Indianapolis Residents' Understanding of & Engagement with STEM & Urban River Ecology

Project: **Indianapolis: City as a Living Laboratory**

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Executive Summary

A mixed-methods series of surveys were used to explore public literacy related to environmental science and sustainability in Indianapolis. Surveys also explored predictive variables including environmental identity, nature affinity, use of nature places as learning opportunities, and motivations for visiting nature spaces. An online, citywide consumer survey was distributed alongside a parallel identical survey of employees at a major science-based corporation to assess variation in knowledge, attitudes, and learning behaviors. This science-based corporation provides substantial support to the restoration and improvement of the city's waterways and cultural institutions. Through the company's commitment to an annual day of service, staff remediate public and environmental spaces in the city. A third survey was undertaken at five public nature space locations adjacent to the five major waterways that traverse Indianapolis.

Results demonstrated that employees of the company that invests in environmental restoration as a day of service activity learn about important earth science topics that can help them be more informed decision-makers. These employees, however, are also less likely than general residents to use the city's nature spaces and cultural centers for informal science learning. This result suggests that science literacy can be advanced when cultural institutions, nature spaces, and volunteer activities are situated as complementary vectors for learning and public discourse about science topics.

INTRODUCTION

In 2013, the Center for Urban Ecology at Butler University was awarded a National Science Foundation grant (#DRL-1323117) to explore informal science learning opportunities on public lands in Indianapolis, Indiana. The five-year project, entitled *Indianapolis City as a Living Laboratory: Science Learning for Resilient Cities* (I/CaLL), investigates how different types of art can be used as conduits for informal science learning on a citywide scale. The project set out to explore art and art process as a new strategy for enhancing informal science education for environmental sustainability. As a collaborative endeavor, the project brought together earth science researchers, artists committed to exploring environmental issues, and social scientists who sought to explore cultural phenomena related to professional collaborations and public encounters with the art products.

Butler University collaborated with Indiana University - Purdue University Indianapolis (IUPUI), Mary Miss/City as Living Laboratory, Reconnecting to Our Waterways (ROW), and New Knowledge Organization Ltd. (NewKnowledge), in addition to individual artists and curators on the project.

This report describes the results of a benchmarking study conducted in 2013 to address how we might measure and define scientific literacy for environmental sustainability in a community, growth opportunities, and possibilities for place-based science learning in public spaces where art–science collaborative installations or events might be located.

Background & Literature

Urban ecosystems play a large role in environmental sustainability, making it important to increase environmental awareness among city residents (Grimm et al., 2008). In particular, urban water systems and the increasing prevalence of water scarcity are intrinsically linked with global social and environmental issues such as poverty, habitat degradation, land management, and social inequality (ICA, 2012; Vairavamoorthy, Gorantiwar, & Pathirana, 2008). These areas of concern combined with a perceived lack of public knowledge about urban water systems point to a need for innovative education interventions to increase awareness and informed action on urban water sustainability.

Public art has been proposed as an effective medium for conveying environmental and conservation information to a large audience because of its profound, accessible, and engaging nature (Bagdassarian, 2009; Barnett & Whittle, 2006; Jacobson, McDuff, & Monroe, 2007; Mandelbrojt, 2006; Rubin, 2008; Tolisano, 2007). To date, however, little research has explored the impacts of coupling public art and environmental learning in urban spaces (see, however, Curtis, 2003; Motoyama & Hanyu, 2014).

Guided by the following key questions, I/CaLL researchers are studying how artistic installations and programs at Indianapolis waterways can promote community engagement and science learning among city residents: 1) How do art experiences prompt science reasoning?; 2) How can we measure and define scientific literacy, growth, and vectors for science learning in a community?; and 3) How does informal science learning happen as part of family and civic life outside the home? This benchmarking study focused on gaining insight into the second and third research questions.

METHODS

This benchmarking study of science knowledge and connections to waterways comprised three parallel mixed-methods studies to characterize the context for the project. First, a single quantitative online survey instrument was distributed simultaneously to two distinct populations, Indianapolis residents and staff at a local pharmaceutical company, Eli Lilly, which supports a day of staff community service involving river restoration efforts. Second, in parallel to the online survey study, we conducted a series of qualitative intercept surveys with visitors to the six sites where I/CaLL artwork was installed. All research was conducted under the auspices of the IUPUI Institutional Review Board (Study #1308038463).

For the online survey study, we selected these two groups – general Indianapolis residents and staff at Eli Lilly – based on the hypothesis that the day of service may contribute to environmental science literacy, or that working for a science-based company may develop among employees a higher level of environmental science literacy than that found among residents overall. Regardless of the results, researchers felt that pharmaceutical company staff may be an important vector for advancing broader public science literacy through channels such as family interactions, social networks, and public discourse.

Citywide & Eli Lilly Survey

Recruitment

The online survey was distributed to Indianapolis residents and staff at the local pharmaceutical company. We used an online sample recruitment company, Soapbox, to recruit a panel of 1,000 Indianapolis residents to take the online survey (i.e., Citywide Survey). Recruitment for the Citywide Survey was balanced to reflect the demographics of Indianapolis residents. Our contact at Eli Lilly emailed the same survey instrument to Eli Lilly staff (i.e., Eli Lilly Survey). The survey took about 10 to 15 minutes to complete. All survey responses were anonymous and individuals had to be over 18 years of age to participate.

Instrument

The majority of the survey was composed of quantitative scale items. The scales were:

- *Psychosocial motivations for nature experiences*, which focused on reasons participants choose to spend time in Indianapolis' outdoor green spaces;
- *Sense of place*, which focused on how Indianapolis waterways related to participants' lives, including identifying the emotions they elicit and the personal enjoyment that participants receive from these places (Jorgenson & Stedman, 2001);
- *Environmental identity*, which focused on how participants think about and interact with nature, including how nature helps to define them (Winter & Chavez, 2008; Clayton, 2003);
- *Environmental behaviors*, which focused on the extent to which participants engaged in pro-environmental behaviors such as recycling, composting, writing letters supporting environmental issues, and taking public transportation (Schultz & Zelezny, 1999); and
- *Use of informal science learning settings*, which focused on understanding how often participants visit informal learning settings, such as parks in the city, green spaces near the river, museums, botanic gardens, and aquariums.

The survey also included two open-ended questions gauging participant knowledge about two randomly selected science concepts. The items were selected from a list of 22 concepts that the project team identified as relevant to the waterways of Indianapolis and which later informed all subsequent project work, including art installations. For this survey, we collapsed two pairs of related concepts for a total of 20 concepts (Table 1). The question was *How do you think the following issue affects Indianapolis waterways?* We received about 100 responses per concept, which allowed us to gauge baseline understanding and awareness of science topics related to the I/CaLL project. (See Appendix A for the full survey instrument).

Table 1. I/CaLL science concepts explored in the Citywide & Eli Lilly Survey study.

1	Health effects of chemical pollution in water.
2	Health effects of bacterial water pollution.
3	Health effects of pharmaceuticals in waterways.
4	Indianapolis's Deep Rock Tunnel.
5	Natural habitats in urban waterways.
6	The effects of invasive species.
7	The flow of nutrients in urban waterways.
8	Pollutants flowing through urban waterways.
9	Urbanization impacts on our waterways.
10	Urban heat island affects on local weather patterns.
11	Managing urban storm water.
12	The impact of cities on local groundwater.
13	Water leakage in the urban water infrastructure.
14	How we can restore urban streams.
15	Creating healthy urban aquatic ecosystems.
16	Legal issues around urban watershed management.
17	Designing sustainable water supplies for cities.
18	How we should manage urban water allocation.
19	How engineered water systems affect urban waterways.
20	Land use impacts on stream health.

Analysis

We analyzed quantitative data using the psych package in RStudio (version 1.5.1; Revelle, 2015). We reverse coded the appropriate items and calculated reliability for the five scales, judging a scale to be reliable if the standardized Cronbach's α was greater than 0.70 (Nunnally & Bernstein, 1994). All scales were reliable (Appendix B), so we calculated the mean for all items in a scale and used these aggregate variables for further analyses.

We conducted ANOVA tests to assess differences between the groups (i.e., respondents to the Citywide versus Eli Lilly surveys) and Pearson's correlation tests to identify correlations among items and scales. We judged tests to be significant if $p < 0.05$.

Two researchers independently coded 20% of the responses to the open-ended questions gauging knowledge about the 20 science concepts, using a 4-level coding scheme (0 = none, 1 = little, 2 = moderate, 3 = expert) to rate respondents' knowledge. Inter-rater reliability was high, ranging from 77% to 98%, so one rater coded the remaining responses for all questions. The survey included responses to two science concepts; we analyzed the topics separately, and took the average of the two scores to obtain an overall knowledge score.

We conducted a regression analysis to understand if aggregated scale variables predicted overall knowledge score.

Participants

We received 1,322 responses to the Citywide Survey and 300 responses to the Eli Lilly Survey. We removed all responses for which consent was declined, the respondent was under the age of 18 or located over two degrees latitude or longitude outside the Indianapolis area, or the respondent provided unintelligible responses to open-ended questions. The final citywide dataset included 1,011 respondents and the final Eli Lilly dataset included 262 respondents, for a total of 1,273 respondents.

Our survey was sent to a representative sample of city residents across Indianapolis, based on US Census Bureau statistics from 2010 (US Census Bureau, n.d.). However, the sample of respondents is not representative in several demographic categories. Our sample was more female and White than the representative population of Indianapolis, yet reflected city resident demographics with respect to age, income, and home ownership.

Sixty-eight percent of our sample identified as female compared to the citywide population of 59%, while 85% of our sample identified as White compared to the citywide population of 62%. Likewise, only 8% identified as African American, 3% as Hispanic, and 2% as Asian American, compared to the citywide population, which is 28% African American, 9.7% Hispanic, and 2.6% Asian American.

Respondents to the Citywide Survey represented all age categories, however, the largest percentage of respondents was 25 to 34 years old (21%), reflecting a similar yet slightly younger population than the median age of Indianapolis citizens, 34 years, as determined by the US Census data (US Census Bureau, n.d.). Respondents were also representative of the city's income levels; the largest percentage indicated an annual household income of \$20,000–\$39,999 (29%), and 2010 census data similarly suggests that 27.8% of Indianapolis residents earned between \$25,000 and \$50,000. More than half (57%) of participants owned their home, compared to the 2010 census finding of 53.7% home ownership citywide. For detailed demographics, see Appendix C.

Respondents to the Eli Lilly Survey were more unevenly distributed across the age categories, with the largest representation being adults between 45 and 54 years of age (36%). Fifty-seven percent of respondents were female. Almost all respondents (94%) identified as White; 5% were Hispanic. Respondents were concentrated in the higher household income levels, with 66% making more than \$100,000/year, and 17% making between \$80,000 and \$100,000/year. Most (81%) owned their home. The largest percentage of respondents had lived in their neighborhoods for 10 to 20 years (31%). For detailed demographics, see Appendix C. Researchers could not locate company data, so we were unable to discern whether these respondents were representative of the company's overall demographics.

Intercept Survey at Waterway Sites

Recruitment

I/CaLL project leadership identified sections of six waterways in Indianapolis as ideal sites for public art installations aimed at exploring how to advance science literacy in a community by linking science education to environmental sustainability. These sites were chosen based on their potential to connect local people to the waterway, show improved ecological conditions, create economic opportunities, and increase the well-being of citizens. Partway through the project, one site – Little Eagle Creek – was eliminated because there were few visitors to the site, resulting in a total of five sites. Seven data collectors administered intercept surveys at the waterway sites in summer 2014, balancing data collection across time of day and day of week.

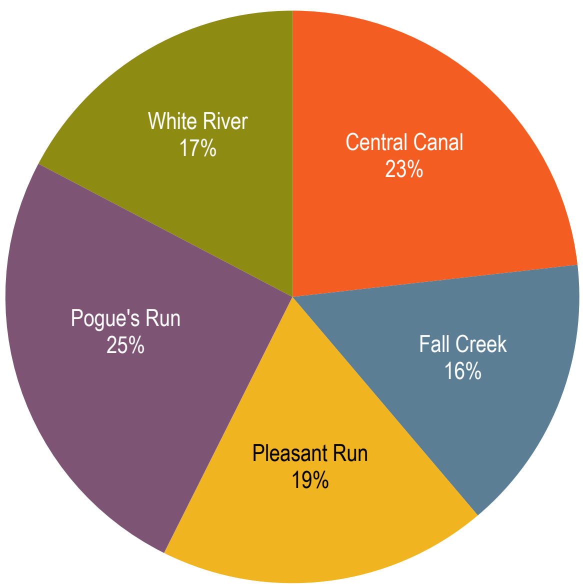

Figure 1. Distribution of respondents across five sites.

Researchers worked in pairs to invite visitors over the age of 18 to take a short survey about their perceptions, knowledge, and connections to the waterway. Visitors were informed that they could withdraw from the survey at any time. Quantitative questions were completed on an iPad mini. After the visitor completed the survey, the researchers asked if the visitor would like to respond verbally to several open-ended questions. Researchers obtained consent to audio record the responses to these open-ended questions or transcribed them on paper.

Instrument

This intercept interview instrument was created to better understand individuals' relationships with the waterways. The survey included ten close-ended items about the waterway's importance and health, and participants' personal connections and patterns of visitation. It also included ten demographic questions and four open-ended questions to get more detail about participants' perceptions and connections to the waterway. Similar to the online Citywide and Eli Lilly Survey, the Intercept Survey asked respondents to describe their knowledge about two topics chosen from the list of 20 I/CaLL science concepts. A full version of the survey instrument is included in the Appendix D.

Analysis

We calculated summary statistics for all close-ended items. A researcher transcribed all responses to the open-ended items and two researchers reviewed these transcripts to identify themes in the data and code responses according to these themes. We calculated inter-rater reliability using the Cohen's Kappa in the R analytical software package (version 0.84; Gamer, Lemon, Fellows, & Singh, 2012) in RStudio (version 0.98.1102). Kappa ranged from 0.94 to 0.98 and we judged inter-rater reliability to be acceptable for all questions (Nunnally & Bernstein, 1994).

The same researcher who coded the responses to the science knowledge questions on the Citywide and Eli Lilly Survey also coded the open-ended responses to the Intercept Survey, to ensure consistency. Respondents' knowledge was rated on a scale of 0 to 3, as before. We used ANOVA tests to identify significant differences between the knowledge of Intercept Survey respondents and respondents to the Citywide and Eli Lilly Survey.

Participants

In total, data collectors were able to solicit 265 responses to the Intercept Survey, with between 37 and 60 responses per site (Figure 1). Data collectors observed that refusal rates were low, though they did not provide precise counts.

Respondents represented multiple age categories, with respondents between 25 and 34 years of age representing

21% of the sample, and respondents aged 55 to 64 representing another 20% of the total. There were slightly fewer respondents aged 18 to 24 (12%) and older than 65 (12%). The majority (71%) identified as White, 16% identified as African American, and 1% as Asian American. Four percent identified as Other, and one respondent identified as Indian or Alaskan Native. Three percent of respondents identified as Hispanic / Latino. Respondents also spanned annual household income levels; the largest proportions reported an annual income of less than $20,000/year (21%) and more than $100,000 per year (22%). Slightly over half (57%) owned their home. Twenty-three percent of respondents had lived in their neighborhood for more than 20 years. For detailed demographics, see Appendix C.

RESULTS

Environmental Identity & Behaviors

We asked Citywide and Eli Lilly Survey respondents to reflect on how they think about themselves in relation to nature using the Environmental Identity scale. The scale comprised items that assessed the extent to which the environment was important to respondents' personal identities, and included items about the importance of learning about the natural world, the inherent beauty of nature, nature's healing properties, and time spent in natural settings, rated on a 7-point scale (1 = not at all true of me, 7 = completely true of me). Mean responses were moderate (M = 4.75, SD = .71, n = 1,262), suggesting that respondents only moderately saw themselves as connected with their local environment. Respondents to the Citywide and Eli Lilly Survey did not differ significantly on the Environmental Identity scale (t = .05, df = 416, p = .61). There was also no significant difference between these groups by age or other demographic factors.

Respondents also reflected on their general environmental behaviors using the Environmental Behaviors scale. This scale encouraged them to report on how often they perform certain activities, such as reusing items, picking up someone else's litter, writing a letter supporting environmental issues, volunteering for an environmental cause, and using public transportation, rated on a 5-point scale (1 = never, 5 = always). We found a moderate level of engagement in environmental behaviors overall (M = 3.05, SD = .83, n = 1,257), with most respondents performing environmental behaviors sometimes. The most common behaviors were *recycling cans and bottles*, *looking for ways to reuse things*, and *picking up litter than is not your own*; the least common behaviors were *writing a letter supporting environmental issues*, *using public transportation instead of driving*, and *composting food scraps* (Figures 2a & 2b). Respondents to the Citywide and Eli Lilly Survey did not differ significantly on the Environmental Behaviors scale (t = 1.19, df = 531, p = .24). There was also no significant differentiation in these data by age or other demographic factors.

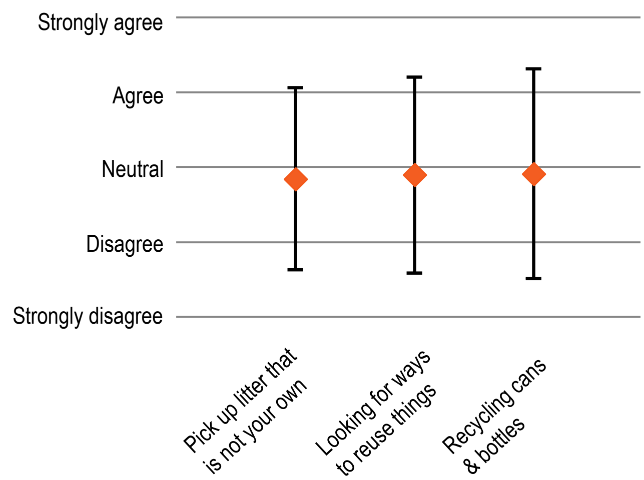

Figure 2a. Average response for the three most common behaviors included on the Environmental Behaviors scale. Respondents rated their frequency of engaging in these behaviors from never (1) to always (5). Error bars represent standard deviation.

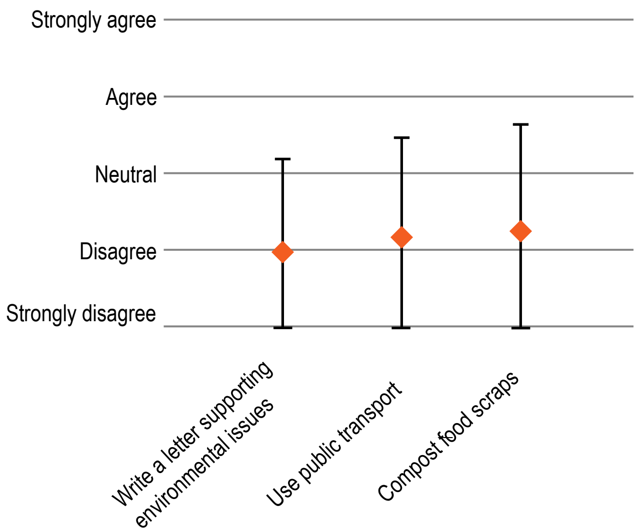

Figure 2b. Average response for the three least common behaviors included on the Environmental Behaviors scale. Respondents rated their frequency of engaging in these behaviors from never (1) to always (5). Error bars represent standard deviation.

Not surprisingly, there was a significant positive correlation between respondents' environmental identity and environmental behaviors (r = .62, df = 1255, p < 0.001), indicating that respondents with stronger environmental identities are more likely to participate in environmental activities.

Connections to Nature

We used the Psychosocial Motivations to Spend Time in Nature scale on the Citywide and Eli Lilly Survey to understand why individuals enjoy being in natural places. All items were rated on a 5-point scale (1 = strongly disagree, 5 = strongly agree). This scale was composed of three subscales, each focusing on a different reason for spending time in nature: self-restoration, learning, and socializing.

The restorative subscale included items about appreciating nature's beauty, stimulating one's senses, experiencing peace, and escaping from one's routine life. The subscale was reliable (Chronbach's alpha = .91) and these items represented the strongest motivation for the public to spend time in nature (M = 3.82, SD = .80, n = 1,273). The science learning subscale included items about learning about nature, natural systems, and science concepts. The subscale was reliable (Chronbach's alpha = .83) and respondents indicated a moderate interest in spending time in nature to learn about science (M = 3.39, SD = 1.01, n = 1,273).

The subscale about spending time in nature to socialize neared, but did not meet, the reliability cutoff (Chronbach's alpha = .66), so we assessed items individually (Figure 3a). Respondents were most likely to agree with the item about spending time in nature to *experience family togetherness* (M = 3.89, SD = 1.16, n = 1,273). Respondents felt less strongly about spending time in nature to *socialize with others* (M = 3.48, SD = 1.17, n = 1,273) or *be of assistance to others* (M = 2.84, SD = 1.22, n = 1,273).

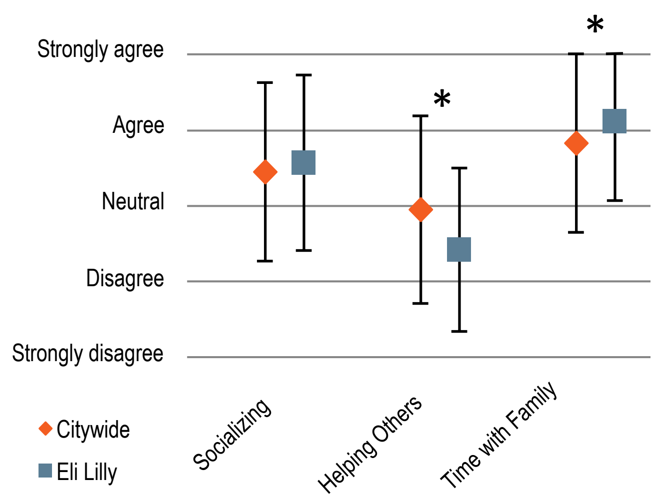

Figure 3a. Mean response to items about motivations for spending time in nature assessed on a scale from strongly disagree (1) to strongly agree (5). * indicates differences that are significant at α = .05.

Correlation analysis indicated that survey respondents who were more motivated to spend time in nature also had stronger environmental identities (r = .66, df = 1260, p < 0.001) and were more likely to participate in environmental activities (r = .51, df = 1255, p < .001).

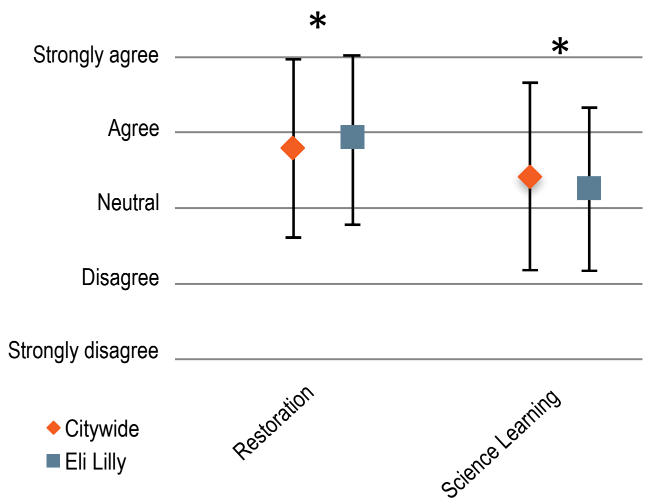

Figure 3b. Mean response to items about motivations for spending time in nature assessed on a scale from strongly disagree (1) to strongly agree (5). * indicates differences that are significant at $\alpha = .05$.

Respondents to the Citywide and Eli Lilly Survey differed significantly in several ways. Eli Lilly employees were more strongly motivated to spend time in nature for its restorative effect and opportunities to spend time with family than were city residents (Figure 3a and 3b; $t = -2.97$, $df = 494$, $p = .003$). In contrast, Eli Lilly employees were less strongly motivated by learning opportunities and opportunities to help others than were city residents (Figures 3a & 3b). The groups did not differ in motivations to spend time socializing in nature.

Connections to City Waterways

We included the Sense of Place scale on the Citywide and Eli Lilly Survey to assess respondents' emotional connection, alignment with their personal identity, and dependence on Indianapolis waterways as assessed on a 5-point scale (1 = strongly disagree, 5 = strongly agree). Overall, respondents were neutral about the importance of Indianapolis waterways to their lives ($M = 2.97$, $SD = 1.23$, $n = 1{,}273$). However, the waterways were slightly but significantly more important to city residents ($M = 3$, $SD = 0.84$, $n = 1011$) than to Eli Lilly respondents ($M = 2.84$, $SD = 0.74$, $n = 262$) ($t(DF = 1231) = 2.62$, $p = 0.01$).

Looking at the subscales within the Sense of Place scale we note that respondents felt a moderate emotional connection with Indianapolis waterways (M = 3.02, SD = 0.09), with no significant differences between city residents Eli Lilly respondents ($t(DF = 1243) = 1.64$, $p = 0.1$). Respondents were moderately identified with Indianapolis waterways (M = 2.86, SD = 0.16). However, city residents (M = 2.97, SD = 0.87) identified with the waterways slightly more than Eli Lilly respondents (M = 2.75, SD = 0.78); this difference was significant ($t(DF = 1253) = 3.6$, $p < 0.001$). Lastly, respondents felt moderately dependent on Indianapolis waterways ($M = 2.88$, $SD = 0.09$). However, city residents ($M = 2.95$, $SD = 0.86$) felt slightly more dependent on the waterways than Eli Lilly respondents ($M = 2.82$, $SD = 0.8$); this difference was significant ($t(DF = 1238) = 2.13$, $p = 0.03$).

We found significant positive correlations between the Sense of Place scale and motivations to spend time in nature ($r = .45$, $df = 1253$, $p < .001$), environmental identities ($r = .56$, $df = 1253$, $p < .001$), and environmental behaviors ($r = .50$, $df = 1253$, $p < .001$). Respondents who felt more attached to Indianapolis waterways were more motivated to spend time in nature, had stronger environmental identities, and were more likely to do environmental activities.

The Intercept Survey at the I/CaLL waterway sites included questions that assessed respondents' personal connections to the waterway site they were visiting. There was variation across sites regarding visitors' knowledge of the name of the waterway they were visiting (Central Canal, 95%; White River, 86%; Fall Creek, 64%; Pleasant Run, 39%; Pogue's Run, 34%; $n = 251$). Despite low name recall for some waterways, visitors at all sites felt connected to the waterway and noted that it was important to them (Figure 4). Visitors to Central Canal were especially likely to feel a strong connection to the waterway.

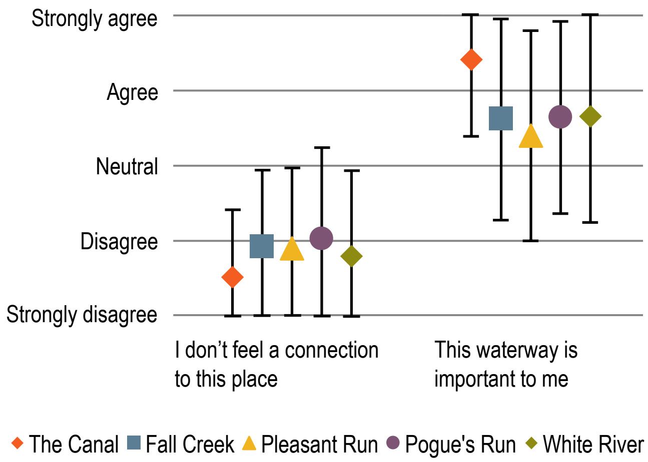

Figure 4. Mean response to questions about feelings of connectedness to the sites assessed on a scale from strongly disagree (1) to strongly agree (5).

Most respondents visited the sites to exercise or spend time outdoors. Others visited on their way to indoor activities (e.g., visiting the brewery, shopping), or said they live, work, or commute in or near the site (*n* = 247; Figure 5).

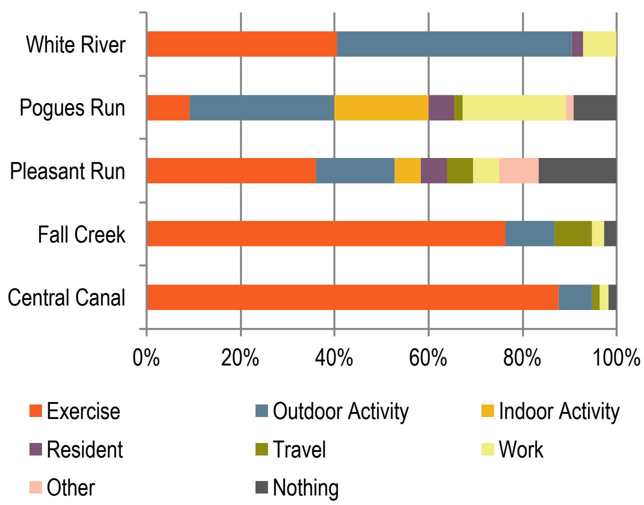

Figure 5. Coded responses to the question *What usually brings you to this waterway?*

When asked to describe a meaningful visit to the site, respondents typically described an activity that they did at the site, such as fishing or playing basketball. Others said that they enjoyed access to nature. A small number of respondents at four of the sites (White River, Pogue's Run, Pleasant Creek, and Fall Creek) mentioned a visit when they noticed that the site or waterway was improving. Between 11% and 49% of respondents at each site said that they could not think of a meaningful visit to the site; these values were lowest for Fall Creek and Central Canal, and highest for Pleasant Run.

When asked what they most valued about the waterway, respondents at all sites mentioned the importance of having access to nature or a calm place where they could escape to find peace and quiet (*n* = 251; Figure 6). Others appreciated the activities available at the sites, or stressed the importance of having a public space for people from the neighborhood to enjoy. People at three sites mentioned that the waterway was important for the community because it provided drinking water.

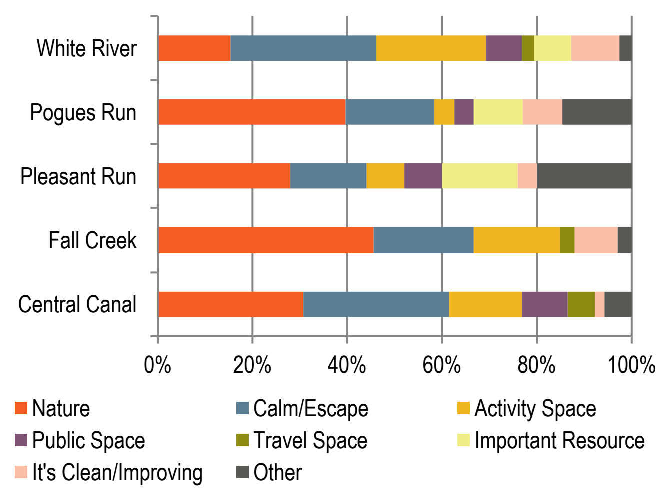

Figure 6. Coded responses to the question *What do you value most about this waterway*?

Perceptions of Waterways

Respondents to the Intercept Survey felt the waterway settings seem natural. They also gave neutral responses or disagreed when asked if the waterway was healthy (Table 2). Visitors at most of the I/CaLL waterway sites agreed or strongly agreed that human activity has harmed the waterway

Table 2. Mean responses to questions about the condition of the waterway, assessed on a scale from strongly disagree (1) to strongly agree (5).

	I think this waterway is healthy.			This setting feels natural to me.			Human activity has harmed this waterway.			This waterway is artificial.		
	M	*SD*	*n*	*M*	*SD*	*n*	*M*	*SD*	*n*	*M*	*SD*	*n*
White River	2.45	1.30	40	3.95	.90	40	4.13	1.14	40	2.75	1.51	40
Pogue's Run	2.59	1.08	58	3.83	1.13	58	4.16	1.21	57	2.37	1.05	57
Pleasant Run	1.93	1.30	43	3.41	1.37	44	4.07	1.22	43	2.58	1.28	43
Fall Creek	2.54	1.31	35	4.31	.82	36	3.68	1.40	37	2.41	1.17	37
Central Canal	3.37	1.15	54	4.43	.92	54	2.94	1.42	53	3.11	1.55	54

and gave neutral responses when asked if the waterway is artificial (Table 2). There was variation in visitors' perceptions of the different waterways. Visitors to the Central Canal perceived the waterway to be calmer, healthier, and more natural than visitors at other waterway sites, who often mentioned that the waterway was unclean (Table 2; Figure 7, *n* = 238).

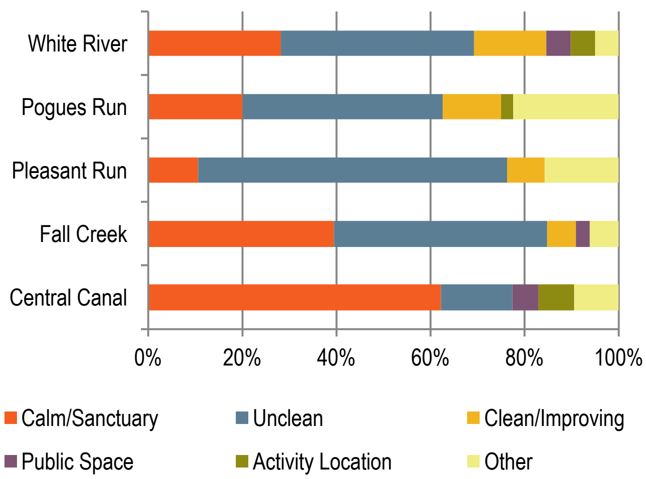

Figure 7. Coded responses to the question *How would you describe this waterway?*

Visitation to Informal Science Learning Sites

Respondents of the Citywide and Eli Lilly Survey noted frequency of visits to informal science learning sites such as parks, museums, and zoos on a 4-point scale from never (1) to always (4). On average, respondents occasionally visited these sites (M = 2.18 on a 4-point scale, SD = .64, n = 1,240), with city residents visiting significantly more often than Eli Lilly employees (t = 2.37, df = 548, p = .01).

Visitation to informal science learning sites among city residents and Eli Lilly employees was significantly and positively related to motivations to spend time in nature (r = .42, df = 1238, p < 0.001), environmental identity (r = .44, df = 1238, p < 0.001), environmental behaviors (r = .53, df = 1238, p < 0.001), and sense of place (r = .42, df = 1238, p < 0.001).

Science Knowledge

Overall Knowledge

Based on responses to open-end questions about the 20 science concepts, we measured science knowledge across all three data sets: Citywide Survey, Eli Lilly Survey, and Intercept Survey. We used a 4-point scale from no knowledge (0) to expert knowledge (3). We assessed overall science knowledge per respondent by averaging scores for the two randomly selected knowledge questions about earth science concepts. Overall knowledge was low, with a mean of 0.78 (SD = .72, n = 1,383), but we found significant differences among the populations surveyed, with the respondents to the Intercept Survey scoring highest, followed by Eli Lilly employees, followed by general city residents (Table 3; F = 28.76, df = 2, p < 0.001).

Overall the knowledge score was not correlated with any of the scales in the Citywide and Eli Lilly Survey, including motivations to spend time in nature, environmental identity, environmental behaviors, sense of place, or use of informal science learning sites.

Table 3. Overall science knowledge by population.

Population	*M*	*SD*	*n*
Citywide Survey	.70	.68	957
Eli Lilly Survey	.96	.88	168
Intercept Survey	1.03	.70	258

Knowledge of 20 Science Concepts

We found that knowledge was low for all 20 of the I/CaLL-related science concepts, with mean scores across all survey respondents indicating no knowledge or minimal knowledge about each (Appendix E). Respondents had the least knowledge about *Indianapolis' Deep Rock Tunnel* (*M* = .32, *SD* = .65, *n* = 140) and *urban heat islands* (*M* =.36, *SD* = .62, *n* = 167) and the most knowledge about *urbanization impacts on waterways* (*M* = 1.05, *SD* = .90, *n* = 147) and the *impact of cities on local groundwater* (*M* = 1.05, *SD* = .91, *n* = 135). Even for concepts for which respondents' knowledge level was highest, they still knew relatively little about the target science concepts.

There were significant differences in knowledge across the three target populations for 9 of the 20 science concepts (Table 5). City residents had the lowest knowledge scores for 8 of the 9 concepts, and did particularly poorly on *legal issues around urban watershed management* and *managing urban water allocation*. Eli Lilly employees had the highest knowledge scores for 5 of the 9 concepts, and scored particularly well on *urban stream restoration* and *invasive species*. Responses to the Intercept Survey matched the public survey data.

Regression Analysis

We conducted a regression analysis with the data from the Citywide and Eli Lilly Survey to identify significant predictors of science knowledge. The full model including all the aggregate scale variables – motivations to spend time in nature, environmental identity, environmental behaviors, sense of place, and visitation to informal science learning sites – was significantly better at predicting science knowledge than was the null model (F = 4.08, df = 4 and 1117, p < .001). The only significant predictor of respondents' performance on the science knowledge questions was whether they were part of the Citywide or Eli Lilly participant pool (Table 4). None of the other independent variables were significant.

Table 4. Regression analysis to identify predictors of science knowledge.

Predictor	β	*SE*	*t*	*p*
Intercept	.58	.11	5.08	<.001**
Survey	.27	.06	4.52	<.001**
Motivations	.02	.04	.49	.63
Env. Identity	.01	.03	.58	.56
Env. Behaviors	-.06	.04	-1.57	.12
Sense of Place	.04	.03	1.28	.20
Science Learning Visits	.01	.04	.35	.73

Note. ** indicates significant difference at α<0.01.

SUMMARY RESULTS

City residents and Eli Lilly employees identified somewhat with the environment and engaged in some environmental behaviors, particularly individual-level behaviors like recycling and picking up litter.

Respondents, especially Eli Lilly staff, were most likely to spend time outside for restorative effects. Meanwhile, city residents were more likely to spend time outside for learning opportunities than were Eli Lilly staff.

City residents identified more strongly with Indianapolis waterways than did Eli Lilly staff, but all respondents generally indicated a weak Sense of Place.

Intercept Survey respondents at the I/CaLL waterway sights revealed that visitors had strong feelings of connection to the sites, even while many considered the sites to be unhealthy or unclean. Visitors to the Central Canal had particularly positive feelings toward and descriptions of the site.

City residents visited informal science learning sites more frequently than did Eli Lilly staff.

Table 5. There were differences in knowledge across the three target populations for 9 of the 20 science concepts. Knowledge was assessed on a scale of 0 to 3, with 0 indicating no knowledge about the topic and 3 indicating expert knowledge.

	Citywide Survey			Eli Lilly Survey			Intercept Survey			ANOVA	
	M	*SD*	*n*	*M*	*SD*	*n*	*M*	*SD*	*n*	*F*	*p*
Natural habitats in urban waterways.	.58	.77	77	.82	.98	11	1.06	.91	32	3.83	.02*
The effects of invasive species.	.94	.89	94	1.56	0.98	18	.84	.69	19	4.16	.02*
Managing urban storm water.	.76	.84	100	1.44	1.20	18	1.37	.93	27	7.75	<.001**
The impact of cities on local groundwater.	.94	.86	98	1.17	1.11	12	1.44	.92	25	3.24	.04*
How we can restore urban streams.	.72	.76	93	1.71	1.10	17	1.75	.94	24	20.56	<.001**
Creating healthy urban aquatic ecosystems.	.68	.70	95	1.25	1.00	16	1.07	.81	28	5.54	<.01**
Legal issues around urban watershed mgmt.	.39	.63	89	.76	1.03	17	.79	.93	24	3.71	.03*
How we should manage urban water allocation.	.42	.70	84	.67	.97	21	1.00	.92	27	5.70	<.01**
How engineered water systems affect urban waterways.	.50	.62	90	.78	1.06	18	1.14	.83	22	7.00	<.01**

Note. * indicates significant difference at $\alpha<.05$; ** indicates significant difference at $\alpha<.01$

Overall and topic-specific science knowledge was very low across all respondents. For measures of overall knowledge, visitors to the waterways sites scored higher than did Eli Lilly staff, who scored higher than general city residents. However, the relative knowledge levels among these three groups were not always consistent for individual topics. Of all the topics, respondents were most familiar with urbanization impacts on waterways, although knowledge still remained relatively low.

Survey population – citywide or Eli Lilly staff – was the only significant predictor of overall knowledge about the earth science topics addressed by this project.

DISCUSSION

In general, Indianapolis has a national reputation as a socially active community with high levels of volunteerism. One study documented the city's community engagement, ranking it as the metropolitan area with the 10th highest level of volunteerism in the US (Corporation for National & Community Service, 2016). Eli Lilly, a notably civic-minded corporation based in Indianapolis, gives back to the city through financial contributions to culture, infrastructure development, and a highly publicized day of service. Unfortunately, the city's six major waterways face significant challenges that require remediation, an issue generally known by local residents.

Despite these seemingly obvious connections to science education for environmental sustainability, there's a concerning deficit in public literacy surrounding river health science that may take more remediation than simple awareness-building. City residents scored poorly on basic literacy questions, and though the staff at the science-based corporation displayed comparatively higher levels of literacy, the results suggest that they are also unequipped to understand the challenges their river systems face.

One finding that lends a degree of hope to the issue is Eli Lilly employees' knowledge about *urban stream restoration* and *invasive species.* These are core issues that the day of service workers have contributed time and effort to remediating. Even though the day of service program is presented to staff as action rather than education, these volunteer activities seem to translate into effective learning opportunities that advance science literacy. We consider this result particularly promising because these same employees did not score as well on topics more distant to their day of service activities.

Another predictive result is that sense of environmental identity and environmental connectedness were likely to predict higher knowledge scores on environmental issues and awareness, suggesting that increased identification with nature can directly expand interest in pursuing STEM knowledge acquisition related to environmental sustainability.

Yet another result that inspires hope is that city residents perceive nature as offering learning opportunities. This pattern suggests that interventions in nature spaces such as parks or areas near waterways may be well-suited to advancing science literacy.

CONCLUSIONS

It seems that day of service work on river restoration can support science education and literacy for environmental sustainability among employees of a science-based company. These employees are less likely than the public at large to use cultural institutions for their own pursuit of science learning, and may be more likely to use their day of service as a key factor influencing their thinking about local restoration ecology issues. General city residents, on the other hand, are more likely to use cultural institutions and public spaces for learning about these issues. This finding suggests that two parallel vectors are advantageous for advancing civic learning programs and opportunities that enhance visits to public nature spaces.

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