism and increases postrelease employment (Karpowitz, 2005; MacKenzie, 2006).

Incarcerated populations are also disproportionately composed of underserved populations. Ethnic minorities make up a disproportionate amount of this population: Approximately 57% of prisoners are African American or Latino, although they make up only 29% of the total population in the United States (U.S. Census Bureau, 2010). Additionally, inmates have low levels of educational attainment relative to the general population: 41% of inmates do not have high school diplomas (relative to 18% for the general U.S. population), and only 13% of incarcerated people have any amount of postsecondary education (relative to 48% for the general U.S. population; Harlow, 2003).

While formal prison education has clear benefits, these programs can be difficult to initiate, maintain, and evaluate, especially in states where legislators do not wish to appear "soft on crime" by expending state educational funds for those who have broken laws. Additionally, prison education programs are often focused on life skills and job training, which are important to corrections administrators and politicians because they represent efforts to reduce rates of recidivism and increase postrelease employment. Few programs in correctional institutions have been structured within the framework of ISE, which is characterized by fostering changes in knowledge and understanding through lifelong learning; growing skills that develop capabilities, values, and ways of thinking; and understanding and appreciating critical thinking and scientific processes, all outcomes that can be achieved through informal (outside of the classroom) contexts (National Research Council, 2009).

In 2012, we started the Initiative to Bring Science Programs to the Incarcerated (INSPIRE), a program that applies the framework of ISE to incarcerated populations. This program was modeled on the Sustainability in Prisons Project, a partnership (cofounded in 2003 by the author, NMN) between The Evergreen State College and the Washington State Department of Corrections that has established science and conservation programming at all security levels of correctional institutions (Gallagher, 2013; Nadkarni, Hasbach, Thys, Crockett, & Schnacker, 2017; Ulrich & Nadkarni, 2009). The mission of INSPIRE is to bring science and nature to incarcerated populations, with the explicit goals of (1) providing inmates access to science and scientists to inspire interest in and a sense of connection to science, (2) promoting a shift in the self-images of inmates (who often have poor educational backgrounds) from being "science-incapable" to being "science learners," and (3) providing science knowledge, training, and skills to support a successful return of inmates to their communities. INSPIRE has established a variety of programs at correctional facilities in Utah that build connections between science, scientists, inmates, and the corrections community through science lectures, workshops, and conservation projects.

The work we describe here operates within the ISE framework whose goal is to stimulate capabilities for the "strands" of informal science learning (National Research Council, 2009). Of those, our activities apply to four of the six strands: Strand 1. Experience excitement, interest, and motivation to learn about phenomena in the natural and physical world; Strand 2. Come to understand, remember, and use concepts, explanations, and facts related to science; Strand 4. Reflect on science as a way of knowing, and on a participant's own process of learning about phenomena; and Strand 6. Think about themselves as science learners and develop and identity as someone who knows about, uses, and sometimes contributes to science. Our work did not directly address capabilities for the other two strands. The short time for interactions and use of a lecture format did not facilitate the inmates' capacity to deeply explore, manipulate, test, and make sense of the physical and natural world (Strand 3). The restricted logistical capacity of the corrections environment prevented participation in an authentic research investigation (Strand 6).

Here we present two distinct and separate data sets that are important for understanding participants in this program (inmates) and their reception of one form of science programming. The first data set (baseline surveys) is from institution-wide onetime surveys to inmates and staff at the Salt Lake County Jail and the Utah State Prison. These surveys characterize and compare baseline attitudes and perspectives about science, math, and nature of different groups of inmates and corrections staff. We compared inmates survey results among demographic variables (gender, ethnic background, and education level) and correctional institutions (jail and prison), given that the differences between institutions (e.g., in duration of incarceration, mental health [Gibbs, 1975], and opportunities for participation in other programs) may lead to different impacts on inmates. We also wanted to understand how inmate perspectives compare to the general U.S. population. For this, we used staff as a proxy for the general U.S. population, given that they have similar demographics and education levels (U.S. Census Bureau, 2010, 2016).

The second data set we present here if from our monthly science lecture series. This data set assesses the impacts of science lectures on inmates' content knowledge, attitudes, and behavioral intentions about science, math, and nature. Our lecture series program is voluntary for inmates and scientists, has no set curriculum, and does not grant academic credit. These lectures were created collaboratively by scientists and INSPIRE staff with the express goals of (1) promoting a high degree of interaction between presenter and audience (within the logistical constraints imposed by correctional facilities) and (2) promoting understanding by all or most audience members, while accommodating the broad range in educational background of participants.

Because there was no precedent for documenting the impacts of informal science lectures on adult populations inside corrections institutions, we carried out exploratory research (Institute of Education Sciences, 2013) based on our previous program work with incarcerated populations. We had to create very short surveys with simple language because of the limited time available for our lecture sessions due to jail/prison scheduling constraints and to allow broader participation given the low literacy and educational levels of some participants. This approach is appropriate because (1) we were taking first steps to answer questions about reception of science lectures to a novel audience, rather than testing theory about science communication or educational constructs, and (2) we did not have access to large numbers of participants due to security and logistical constraints. Where possible, we used items from validated surveys, modified items as necessary, and developed our own questions when preexisting surveys did not apply. This study represents a first step in examining the potential impacts of ISE on a population with virtually no access to formal or informal science education and may serve as a valuable resource for engagement programs focused on communicating science to nontraditional audiences.

Materials and Method

General Framework and Survey Design

For each facility (Salt Lake County Jail and Utah State Prison), our study consisted of two parts: (1) a onetime baseline survey of the entire population of inmates (not including maximum security units) and staff and (2) pre- and postlecture surveys administered to participants at each lecture. All surveys were voluntary and were accompanied by approved consent letters. Survey design and data management were carried out in collaboration with the Utah Education Policy Center, an independent educational research organization within the University of Utah. This study was reviewed and approved by the Institutional Review Board (IRB) of the University of Utah (IRB_00061095), including the protocols for implementing the baseline and lecture surveys, and data management procedures. The consent letter, survey documents, study logic model, and recruitment flyer texts were also reviewed and approved for the duration of this study.

The exploratory nature of this work suggests a preliminary qualitative research approach, but we have used quantitative surveys for assessment. Our research team has been carrying out a range of activities that bring science and nature to the incarcerated since 2003 (Ulrich & Nadkarni, 2009). For the first 8 years, science lectures were sporadically delivered to adult inmates in a variety of corrections institutions without formal and systematic evaluation instruments. However, these provided opportunities for informal feedback of inmates and corrections staff and allowed us to gauge the level of appropriate lecture terminology and concepts and to understand the reading abilities and attention spans of inmates. This information led us to place necessary constraints on language, amount of text, and length of written surveys.

Using this knowledge, the questions and categories for our surveys were created by a professional evaluator at the Utah Education Policy Center (based at the University of Utah). Survey questions were based around the topics of science, math, nature, and conservation because those are the primary focus on INSPIRE programming. Evaluation instruments were based in part on the theory of planned behavior and the theory of reasoned action (Ajzen & Fishbein, 1980; de Leeuw, Valois, Aizen, & Schmidt, 2015). However, the novel nature of this audience (incarcerated men and women and corrections staff) and lack of preceding studies did not allow direct use of that literature. Where possible, we used items from validated surveys, modified items as necessary, and developed our own questions when preexisting surveys did not apply. The following survey question topics were derived from validated scales: attitudes toward science, who can do science, and enjoyment of studying science and math (Scientific Attitude Inventory; Moore & Foy, 1997); perception of the utility of science in daily life (Motivated Strategies for Learning Questionnaire; Pintrich & De Groot, 1990); value of knowing math to help earn a living (Fennema–Sherman Mathematics Attitudes Scale; Fennema & Sherman, 1976); and value of environmental protection for benefits to self and others (New Environmental/Ecological Paradigm scale; Dunlap & Van Liere, 1978; Dunlap, Van Liere, Mertig, & Jones, 2000). All other survey questions were original and not derived from validated scales.

Study Sites

The Salt Lake County Jail is operated by the Salt Lake County Sheriff's Office and houses approximately 2,300 inmates. The Utah State Prison, located 20 miles south of Salt Lake City, is managed by the Utah Department of Corrections. It is the primary state prison in Utah and has a capacity of 4,300 inmates, from minimum to maximum security. Baseline surveys were delivered to all inmates (both men and women) in minimum and medium level security at both the jail and prison. Because of logistical constraints, science lectures were delivered to men only. At the jail, lectures occurred in a minimum and medium security cellblock in the “Metro” facility, which houses up to 64 inmates in double-tiered cells. At the prison, lectures were delivered in the gymnasium of the “Promontory” Unit, a 400-bed medium security–level sub-unit for men who participate in structured substance abuse or sex offender treatment programs.

Baseline Survey

Inmates. At the Salt Lake County Jail, all inmates (both men and women) in minimum- and medium-level security facilities (approximately 1,500 inmates total) were invited to participate in the baseline survey. INSPIRE staff visited each participating housing unit to distribute surveys. Inmates who chose to participate completed the surveys immediately, which were then collected by jail officers. At the Utah State Prison, all inmates (approximately 2,800, both men and women, excluding maximum security and severe mental illness units) were invited to complete baseline surveys. Prison staff distributed the surveys. Inmates returned their completed survey within 3 days, using the internal mail system. Inmate surveys at both locations were available in English and Spanish. Baseline survey questions were based in the following constructs (with Cronbach’s alpha or Spearman–Brown (r_{SB}) reliability scores): (1) Identity With Science and Scientists (α = .70), (2) Science and Math Connection to Life (α = .81), (3) Relationship With the Environment (α = .83), (4) Behavioral Intentions Related to Science (r_{SB} = .79), (5) General Education or Job Training (r_{SB} = .69), (6) Science Education (r_{SB} = .76), (7) Math Education (r_{SB} = .56), (8) Employment Related to the Environment (α = .87), (9) Incarceration (α = .13), and (10) Logistics (r_{SB} = .56). As indicated by Cronbach’s alpha and r_{SB} scores (for two-item categories; Eisinga, Grotenhuis, & Pelzer, 2013), constructs for science-, math-, and nature-related questions were acceptably reliable. For Incarceration questions, reliability was low. Questions on the surveys were randomly ordered but are reordered here to facilitate interpretation. Questions were formatted as 5-point Likert-type scale items. The response scale ranged from *strongly disagree* to *strongly agree*; for behavioral intention-based questions, the scale ranged from *very unlikely* to *very likely*.

Staff. Staff working at the jail (approximately 700) and prison (approximately 890) were invited to complete staff baseline surveys. These surveys were conducted online (Qualtrics LLC, Provo, UT) and were accessed through a recruitment e-mail message that was written by INSPIRE staff and distributed by administration at each facility. Baseline survey questions were based in the following constructs (with Cronbach's alpha reliability scores): (1) Identity With Science and Scientists (α = .66), (2) Science and Math Connection to Life (α = .84), (3) Relationship With the Environment (α = .83), (4) Science Education (α = .77), and (5) Math Education (α = .57). Reliability scores are calculated for inmate and staff data separately because the surveys were not identical (some inmate-focused questions were not applicable to staff). Questions on the actual surveys were randomly ordered. Questions were reordered here to facilitate interpretation.

Analysis. Demographic data were self-reported on surveys. For gender, we compared individuals identifying as men and women. For ethnic background, because of the small percentage of minority inmates at the jail (35%) and the prison (19%), we compared White non-Hispanics with all minorities pooled. For the analysis based on educational level, we used three groupings: less than high school diploma, high school diploma or GED, and more than high school diploma (included some college, associate's or bachelor's degree, and graduate or professional school). To determine if baseline survey responses differed by institution and demographic variables, we used a 2 (location: jail, prison) × 2 (gender: men, women) × 2 (ethnic background: White, minority) × 3 (education level: less than high school degree, high school degree of GED, more than high school) analysis of variance (ANOVA) with each set of construct scores as dependent variables. To examine differences in construct scores among demographic variables within each institution, we used 2 (gender) × 2 (ethnic background) × 3 (education level) ANOVA tests with post hoc Dunn tests for 3-group comparisons (educational level). To compare data between inmates and staff within each institution, we used 2 (group: inmates, staff) × 2 (gender) × 2 (ethnic background) × 3 (education level) ANOVA tests. Construct scores for inmates-staff comparisons were built from common questions between inmate and staff surveys (indicated on tables). Additionally, we used Wilcoxon rank sum tests to examine differences for individual survey question responses. Within each set of comparisons, p values were adjusted using the false discovery rate procedure (Benjamini & Hochberg, 1995). To summarize baseline survey data, we calculated the percentage of *agree* or *strongly agree* responses for each survey question. For questions with reversed polarity, we calculated the percentage of *disagree* or *strongly disagree* responses. For behavioral intention questions, percentages represent *likely* or *very likely* responses. All analyses were carried out in the R Statistical Programming Environment (R Development Core Team, 2016).

Lecture Surveys

Inmates. Lectures were carried out in men's facilities only at both the jail and prison. At the jail, the lecture was verbally announced 5 minutes before it started and was available to any inmate in the unit who chose and was allowed to attend. At the prison, the lecture was announced by printed flyers 2 weeks in advance. All attendees at science lectures were given the opportunity to complete voluntary pre- and postlecture surveys (approximately 25-80 people per lecture). The surveys were passed out by corrections staff and/or INSPIRE staff. Prelecture surveys were distributed and collected before the lecture started. Postlecture surveys were distributed and collected after the lecture had ended. Pre- and postlecture survey questions were identical.

Science content knowledge questions (3 lecture-specific questions, grouped at the beginning of each survey) were unique for each lecture. These were written by INSPIRE staff and were designed to gauge learning of broad concepts covered in a given lecture. For example, in a lecture on diabetes, the following true/false content knowledge questions were asked: (1) Diabetes affects only people who are very unhealthy; (2) Blood sugar levels should always be high; and (3) Insulin helps control the level of sugar in the bloodstream. For a lecture on the sun, the questions were the following: (1) The sun outputs about the same amount of power as an atomic bomb; (2) The sun does not have a magnetic field; and (3) The sun releases only visible forms of light. For a lecture on CRISPR, the questions were the following: (1) CRISPR is a gene editing tool that scientists invented and (2) Scientists understand the function of all the DNA in the human genome; (3) Enhancers are pieces of DNA that act like switches to control genes.

Survey questions focusing on attitudes related to science and math were based in the following categories: (1) Identity With Science and Scientists, (2) Science and Math Connection to Life, (3) Relationship With the Environment, (4) Science Education, (5) Math Education, and (6) Employment Related to the Environment. These attitude-based questions were reliable as a construct for both pre- and postlecture surveys (α = .79 and .80, respectively). Questions on the actual surveys were randomly ordered but are reordered here to aid in interpretation. Survey questions focusing on behavioral intentions related to science and science media were grouped at the end of each survey. The reliability for the behavioral intention–based question construct was also satisfactory (α = .80 and .83 for pre- and postlecture surveys).

Lectures and Recruitment of Speakers. We coordinated 23 lectures at the jail and 12 at the prison. Topics included a wide variety of scientific research: trees, cone snail venom, worm memory, human gut microbiota, antibiotic resistance, ant diversity, pika ecology, physics of the human voice, biomechanics of gray wolves, structure of viruses, watersheds, the effects of inactivity on human health, bird anatomy, ant–plant ecological interactions, biochemistry of cancer drugs, bird migration, large carnivore conservation, mathematical modeling of the common cold, and the genetics of feather traits in pigeons. All speakers delivering lectures were academic researchers (faculty, graduate students, and postdoctoral researchers) from science departments at universities in Utah. INSPIRE staff assisted speakers in the design of their presentations in order to ensure that the material was at the correct educational level, was the correct length, and incorporated audience interactions. Speakers were encouraged to pose questions during the presentation and to solicit frequent feedback from the audience. Following each lecture, a question-and-answer session occurred that typically lasted about 15 minutes. Lectures were each stand-alone presentations, and there was no set curriculum. This is crucial in correctional institutions, where turnover is high. Indeed, most lecture participants attended only one lecture (detailed below).

To recruit speakers, an initial solicitation for speakers was sent through departmental correspondence within the University of Utah. Following this, all speaker recruitment has been word of mouth and has been sustained through the perceived values of the program and positive experiences of speakers. Speakers were offered a letter of appreciation and a modest stipend (most speakers declined the stipend).

Analysis. Pre- and postlecture surveys were matched using inmate identification numbers (issued by the correctional institutions) that participants provided on surveys. Unmatched surveys were omitted from analysis. A small number of surveys ($n = 33$ and 16 at the jail and prison, respectively) were omitted due to our interpretation that responses were arbitrary (e.g., a line drawn through all rows, indicating that participant was not actually answering each question individually). To determine if survey responses changed as a result of the lecture experience, we compared survey constructs between pre- and postlecture survey data using nonparametric Wilcoxon signed rank tests on the first factor of each survey construct. For this analysis, we used only data from the first lecture attended by each participant (some individuals attended multiple lectures). We also used Wilcoxon signed rank tests to examine individual survey questions. To summarize pre-post changes by question type (content, attitude, and behavioral intention), we compared the mean difference in responses from pre- to postlecture. To determine if the pre-post changes differed by institution, we compared data from the jail and prison. Within each set of comparisons, p values were adjusted using the false discovery rate procedure (Benjamini & Hochberg, 1995).

Results

Baseline Surveys

Demographics. About one third of the eligible inmates at both the jail (34%) and prison (38%) completed the baseline surveys (n = 511 and 1066, respectively). About 8% of jail staff and 28% of prison staff completed surveys (n = 57 and 247, respectively). Demographic summaries for all participants indicate that survey respondents at both the jail and the prison were mostly men (77% and 70%, respectively) and that the majority were White non-Hispanic (65% at the jail and 81% at the prison). Hispanics made up the largest proportion of minority groups (26% at the jail and 12% at the prison). For highest level of educational attained, the largest category in both the jail and prison was a high school diploma (26% and 34%), followed by "some college" (23% and 29%) and "some high school" (18% and 6%). Participating staff from both institutions had a fairly even gender balance, with men representing 56% of respondents at the jail and 59% at the prison. Staff were mostly White non-Hispanic (89% at the jail and 83% at the prison). As with inmates, the highest proportion of minority groups was Hispanic (9% and 4%). For education level, the most common category for staff was "some college" (42% and 31%) or an associate's degree (26% and 23%).

Survey Responses. In general, responses for attitudes about science, math, and nature were highly positive, with an average of 83% and 78% of inmates responding with *agree* or *strongly agree* (on attitude questions) or *likely* or *very likely* (on behavioral intention questions) at the jail and prison, respectively (Table 1). Positive responses were highest for questions in the categories of Science Education, Relationship With the Environment, Math Education, Identity With Science and Scientists, and Science and Math Connection to Life. Inmates responded positively to questions on Employment Related to the Environment and were fairly likely to seek out science media or discuss science with others (Behavioral Intentions Related to Science). Questions not related to science/math/nature indicated that inmates were highly interested in continuing their education (General Education or Job Training), that they did not feel strongly connected to the outside world (Incarceration), and that they did not like filling out surveys (Logistics). Responses were significantly more positive ($p < .05$; ANOVA) for jail inmates as compared to prison inmates for 8 of 10 survey constructs (the exceptions were General Education or Job Training and Incarceration) and in 30 of 39 survey questions. Prison inmates had more positive responses for one survey construct (Incarceration).

Table 1. Summary of Responses From Institution-Wide Baseline Surveys for Inmates at the Salt Lake County Jail and the Utah State Prison.

Baseline survey constructs and questions	*% Agree or strongly agree*	
	Jail	Prison
Identity With Science and Scientists ($F = 26.07$, $p < .001$*; mean difference = −0.245)		
1[a]. Only highly trained scientists can understand science.[b]	82*	75
2. Scientists are not so different from me.	66	65
3[a]. Scientific work is useful only to scientists.	75	80*
4[a]. Scientific work would be too hard for me.[b]	72*	68
5. Working in science or learning about science would be fun.	92*	86
6. I would probably sign up for a university presentation on science if it were available.	90*	78
7. I would probably sign up for university presentation about something other than science if it were available.	84*	79
	80	**76**
Science and Math Connection to Life ($F = 6.21$, $p = .014$*; mean difference = −0.116)		
8. Science helps me in my daily life.[b]	74*	72
9. Math helps me in my daily life.	86*	84
10. Knowing science will help me earn a living.	67*	60
11. Knowing math will help me earn a living.[b]	82	83
	77	**75**
Relationship With the Environment ($F = 17.67$, $p < .001$*; mean difference = −0.241)		
12. The earth has plenty of natural resources if we just learn how to develop them.	90*	80
13. Engaging in actions that help the Earth, such as recycling and reducing waste, is important to me.	90	89
14. I think of myself as a part of nature, not separate from it.[b]	84*	81
15. I really enjoy being outdoors.	98*	95
16. I would like to learn to grow my own vegetables.	91*	87
17. I feel a personal bond with things in my natural surroundings, like trees, a stream, wildlife, or the view on the horizon.	89*	82
18[a]. I do not worry about environmental problems.	80	79
19. Sustainability is about balancing economic development with environmental conservation and fairness.	74*	70

(continued)

Table 1. (continued)

	% Agree or *strongly agree*	
Baseline survey constructs and questions	Jail	Prison
20. Sustainability is about conserving resources, so that they are available to future generations.	86*	82
21. In order to conserve resources, I would be willing to take personal action such as using less water and turning off lights.	92*	88
22. Environmental protection benefits everyone.[b]	94*	91
	88	**84**
Behavioral Intentions Related to Science (F = 13.63, p < .001*; mean difference = −0.137)		
23[c]. How likely are you to look for information about science (for example, on television or in newspapers)?[b]	77*	71
24[c]. How likely are you to talk to someone in the jail/prison about issues related to science?[b]	64*	61
	71	**66**
General Education or Job Training (F = 2.63, p = .105)		
25. I would like to continue my education.	95*	92
26. I am interested in vocational education or job skills training.	89	88
	92	**90**
Science Education (F = 30.06, p < .001*; mean difference = −0.275)		
27. I would enjoy studying science while I'm in jail/prison.[b]	91*	82
28. I would like to participate in a science project during my time in jail/prison (such as raising endangered butterflies or endangered plants).	93*	84
	92	**83**
Math Education (F = 7.30, p = .010*; mean difference = −0.140)		
29. I would enjoy studying math while I'm in jail/prison.[b]	82*	72
30. I am sure that I can learn math.	90*	88
	86	**80**
Employment Related to the Environment (F = 42.44, p < .001*; mean difference = −0.363)		
31. When I leave jail/prison, I would prefer a job where I work with plants or animals.[b]	73*	56
32. When I leave jail/prison, I would prefer a job that helps protect the natural environment.[b]	76*	64

(continued)

Table 1. (continued)

Baseline survey constructs and questions	% Agree or *strongly agree* Jail	Prison
33. I would like to spend time in jail/prison learning skills I could use in a "green" job when I leave jail/prison. (Green jobs are those that help improve the environment.)	84*	73
	78	**64**
Incarceration ($F = 6.59$, $p = .013$*; mean difference = 0.140)		
34. My family or friends outside jail/prison know what sort of work or programs I am involved in here.	58	72*
35. I don't feel like I am part of a community inside this jail/prison.	47*	43
36. Even though I am in jail/prison, I still feel connected to the outside community.	37	40*
37. Even though I am in jail/prison, it is important to me to contribute to the outside community if I can.	86	84
	57	**60**
Logistics ($F = 37.42$, $p < .001$*; mean difference = −0.272)		
38[a]. I do not like filling out surveys.	52*	33
39. I would be willing to complete a longer survey than this one.	72*	61
	62	**47**

Note: Analysis of variance tests were used to compare factor scores for each survey construct (results shown after category heading; mean difference between factor scores, prison relative to jail, for significant results). Wilcoxon rank sum tests were used to compare raw Likert-type scale data between institutions for individual survey questions. Mean percentage scores for each question category are in boldface.
[a]Questions with reversed polarity; percentages represented are for *disagree* or *strongly disagree*. [b]Similar or identical question also appears on lecture surveys. [c]Behavioral Intention questions; percentages represented are for *likely* or *very likely*.
*$p < .05$, after correction for multiple comparisons using the false discovery rate method.

Our demographic analysis included comparisons of inmates within each institution based on gender, ethnic background, and highest level of education attained (Table 2). No significant differences in survey constructs were found between men and women inmates at the jail. However, among prison inmates, men had significantly more positive scores ($p < .05$; ANOVA) in 7 of 10 survey constructs. For the analysis incorporating ethnic background, minorities had significantly more positive scores ($p < .05$; ANOVA) than White, non-Hispanic inmates in one survey construct (Math Education) at the

Table 2. Results From demographic Analysis (Gender, Ethnic Background, and Education Level) of Institution-Wide Baseline Surveys for Inmates at the Salt Lake County Jail and Utah State Prison.

	Gender		Ethnicity		Education	
Baseline survey constructs	*F*	Difference	*F*	Difference	*F*	Difference[a]
Jail						
Identity With Science and Scientists	3.40		1.75		8.53*	$HS^+ > HS, HS^-$
Science and Math Connection to Life	2.60		1.38		6.62*	$HS^+ > HS, HS^-$
Relationship With the Environment	1.80		0.58		2.40	
Behavioral Intentions Related to Science	2.84		4.48		11.07*	$HS^+ > HS, HS$
General Education or Job Training	0.86		0.10		1.05	
Science Education	0.18		2.10		1.71	
Math Education	1.04		1.68		3.61	
Employment Related to Environment	0.10		1.12		0.07	
Incarceration	0.80		1.58		2.18	
Logistics	0.43		0.94		5.00*	$HS^+, HS^- > HS$
Prison						
Identity With Science and Scientists	9.35*	♂ > ♀	1.17		31.90*	$HS^+ > HS, HS^-$
Science and Math Connection to Life	4.81*	♂ > ♀	0.31		12.04*	$HS^+ > HS, HS^-$

(continued)

Table 2. (continued)

	Gender		Ethnicity		Education	
Baseline survey constructs	*F*	Difference	*F*	Difference	*F*	Difference[a]
Relationship With the Environment	8.06*	♂ > ♀	1.32		4.50*	$HS^+ > HS$
Behavioral Intentions Related to Science	51.69*	♂ > ♀	1.06		23.02*	$HS^+ > HS, HS^-$
General Education or Job Training	0.85		6.47		1.17	
Science Education	2.35		0.28		8.17*	$HS^+ > HS$
Math Education	5.24*	♂ > ♀	9.42*	M > W	8.52*	$HS^+ > HS$
Employment Related to Environment	8.35*	♂ > ♀	0.72		2.37	
Incarceration	2.36		0.25		0.74	
Logistics	11.05*	♂ > ♀	0.90		7.33*	$HS^+ > HS, HS^-$

Note: Analysis of variance tests (with post hoc Dunn tests for three-group comparisons) were used to compare data from demographic groups using factor scores for each survey construct. For gender, we compare self-identified men (♂) and women (♀). For ethnic background, we compare White, non-Hispanic (W) to all minorities (M) pooled, given the low proportion of minorities in our sample. For education level, we compare those that have attained a GED or high school diploma (HS), those with less education (HS^-), and those with more education (HS^+). Relationships between mean differences in construct factor scores are indicated when significant differences were found.

[a]Differences shown only if significant ($p < .05$) using post hoc Dunn tests with correction.

*$p < .05$, after correction for multiple comparisons using the false discovery rate method.

prison, whereas no differences were found at the jail. For the analysis based on educational level, we found significantly more positive scores with greater levels of educational attainment in four survey constructs at the jail (Identity With Science and Scientists, Science and Math Connection to Life, Behavioral Intentions Related to Science, and Logistics) and in seven constructs at the prison (all except General Education or Job Training, Employment Related to Environment, and Incarceration; $p < .05$; ANOVA with post hoc Dunn tests).

Staff baseline survey data indicated generally positive responses (Table 3), with the highest scores in the categories of Relationship With the Environment and Identity With Science and Scientists. Scores were fairly positive in the other three categories: Science Education, Math Education, and Science and Math Connection to Life. There were no significant differences between survey constructs or individual survey question responses by jail and prison staff.

When comparing staff and inmate responses within institutions, inmates had significantly more positive responses ($p < .05$; ANOVA) in all five survey constructs at both facilities and in 20 of 24 comparable individual survey questions at the jail and in 22 of 24 at the prison (Table 3). An important note for interpreting the results of individual survey questions comparing staff and inmate data is that for six of these comparisons (2 for jail data, 4 for prison data), inmates had higher mean Likert-type scale scores while, simultaneously, staff had higher values for % *agree* or *strongly agree.* This occurred because, in these cases, inmates had proportionally more *strongly agree* responses (Likert-type scale score = 5) than staff, who had proportionally more *agree* responses (Likert-type scale score = 4).

Lecture Surveys

Demographics. Participating inmates ($n = 395$ and 167 unique participants at the jail and prison, respectively) at both institutions were mostly White non-Hispanic (62% and 80%). Hispanics made up the largest proportion of minority groups (24% and 13%). For highest level of educational attained, the largest category in both the jail and prison was a high school diploma (32% and 35%), followed by "some college" (18% and 27%) and "some high school" (18% and 8%).

Survey Responses. Analysis included 521 matched pre- and postlecture surveys (23 lectures, 395 unique participants) from the jail and 402 matched surveys (12 lectures, 167 unique participants) from the prison (Table 4). Lecture-specific science content knowledge increased from pre- to postlecture surveys at both the jail (58% to 84% of questions answered correctly) and

Table 3. Summary of Responses From Institution-Wide Baseline Surveys for Staff at the Salt Lake County Jail and the Utah State Prison.

Baseline survey constructs and questions	% *Agree* or *strongly agree*	
	Jail (n = 57)	Prison (n = 247)
Identity With Science and Scientists ($F = 0.03$, $p = .948$)		
Jail inmates/staff: $F = 9.08$, $p = .003$*; mean difference = 0.175		
Prison inmates/staff: $F = 13.19$, $p < .001$*; mean difference = 0.099		
1[a]. Only highly trained scientists can understand science.[b]	93 I	84 S
2. Scientists are not so different from me.	69 N	64 I
3[a]. Scientific work is useful only to scientists.	90 N	91 I
4[a]. Scientific work would be too hard for me.[b]	83 N	77 N
5. Working in science or learning about science would be fun.	76 I	82 I
	82	**80**
Science and Math Connection to Life ($F = 0.66$, $p = 0.948$)		
Jail inmates/staff: $F = 20.65$, $p < .001$*; mean difference = 0.453		
Prison inmates/staff: $F = 72.91$, $p < .001$*; mean difference = 0.517		
6. Science helps me in my daily life.[b]	72 I	74 I
7. Math helps me in my daily life.	81 I	82 I
8. More science education would be good for my professional advancement.	55 I	53 I
9. More math education would be good for my professional advancement.	64 I	56 I
10. Science education will help offenders get jobs when they leave jail/prison.	53 N/A	48 N/A
11. Math education will help offenders get jobs when they leave jail/prison.	64 N/A	71 N/A
	65	**64**
Relationship With the Environment ($F = 1.25$, $p = 0.948$)		
Jail inmates/staff: $F = 26.85$, $p < .001$*; mean difference = 0.594		
Prison inmates/staff: $F = 87.83$, $p < 0.001$*; mean difference = 0.604		
12. The earth has plenty of natural resources if we just learn how to develop them.	74 I	79 I
13. Engaging in actions that help the earth, such as recycling and reducing waste, is important to me.	84 I	87 I

(continued)

Table 3. (continued)

	% Agree or *strongly agree*	
Baseline survey constructs and questions	Jail ($n = 57$)	Prison ($n = 247$)
14. I think of myself as a part of nature, not separate from it.[b]	74 I	79 I
15. I really enjoy being outdoors.	95 I	93 I
16. I would like to learn to grow my own vegetables.	81 I	78 I
17. I feel a personal bond with things in my natural surroundings, like trees, a stream, wildlife, or the view on the horizon.	72 I	68 I
18[a]. I do not worry about environmental problems.	79 N	76 I
19. Sustainability is about balancing economic development with environmental conservation and fairness.	71 I	75 I
20. Sustainability is about conserving resources, so that they are available to future generations.	89 I	86 I
21. In order to conserve resources, I would be willing to take personal action such as using less water and turning off lights.	89 I	88 I
22. Environmental protection benefits everyone.[b]	89 I	81 I
	82	**81**
Science Education ($F = 0.26$, $p = .948$)		
Jail inmates/staff: $F = 42.66$, $p < .001$*; mean difference = 0.613		
Prison inmates/staff: $F = 73.65$, $p < .001$*; mean difference = 0.468		
23. I would enjoy studying science.[b]	81 I	78 I
24. Science education will improve offenders' lives while they are in jail/prison.	64 N/A	63 N/A
25. A lecture series on science would be worthwhile to implement at this jail/prison.	66 I	63 I
	70	**68**
Math Education ($F < 0.01$, $p = .948$)		
Jail inmates/staff: $F = 27.83$, $p < 0.001$*; mean difference = 0.503		

(continued)

Table 3. (continued)

Baseline survey constructs and questions	% Agree or *strongly agree* Jail (n = 57)	Prison (n = 247)
Prison inmates/staff: $F = 67.99$, $p < .001$*; mean difference = 0.421		
26. I am sure that I can learn math.	89 I	85 I
27. I would enjoy studying math.[b]	52 I	51 I
28. Math education will improve offenders' lives while they are in jail/prison.	68 N/A	69 N/A
	70	**68**

Note: Wilcoxon rank sum tests were used to compare data from each location using the first factor for each survey construct (results shown after category heading; mean difference between factor scores, prison relative to jail, for significant results), to compare staff to inmate survey construct factors (results shown below category heading; mean difference between factor scores, inmates relative to staff, for significant results), and to compare raw Likert-type scale data between staff and inmates at each institution. Mean percentage scores for each question category are in boldface.

[a]Questions with reversed polarity; percentages represented are for *disagree* or *strongly disagree*. [b]Similar or identical question also appears on lecture surveys.

*$p < .05$, after correction for multiple comparisons using the false discovery rate method. Significantly greater values in groups ($p < .05$, after correction for multiple comparisons): I: inmates; S: staff; N: no difference; N/A: no comparison (no comparable question on Inmate Baseline Survey).

Table 4. Summary and Comparisons of Pre- and Postlecture Survey Responses for Science Lectures Given at the Salt Lake County Jail (n = 23 Lectures, 521 Matched Surveys From 395 Unique Participants) and Utah State Prison (n = 12 Lectures, 402 Matched Surveys From 167 Unique Participants).

	% Agree or *strongly agree*			
	Jail		Prison	
Lecture survey constructs and questions	Pre	Post	Pre	Post
Content questions (3 lecture-specific questions per survey, combined for analysis)				
1-3[a]	58	84*	67	89*
Attitude questions				
Jail: $V = 16{,}784$, $p < .001$*; mean difference = 0.014				
Prison: $V = 2{,}076$, $p < .001$*; mean difference = 0.069				
Identity With Science and Scientists				
4[b]. Only highly trained scientists can understand science.	86*	79	90	88
5[b]. Scientific work would be too hard for me.	68	70	81	84

(continued)

Table 4. (continued)

	% *Agree* or *strongly agree*			
	Jail		Prison	
Lecture survey constructs and questions	Pre	Post	Pre	Post
Science and Math Connection to Life				
6. Science helps me in my daily life.	84	88*	88	94*
7. Knowing math will help me earn a living.	88	88	88	90
Relationship With the Environment				
8. I think of myself as part of nature, not separate from it.	86	88*	94	95
9. Environmental protection benefits everyone.	85	88*	91	93*
Science Education				
10. I would enjoy studying science.	81	83*	86	90*
Math Education				
11. I would enjoy studying math.	70	70*	65	66
Employment Related to the Environment				
12. In general, I would prefer a job where I work with plants or animals.	54	63*	67	72*
13. I would like a job that helps to protect the natural environment.	72	78*	80	83
Behavioral Intentions Related to Science				
Jail: $V = 10{,}158$, $p < .001$*; mean difference = 0.013				
Prison: $V = 1{,}944$, $p = .011$*; mean difference = 0.032				
How likely are you to . . .				
14[c]. look for information that is related to science (for example, on television or in newspapers)?	70	75*	86	89*
15[c]. look for information that is related to the topic of today's lecture?	61	70*	79	83*
16[c]. talk to someone in the prison about issues related to science?	51	60*	83	84*

Note: Wilcoxon signed rank tests were used to compare pre-post data from each location using factor scores for each survey construct (results shown below category heading; mean difference between factor scores, postlecture survey relative to prelecture survey, for significant results; data include first lecture only for each participant) and to compare raw Likert-type scale data between pre- and postlecture surveys (full data set).
[a]Recoded from a 5-point Likert-type scale such that responses of 4 (*agree*) and 5 (*strongly agree*) indicate correct answers. [b]Questions with reversed polarity; percentages represented are for *disagree* or *strongly disagree.* [c]Behavioral intention questions; percentages represented are for *likely* or *very likely.*
*$p < .05$, after correction for multiple comparisons using the false discovery rate method.

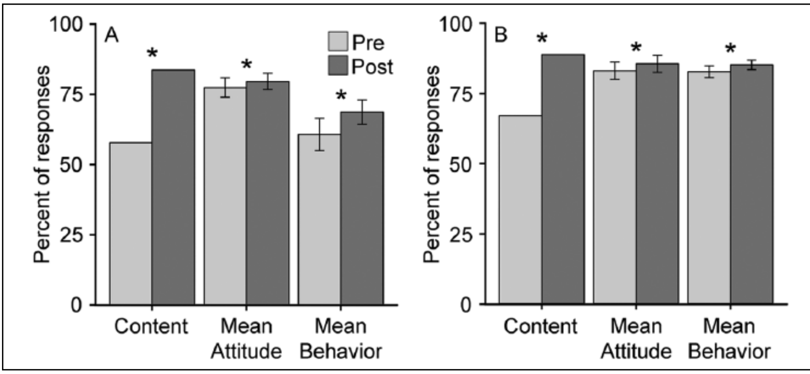

Figure 1. Summary of lecture survey data before (pre) and after (post) science lectures: Data from (A) the Salt Lake County Jail and (B) the Utah State Prison.
Note: Percentages are given for content questions answered correctly (Questions 1-3, data pooled), attitude questions answered with *agree* or *strongly agree* (Questions 4-13, mean), and behavioral intention questions answered with *likely* or *very likely* (Questions 14-16, mean). For each question type, mean response values (and construct scores; see Table 4) increased significantly from prelecture to postlecture ($p < .05$, Wilcoxon signed rank tests with correction for multiple comparisons). For two attitude questions (4 and 5) with reversed polarity, responses represented are for *disagree* or *strongly disagree*. See Table 4 for survey questions and average responses.

prison (67% to 89%; $p < .05$; Wilcoxon signed rank tests). Inmates' attitudes about science, math, and nature (Attitude construct) became significantly more positive from pre- to postlecture ($p < .05$; Wilcoxon signed rank tests; data from first lecture attended for each participant only). Likewise, individual question scores increased in 7 of 10 questions at the jail and 4 of 10 questions at the prison. In one question at the jail (Question 4: Only highly trained scientists can understand science), attitude became more negative from pre-to postlecture. The Behavioral Intention construct also increased from pre- to postlecture ($p < .05$; Wilcoxon signed rank tests; data from first lecture attended for each participant only). Individual survey questions indicated that inmates were significantly more likely to seek out science media and were more likely to talk about science with others after the lecture than before. Results from the subset of data that included each participant only one time (first lecture only) were nearly identical to the results from the full data set. When combining data by question type (content knowledge, attitude, or behavioral intention), mean Likert-type scale scores increased in all three categories for both the jail and prison data ($p < .05$, Wilcoxon signed rank tests; Figure 1). The magnitude of increase in scores from pre- to postlecture was similar for content knowledge and attitude questions at the jail and prison whereas scores for behavioral intention questions increased more at the jail than at the prison.

Discussion

Although incarcerated populations are often characterized as having poor educational backgrounds, being disinterested in learning, and having few tools or desires to seek higher education, our results depict incarcerated audiences as being interested in, capable of, and desirous of science education. In both the jail and the prison, the lecture series produced considerable increases in science content knowledge (pre- to postlecture increases); increases in positive attitudes related to science, math, and nature; and an increase in the self-reported likelihood that inmates would seek out science media and talk about science with others.

There are four limitations to consider when interpreting these results. First, the voluntary nature of this program may have influenced the results of our surveys. Both attendance at the science lectures and completion of pre- and postlecture surveys were voluntary. This may have selected for attendees who were more likely to respond positively on surveys. Second, both response bias and pleasing bias may have influenced our results, given the limited opportunities for inmates to engage with outside parties and the limited number of programming options available within correctional institutions. Third, survey questions about employment (e.g., "I would like a job that helps to protect the natural environment") are difficult to interpret given that most inmates are not employed and thus may have a desire for any type of job. Finally, logistical constraints (e.g., limited access to inmates, high turnover rates of attendees, and lack of ability to contact inmates after our science lectures due to institutional security rules) prevented us from obtaining measures of the durability of changes in science content knowledge and perspectives on science.

Because our survey design was constrained by both logistics (institutional rules) and participant inclusion (to accommodate a very broad range of literacy and educational background), our survey instruments were not directly calibrated with measures from other studies of science literacy or attitudes about science among the general public. However, levels of interest in and attitudes about science in our sample of inmates are remarkably to similar or even exceeded those of the general public, as reported in three measures of science literacy of the U.S. population. First, in a longitudinal study of science literacy of the general public, Miller (2004) reported that approximately 80% of respondents rated that the world was better off and had more opportunities due to science, and that 72% of general public audiences stated that the benefits of science are much or slightly greater than the harms of science. A second nationwide survey in 2014 (Pew Research Center, 2015b) of 2,000 members of the general public indicated that 79% of adults think that science has made life easier for most people and that a majority are positive about scientists' impact on the quality of life. Similarly, more indicated that science has had a positive (62%) rather than negative (31%) impact on the quality of the environment today. The responses from inmates' surveys closest to these assessments indicated a comparable level of positivity: 72% to 86% of inmates viewed science and math as being an important part of their lives (Table 1).

Many inmates saw themselves as interested in (78% to 92%) and capable of (68% to 82%) science, and that they would "sign up for a university presentation if it were available" (78% to 90%). On institution-wide baseline surveys, the mean percentage of positive responses for questions based on interest and connection to science, math, and nature ranged from 75% to 88%. Inmates were enthusiastic about science and math education (80% to 92% positive responses) and employment related to the environment (64% to 78% positive responses). Inmates were also fairly likely to seek out science media and talk with others about science (66% to 71%).

Science/math/nature positivity was higher among jail inmates compared to prison inmates. This result is important because it may reflect one of the effects of the duration of incarceration. Prison sentences are generally greater than a year, whereas the length of incarceration in jails is much shorter. At the Salt Lake County Jail, for example, the average length of stay is 20 days and 55% of inmates are released from jail within 3 days (Salt Lake County Auditor, 2001). The effects of jail and prison incarceration on inmates differ in other ways that may lead to differences in perspectives, such as a focus outward (on release and outside support community) versus inward (on personal security and self-reliance) for jail and prison inmates, respectively (Gibbs, 1975).

We found that jail and prison staff also had generally positive attitudes: Mean percentage of positive responses for Identity With Science and Scientists, Science and Math Connection to Life, and Relationship With the Environment questions ranged from 64% to 82%. When using staff as a proxy for the general U.S. population (these groups have similar demographics and education levels; U.S. Census Bureau, 2010, 2016), we found that inmates had more positive scores in all five survey constructs at both institutions.

Our demographic analysis of inmates indicated that men, as compared to women, at the prison had more positive identity with and connection to science, more positive views of math education, and greater interest in employment related to the environment. These results are similar to those from other studies, which have shown that women generally have less interest in science and technology (National Science Board, 2014; Pew Research Center, 2015a), less favorable attitudes toward science (Hayes & Tariq, 2000), and constitute a larger percentage of "science pessimists" than men (Nisbet & Markowitz, 2014). Studies of student populations have also shown strong gender-stereotyped patterns of science-related attitudes and engagement, including lower levels of optimism and confidence about science among girls (reviewed in Osborne, Simon, & Collins, 2003) that is associated with lower participation by girls in physics (e.g., Gill & Bell, 2013) and other secondary science courses (e.g., Mack & Walsh, 2013). Interestingly, we found no gender differences in survey constructs at the jail.

We found few differences based on ethnic background, though minorities at the prison were more positive view of math education (Math Education construct). Education level had a strong effect on attitude and behavioral intentions related to science, math, nature, and science and math education. Generally, more positive scores for these questions were associated with higher levels of education. These results are consistent with previous studies that have shown strong associations between science positivity and interest and the levels of both formal and science-/math-specific education (National Science Board, 2014; Nisbet & Markowitz, 2014).

Our results are derived from a large sample of inmates in Utah, from which we suggest that interactive science lectures and additional ISE approaches may be of use for incarcerated population. Our results also provide support for the implementation of more science education within prisons and jails, which is consistent with recent reports on the impacts of corrections education in general (Davis et al., 2013; Vacca, 2004). Inmates benefit through increased access to science information and direct exposure to the ways scientists think and act that would otherwise seem or be unreachable. Because only a few prisons offer anything beyond basic education (GED, vocational certificates, high school, and with a very few exceptions, higher education, mostly in the social sciences), informal lectures given by scientists appear to foster the four strands of informal science learning (see above) by providing advanced science content knowledge as well as increasing understanding of the processes and participants in science. Benefits for the corrections community include (1) occupying inmates with topics other than dissatisfaction with their condition, (2) providing awareness of job skills needed in the STEM workforce after release, and (3) improving the image of prisons in the larger community.

Although we did not formally assess benefits for scientists of this practice, we gained anecdotal information (from brief voluntary anonymous online surveys of presenters) that such benefits can include the following: (1) directly engaging and raising scientific awareness and appreciation in a novel and non-traditional, (2) potentially gaining new scientific insights from a diverse audience with unique perspectives, (3) fulfilling Broader Impacts for National Science Foundation grant requirements in powerful and visible ways, and (4) potentially recruiting new students to scientific study—some offenders expressed a keen desire to pursue such work after release. Future work should focus on this area.

Our approach—the delivery of live ISE lectures by scientists—is distinct from the growing number of higher education programs in correctional institutions, which involve faculty teaching programs with a unified curriculum in a given discipline, assessing content knowledge with tests, and awarding academic credit. These tend to involve far more logistical work and cost more to inmates or to an institution than our program, with funds needing to be raised to offset tuition. Participation in college-level classes and/or vocational programs is based on the inmate receiving approval from prison administration, passing entrance exams, and having money to pay all or part of the tuition. Formal correctional science education also has a higher profile and is less "nimble" than informal science lectures, as topics from our different scientists were not constrained by needing to follow a preset curriculum (Chappell, 2004). Our informal science lecture series required only a memorandum of understanding (reviewed and renewed annually) between the correctional institutions and the University of Utah, as well as IRB permissions.

A growing number of corrections administrators and policy makers now recognize that education improves inmates' chances of not returning to prison. Inmates who participate in correctional education programs had 43% lower odds of recidivating than those who do not, which translates to a reduction in the risk of recidivating of 13% (Davis et al., 2013). Education also improves inmates' chances of obtaining employment after release: Those with education had odds that were 13% higher than the odds for those who did not participate in correctional education (Davis et al., 2013).

Providing correctional education can be cost-effective when it comes to reducing recidivism. The 2013 RAND study (Davis et al., 2013) estimated that the direct costs of providing correctional education are cost-effective compared with the direct costs of reincarceration. Because the analysis accounts only for direct costs and not for such things as the financial and emotional costs to crime victims and costs to the criminal justice system as a whole, this is a conservative estimate of the broader effect correctional education could yield. The cost of our program was very low: the salary of a part-time program manager (recruited scientists, worked with presenters to develop lecture content, arranged security clearances, administered IRB protocols, and analyzed evaluations), modest stipends for lecturers, transportation between the university and the corrections institutions, and services of a professional external evaluator. Our program of two science lectures per month cost approximately US$43,000 per year for 12 lectures each in the Salt Lake County Jail and Utah State Prison, which is equivalent to US$45/inmate/year or US$4/inmate/month. Costs for the correctional institutions were minor, as the lectures "piggybacked" on existing security regimes and officers placed posters as part of their regular rounds.

The RAND analysis (Davis et al., 2013) also highlighted a continuing need to understand the processes behind effective corrections educations programs, such as curriculum, quantity, frequency, and quality to inform policy and funding decisions. We recognize that our evaluation approach assessed short-term changes in content knowledge, attitudes, and behavioral intentions and that longitudinal studies will be needed to assess the longer term effects of science lectures. Science learning researchers must invest in well-designed evaluations of correctional education programs with rigorous research designs to examine questions related to potential selection bias and program quantity and frequency and to also measure more proximal outcomes, such as changes in motivation, literacy gains, developing skills needed by local employers, and attaining academic degrees and industry-recognized certificates to help states making strategic decisions on whether and how to recalibrate programs to adjust to changes in funding.

The situation that we have documented with the baseline and lecture surveys of incarcerated populations' reception of informal science presentations leads to the conclusion that men and women in jails and prisons present an appropriate audience for science information and contact with scientists, and may represent a potential but overlooked source of contribution to the scientific enterprise. Although being successful at participating in and learning from science lectures is only a first step to higher education or the STEM workforce, bringing together people of diverse backgrounds and ways of knowing is of benefit to global science. Even if ISE activities do not motivate this population to choose to be direct participants in science, positive exposure of inmates and corrections staff may result in a more informed citizenry and help bridge the presently large gap in trust between the scientific community and a segment of the public that rarely benefits from science communication and education.

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