An aerial photograph of New York City, showing the dense urban landscape of Manhattan and the lush greenery of Central Park. The Empire State Building is prominent in the skyline. The background shows the Hudson River and the George Washington Bridge.

Editors

Alex Russ

Marianne E. Krasny

Essays in Urban Environmental Education



This e-book includes 10 selected chapters from the book “*Urban Environmental Education Review*” to be published by Cornell University Press in 2017. The complete book includes 30 chapters written and edited by 82 experts in the field of environmental education and urban social-ecological systems from six continents.

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<http://www.cornellpress.cornell.edu/book/?GCOI=80140100988800>



Essays in Urban Environmental Education

Editors

Alex Russ

Marianne E. Krasny

Cornell University Civic Ecology Lab, NAAEE, EECapacity

Ithaca, NY and Washington, DC

2016



Cornell University



naaee

North American Association
for Environmental Education

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Cover photo: Central Park, New York City. Photo credit: Alex Russ.

Publication date: June 30, 2016.

Suggested reference:

Russ, A. and Krasny, M.E. (Eds.) (2016). *Essays in urban environmental education*. Ithaca, NY and Washington, DC: Cornell University Civic Ecology Lab and NAAEE.

This publication was developed under Assistant Agreement No. NT-83497401 awarded by the US Environmental Protection Agency (EPA). It has not been formally reviewed by EPA. The views expressed are solely those of authors, and EPA does not endorse any products or commercial services mentioned.

ISBN-10: 0-692-73496-1

ISBN-13: 978-0-692-73496-4

ISBN 978-0-692-73496-4

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Preface

Urban environmental education includes any practices that create learning opportunities to foster individual and community well-being and environmental quality in cities. Similar to how cities are innovation hubs, urban environmental education generates novel educational approaches that advance the field of environmental education more broadly.

This e-book includes 10 selected chapters from the book “*Urban Environmental Education Review*,” to be published by Cornell University Press in 2017. Eighty-two experts from 19 countries have written 30 chapters for the complete book, on topics ranging from the urban context to educational settings, theoretical underpinnings, participants, and educational approaches in urban environmental education. Chapters integrate research and practice to help aspiring and practicing environmental educators achieve educational, youth and community development, and environmental quality goals in cities.

This e-book and the larger 30-chapter book can be used for professional development of environmental educators, in university courses, and for self-learning. For permission, and for information about the complete book, visit the Cornell University Press website:

<http://www.cornellpress.cornell.edu/book/?GCOI=80140100988800>

1. Advancing urbanization

David Maddox, Harini Nagendra, Thomas Elmqvist, Alex Russ



Photo credit: Alex Russ

HIGHLIGHTS

- Cities are human habitat—integrated systems of people, infrastructure and nature—and are key to human-nature relationships and global sustainability.
- We need cities that are resilient, sustainable, livable, and just.
- Urban environmental education can help debunk common assumptions: that cities are ecologically barren, nature is only in wilderness, and city people don't care for, or need, nature.
- Telling the story of “advancing urbanization”—both the global acceleration of urbanization and the promise offered by urbanization—is an essential role for urban environmental education.

Introduction

Cities—their design and how we live in them—will be key in our struggle for sustainability, indeed our future. As cities grow, as they are newly created, and as more and more people choose or require them as places to live, our decisions about urban design and city-building will determine the outcomes of long-term challenges related to resilience, sustainability, livability, and justice. Rather than being the essential cause of the global environmental dangers we face, cities will be central to success in overcoming these dangers. Such success will be based on science and policy, but also on widespread public engagement with and understanding of both the challenges and the potential solutions found in building cities. Environmental education can play a critical role in fostering public engagement through clarifying and transmitting the challenges, values, actions, and methods for achieving sustainable, resilient, livable, and just cities.

What is urban?

At their core, urban spaces are human settlements of various sizes, densities, and physical arrangements. Major urban centers, cities, towns, and even organized collections of populated zones that comprise metropolitan regions are “urban”—that is, urban comprises a diversity and continuum of types of spaces, not one form. The dense and compact European city surrounded by rural land is one form. Classic American cities

and their sprawl is another model. Garden cities, clustered townships, and other urban forms all have characteristics in common.

What are the unifying features of these diverse urban forms? People—and their communities—is one. Buildings, streets and other grey infrastructure is another. And nature is a third. By including nature as a key characteristic of cities we do not mean nature as an idealized or hoped-for feature. Nature is an attribute of every city, both within its borders and as a connection to the wider landscape, because while cities are social and infrastructural spaces, they are also ecological spaces. They are social-ecological spaces of functioning ecosystems of living and non-living things. In this sense cities are essential human habitat.

Acknowledging that cities are themselves ecosystems that exist along gradients with surrounding peri-urban and rural areas has deep implications not only for the humanity and livability of the world’s urban zones, but also for global sustainability more broadly. Urbanization is advancing throughout the world. Urbanization as a positive concept for the good of the Earth is also advancing around the world among thoughtful scholars and within progressive city leadership. It is also advancing in the hands of people on the streets who are building better cities, block by block, through community gardens, street tree plantings, parks and embedded natural areas, and who are engaging in participatory decision-making. Telling the story of this advancement

—both the global acceleration of urbanization and the promise offered by urbanization—is an essential role for an emerging urban environmental education.

The growth of cities

The world is increasingly urban, interconnected, and changing. With current trends, by 2030 the global urban population is estimated to be 4.9 billion, nearly double that of 2000. During this period the total urban area is expected to triple. That is, urban land area is expanding faster than urban populations (Elmqvist et al., 2013). This massive change in where humans live on the planet will have inevitable local and global ecological consequences.

Indeed, more than 60% of 2030s projected urban area has yet to be built (Elmqvist et al., 2013). In three areas—sub-Saharan Africa, China, and India—the combined urban population is expected to grow by more than one billion people. By 2030, nearly one-third of the world’s urban inhabitants will live in China or India (Seto, Güneralp, and Hutyra, 2012). Africa will urbanize faster than any other continent: its urban population is expected to more than double, from 300 million in 2000 to 750 million in 2030. Around 75% of Africa’s total population growth is expected to occur in cities of less than one million. African cities are often settlements with weak governance structures, high levels of poverty, and low capacity in environmental science. Currently, more than 43% of Africa’s urban population

lives below the poverty line, more than in any other continent, making socioeconomic development a priority. Generally weak state control, the presence of a feeble formal economic sector, and the scarcity of local professional skills will constrain responses to the complex environmental challenges posed by rapid urbanization. Even under current conditions, urban areas all over the planet are facing severe challenges, including shortages of natural resources, environmental degradation, climate change, demographic and social changes such as increasing income inequality and poverty, and inconsistent management of sustainability transitions that would reduce ecological impacts.

Climate change, increased migration of people, and ecological degradation will severely test societies and urban regions. However, the urbanization process also presents opportunities. That 60% of 2030 cities are yet to be built is a chance to avoid repeating the city-building mistakes of the past. The infrastructure we build in cities—where we put the roads and the buildings, and how we organize resource use—tends to be with us a long time. The immensity of new building now underway is a chance to get it right, for both people and nature.

Values

What are the cities we want to create in the future, the cities in which we want to live, cities that work for both people and the Earth? What is their *nature*? A vision is

needed for city-building, one that is fundamentally built around goals and informed by values. Visions, goals, values, and actions, along with scientific data and experiential knowledge, are the essence of education, including environmental education.

Certainly the cities we need are *resilient*, so our cities are still in existence after the next 100-year storm, now occurring with increasing frequency. Certainly they are *sustainable*, since we need our cities to balance consumption and resources so that they can last into the future. As we build this vision we know that cities must also be *livable*, because cities are now the places where most of us live. And *justice* must also be key to our urban environments. We have struggled to build just cities for a long time; largely we have come up short.

These are the key characteristics of the cities of our dreams: resilient, sustainable, livable, and just. What are the values that are foundations for these goals? They are, at a minimum, inclusiveness, equity, respect for people and knowledge, innovation, and conservation.

The United Nation's Urban Sustainable Development Goals offer some guidance—a global consensus on what is important (United Nations, 2015). Among the 17 Sustainable Development Goals approved in 2015, is one explicitly about cities, #11: “Make cities inclusive, safe, resilient and sustainable.” This goal offers a roadmap to the operational values we should investigate,

appropriate, share, and teach in the emerging urban world; the roadmap should include targets for open space, sustainable environmental management, and access to nature and its myriad benefits and services. At the center of Sustainable Development Goal #11 and our general approach to cities, explicitly and implicitly, is nature—both as a literal feature of the cities we require for resilience, sustainability, livability, and justice, and as a metaphor for the kinds of cities we desire.

The richness of the urban environment

Why should we care about the impacts of urbanization on ecosystems? In addition to the intrinsic value of nature, urban ecosystems are essential for human well-being, and ultimately, for urban resilience and sustainability. Because urban nature has explicit benefits, its availability to all people is a matter of justice. The environmental consequences of the rapid growth of cities—especially poorly designed and operated ones—is starkly apparent. Urban expansion has degraded and destroyed natural habitats in and around cities worldwide, transforming forests, coastal mangroves, lakes and wetlands into vast expanses of concrete and polluted travesties of their former ecological vigor.

Yet, cities are far from barren. In contrast, cities are often rich in biodiversity (Aronson et al., 2014). Cities can be key stopovers along migratory routes of birds.

Some cities are biodiversity hotspots in their own right. They contain small but thriving pockets of biodiversity with native and non-native (novel) species assemblages (Faeth, Bang and Saari, 2014). Such assemblages of urban species and habitats provide a range of ecosystem services that are critical for the sustainability of cities, indeed for the life of cities. Wetlands clean water contaminated with industrial pollutants and sewage; trees may clean the air of pollutants; and urban ecosystems provide important habitats for insects, birds, bats, and other pollinators and urban wildlife.

For humans, exposure to green spaces fosters physical well-being and psychological relief from stress. Urban green spaces include not only city parks, but also the wide array of macro and micro urban places, from wetlands and bioswales, to street trees, pocket parks, community gardens, and even biophilic workspaces. A diversity of people and communities work in and interact with nature in these spaces, including from civil society (e.g., civic groups, activists), government, and the corporate sector (Kazemi, Beecham and Gibbs, 2011; Beninde, Veith and Hochkirch, 2015). Parks, community gardens, sidewalks shaded by trees, as well as lakes and coastal beaches act as important nodes for people to congregate, strengthening social bonds among disparate urban residents.

Natural areas in cities also often hold an important place in the cultural landscape of residents, and are sometimes considered

sacred and worshipped in Asia, Africa, and elsewhere. In New York City, immigrants and other residents demonstrate care, stewardship, and spiritual practices in natural areas and parks (Svendsen, Campbell and McMillen, 2016). Urban ecosystems also provide resources for foraging in cities, offering food and livelihood security for vulnerable communities through the provision of fish, herbs and vegetables, fodder, fuelwood, and other resources. Many urban ecosystems historically functioned as urban commons, providing collective resources for entire communities in times of scarcity and need.

In addition to enhancing individual and community well-being, urban natural areas provide a buffer against local and global environmental factors such as pollution and climate change. Similarly, through urban agriculture, urban green spaces buffer against economic and food insecurity of the urban poor. In short, green urban spaces are key to global sustainability, and need to be recognized as positive forces in shaping human stewardship of the entire biosphere (Elmqvist et al., 2013).

That cities have dire environmental and biodiversity challenges is certainly true. That they are ecologically dead, or are the causes of all the world's environmental problems, is false. Yet many cities are experiencing a crisis of green and open space, especially in the Global South. The lack of accessible green and open space contributes to desperately poor conditions for both people

and nature (Wolch, Byrne and Newell, 2014). Thus, having sufficient access to good quality urban green space is an issue of ecological and social concern, impacting quality of life and social justice.

Role for education

In a world of advancing urbanization, urban environmental education can play a key role. The story of cities as ecological spaces needs to be told—both in cities and outside them—to adults and to the many young people who increasingly populate the world’s growing cities; to our leaders in government, business and civil society making decisions about the built and natural environment; and to each other in our daily lives. Such stories will have a critical impact on the willingness of the inhabitants of the cities of the future to protect and care for—and create—their urban environments.

Thought leaders and educators can communicate the connection between the urban environment and human and global environmental health. They also can communicate that merely recording the presence of species in urban environments does not necessarily indicate their health; that actions such as thoughtless use of pesticides and planting invasive species may deprive native fauna of feeding and nesting habitats; that the persistence of many species in urban environments, such as macaques, langurs and birds of prey in Indian cities, can be attributed to cultural traditions of good-will towards life; that local food

production with diverse methods is central to local health; that all people, not just the rich, deserve access to ecosystem services; and that consumption and transportation choices are key to global sustainability. Finally, educators can communicate that there is a connection between green urban design and resilience, sustainability, livability, and justice.

Urban environmental education can play a pivotal role in telling these stories by teaching about urban biodiversity, ecosystem services, and nature, and about the myriad connections between the built and natural world in cities. Urban environmental education that is sensitive to its local cultural context and incorporates scientific insights from urban social-ecological systems thinking can make a significant difference, encouraging residents to care about their environment and giving them the knowledge on which to act. Urban environmental education also can engage people directly in action, where lessons are learned through hands-on and collective stewardship practices like community gardening, rather than through directed teaching. What is learned through such active participation in and reflecting on stewardship practices may lead to future more informed engagement in environmental practices and policy related decision-making.

The dire challenges of urban environmental pollution and degradation—and their relevance to resilience, sustainability, livability, and justice—can quickly lead to the trap of purely dismal

narratives. This does not have to be the case. In addition to a narrative of ecological loss and the consequences for human well-being, we can develop and communicate positive messages of real change that simultaneously convey facts, challenges, and potential solutions. We must emphasize the importance of ecological, social, and technical solutions, while also addressing the challenges of equity, conflict and exclusion.

Thus, while focusing on the “what” questions of the intended human, social, and environmental outcomes, the field of urban environmental education can equally focus on the “how” questions of process. This entails helping people to understand—often through hands-on engagement in stewardship and related practices—the ways in which social and environmental change can be initiated and inclusively scaled up in their own cities and social-ecological contexts. In this regard, urban environmental education can play the key influential role that only it can fill: helping to creatively re-conceptualize, re-design, and re-develop existing and emerging cities by helping people learn about and create green infrastructure, influence urban planning and design, change individual behaviors, and undertake collective environmental actions.

Conclusion

Urban environmental education in an emerging urban world faces multiple challenges. Is there a uniquely urban version of environmental education? To a large

extent, that is a subject for this book. We know that some established environmental assumptions must be adjusted in a modern urban context: that nature can only be found in the wilderness, that cities are the enemy of sustainability, that cities are ecologically barren, and that city people don’t engage with nature. All are largely false, or misleading.

How can we advance an urban vision that serves people and our planet, a vision that is fundamentally imbued with values? Tell the story, far and wide, that cities are essential hotspots of nature that serve people and the Earth. Nature exists in cities, and it needs to be seeded, grown and nurtured as a commons. And importantly, urban residents all over the globe are creating innovative approaches that simultaneously address social and environmental injustice. These are stories that must be told to students, to teachers, to leaders, to community members, and to ourselves. This is the key and essential role—advancing progressive urban environmental ideas in a global context—for an emerging urban environmental education. Telling this critical story is the challenge to which environmental education is called in the urban 21st century.

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2. School partnerships

Polly L. Knowlton Cockett, Janet E. Dymont, Mariona Espinet, Yu Huang



Photo credit: Alex Russ

HIGHLIGHTS

- Urban schools can use local environments to serve as stimulus, context, and content for teaching and learning about sustainability.
- School curricula and teacher pedagogies both limit and enable what is possible through urban environmental education.
- When schools establish rich and sustaining partnerships with local communities, opportunities for urban environmental education are significantly enhanced.

Introduction

Urban schools—any public, private, or charter school delivering formal primary or secondary education—are key institutions in the shaping of vibrant and sustainable cities. Imagining such cities depends on the assumptions and ideologies of those involved in the transformation of urban sites, and moving beyond perceiving urban schools as problematic institutions (Pink and Noblit, 2007). Globally, a steady process of urbanization results from migration from rural and conflict areas. This trend points to the urgent need to develop programs—including environmental education—that target schools as pivotal in serving diverse, translocated, and often marginalized students. Such urban environmental education can also empower those who live in challenging circumstances to work together to improve social-ecological well-being, and foster “citizens that are informed and motivated to live more sustainably, be responsible stewards of the environment, and help ensure future generations’ quality of life” (Alberta Council for Environmental Education, 2015).

A variety of programs that encourage student engagement in environmental initiatives have supported schools worldwide. Two foremost international initiatives are the Eco-Schools Program established in Europe in 1992, and the Green Schools Alliance introduced in the U.S. in 2007. They provide environmental education programs, environmental management systems for school facilities and grounds, and award

schemes that promote and acknowledge actions for the environment and transitioning towards sustainability. Further, United Nations Agenda 21 acknowledges local jurisdictions as being best positioned to tailor programs to the individual needs of schools and communities.

In this essay we build on the definition of urban environmental education as “any environmental education that occurs in cities” (Russ and Krasny, 2015, p. 12) by acknowledging the importance of overarching curricular goals set by formal educational institutions. The following sections present “socioecological refrains” adapted from Knowlton Cockett (2013), which incorporate stewardship, pedagogy, interrelationships, and heritage, and highlight the role schools can play in shaping sustainable cities through urban environmental education. These refrains promote a connectedness to place through: (1) the use of the local environment to stimulate learning, (2) the development of curricula and pedagogies that embrace the development of sustainable cities, and (3) the establishment of links with the community to foster relationships, stewardship, and resiliency. Case studies from Canada, Australia, China, and Spain illustrate these refrains, as well as show how schools are engaged more broadly in Green School initiatives.

Local environments as stimulus, context, and content

Creating learning environments where students can develop as citizens with pronounced understandings of sustainability is a major educational challenge. While much emphasis has been placed on incorporating sustainability into formal schooling, recent scholarship shows that significant sustainability learning can happen beyond the four corners of the classroom (Knowlton Cockett, 2013; Russ and Krasny, 2015; Tidball and Krasny, 2010). Urban contexts that can be used to deliver urban environmental education typically include nature centers, parks, community gardens, resource recovery centers, and landfills. Extending to other vital urban settings such as hospitals, jails, shelters, government housing, immigrant organizations, businesses, and women's and seniors' centers provides meaningful opportunities for schools to form partnerships aimed at integrated urban sustainability education. Such partnerships can stimulate learners in schools to understand environmental, political, social, cultural, and economic dynamics of systems.

Through such partnerships, urban environmental education presents concrete social-ecological issues that develop student problem-solving skills, and recognizes urban communities as powerful landscapes to guide learners' understandings, confidence, and competence in relation to sustainability.

In our case studies, we present examples of students working with park managers, landscape architects, and naturalists to understand the management of invasive species to support native biodiversity. Other examples involve partnering with scientific organizations in a constructed wetland on a former coal mine site, and studying water issues in municipal river systems. We also present a case of where a network of schools works with city administrators and universities to develop food systems and seed banks, and to expand agroecology into urban settings. In each case, urban students are working within their local social-ecological contexts.

Curriculum and pedagogy oriented towards sustainable cities

The presence of sustainability and environmental education in the curriculum varies dramatically around the world: in some countries, sustainability or environment is a stand-alone curriculum; in other countries, it features as a cross-curricular interdisciplinary area; in yet other countries, there is a notable silence in relation to sustainability (Dyment, Hill and Emery, 2014). Irrespective of curricular mandates, teachers can identify urban environments as sites for learning involving hands-on or embodied interactions within a particular place. These experiences are often framed by inquiry-based learning that positions students as investigators,

designers, scientists, and gardeners (Stine, 1997).

Teacher understanding of pedagogies that support learning outside the classroom is a vital factor in enabling children to use urban spaces to learn about sustainability (Skamp, 2007). Teaching in urban landscapes requires new and different pedagogies involving letting go of some control and structure afforded by inside spaces, and allowing for risk-taking with students. Luckily, potential Green School activities abound. Students might utilize mathematical concepts such as perimeter or area to determine the capacity of a rooftop to harvest water into tanks. Outdoor sites such as community gardens may provide inspiration for personal writing, artwork, or science activities. In these contexts student learning is focused towards specific features of the urban environment and may be guided by the curriculum or the teacher, or emerge organically from the place itself.

Establishing community links to foster relationships and stewardship

School Agenda 21 and Green Schools programs seek to promote socially and environmentally sustainable schools and municipalities by helping urban schools collaborate with their communities. Despite these mainstreaming efforts, some urban schools experience challenges emerging from the collaboration (Sandäs, 2014). School Community Collaboration for Sustainable

Development, a European Union funded multilateral network supported by the Environment and School Initiatives network, conducted an international comparative cross-case study (Espinete, 2014) to investigate challenges that schools face, such as funding, effective networking, cultural background, and political orientation.

To promote sustainability, schools can adopt unconventional approaches to teaching and learning that invite community actors to cross boundaries and establish vital relationships with other actors and with their place (Wals, van der Hoeven and Blanken, 2009). For example, in our case studies from China and Canada, students are communicating their learning back to the public via websites and interpretive signage. In our case studies from Australia and Spain, several nearby schools developed networks to obtain shared funding, or to have older students mentor younger students, in each case working with community partners toward a common goal.

Four case studies

Natureground and Whispering Signs in Calgary, Alberta, Canada

The Centennial Natureground, situated on the grounds of an urban Kindergarten to Grade 6 school in Calgary, Canada, is a publicly accessible, reclaimed and reconstructed sustainable mini-ecosystem, featuring native plants. The plants have been rescued and transplanted from natural areas undergoing urban development, and directly

sowed from native seeds or planted as seedlings for the purposes of holistic education and enjoyment. The area, established by students and volunteers in 2004, is maintained through local stewardship—by classroom students during the academic year and community members during the summer. These stewards keep invasive species at bay, thus fostering urban biodiversity and supporting pollinators such as bees, birds, and bats. Classes regularly visit the area, for curriculum-related ecological studies and as a space to read, journal, and sketch. The Natureground also features biofiltration basins, swales, and culverts to capture rainwater and snowmelt, thus reducing and filtering stormwater runoff that would otherwise carry pollutants from paved roads straight into open waterways.

Whispering Signs is a curriculum-connected project consisting of a site-specific set of interpretive signs within the Natureground and an adjacent fragment of native shortgrass prairie. Students, teachers, parents, and community members worked together over several years to produce the original art, poetry, and text for 34 beautiful and provocative signs for school-based and public education. For example, an alphabet sign shows a common white-tailed jackrabbit changing its coat over the seasons, during a variety of weather conditions, and under different heights of the sun over the course of a year—all concepts within the school curriculum (Figure 1). Latitude, longitude, and elevation are indicated on each sign, and give

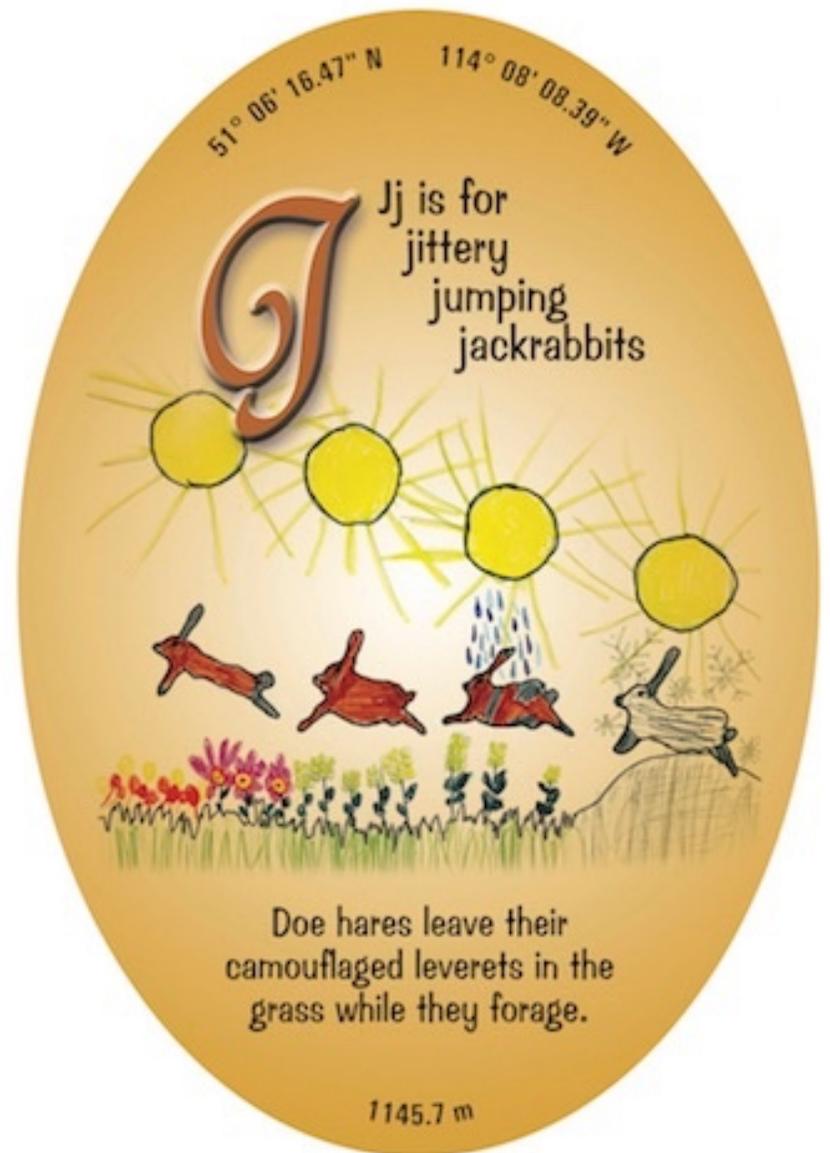


Figure 1. Jackrabbits through the seasons in Calgary, Canada. Image credit: Polly L. Knowlton Cockett.

rise to spatial geography lessons and orienteering activities. These signs stem from a place-based literacy project conducted in the area, where students researched, represented, and communicated information about plants, animals, and physical features of the landscape. Throughout these and other Green School projects, participants developed meaningful interrelationships, and became increasingly connected to place.

Constructed wetlands and frogs in Australia's Latrobe Valley

An unusual urban environmental initiative is found in a surprising place in Australia—the heart of the Latrobe Valley in Gippsland, Victoria. This region supplies electricity through brown coal-fired power generation. Socially and economically disadvantaged, this area has huge open cut brown coal mines, massive power lines, transformer stations, and puffing chimneys of large and small power stations. The Valley has poor air quality and high pollution levels.

However, a local primary school began using the Morwell River Wetlands as a site for teaching and learning about the complex social, cultural, economic, and environmental aspects of this contested area (Somerville and Green, 2012). The wetlands have been constructed in the river overflow site that was relocated to make way for the coal mine, and encompass pools, banks, islands, and many creatures and plants, including frogs, trees, shrubs, and grasses. The primary school has been involved in the wetland since it was constructed and students have monitored the plants and animals that have found “home” there. Shortly after the wetlands were created, three local schools applied for a science grant and received \$20,000 to set up a wetland study and develop a curriculum model. The schools worked with the Amphibian Research Centre to develop the Frog Census program based on the belief that frogs are the gateway to understanding the wetlands.

The wetlands are visited regularly by all school grades, and curriculum links are made across subject areas. Younger students study life cycles of frogs, and raise tadpoles in a mini-wetland constructed on their school ground. Middle year students monitor the wetlands and older students measure water quality and identify micro- and macro-organisms. From an eyesore to a healthy ecosystem, these constructed wetlands have become enriched with educational opportunities for students.

“Water-loving” studies on the Long River in Beijing, China

The high school affiliated with the Beijing Institute of Technology is located on the southern bank of the Long River, which is an indispensable part of the Beijing city water system. Influenced by the Green School movement, which has been supported by the national government in China since 1996, the school has been promoting a series of local environmental education activities since 2001 (Liu and Huang, 2013). For example, in the context of general water inquiries, teachers have established “water-loving” student groups. These grade-level groups carry out many projects, such as investigating water usage in their school and households, as well as researching the watersheds surrounding their campus.

Under teachers’ guidance, members of “water-loving” groups study water issues relevant to the school and the Long River system. After preliminary investigations and analyses, students undertake Long River



Figure 2. Investigating the Long River in Beijing, China. Photo credit: Guochun Zhang.

water surveys and launch environmental fieldwork integrating aspects of geography, biology, chemistry, and physics. As young scientists (Figure 2), the students design their research, divide their work reasonably, and rethink obstacles they encounter, while constantly discussing and revising plans with others. Teachers and students also use information technology to record and share students' research processes and results, and use data they collect as resources in information technology courses. Then they create "water-loving" actions on a website, such as conservation measures and water quality monitoring, which provides a

convenient way to locate and express their research process and results. Thus, this project-based learning provides rich information technology curriculum resources, and offers a medium of communication about project results and actions. These two stages of "Integrated Curriculum of Practical Activity" complement and promote each other.

Through these activities on the Long River, the "water-loving" theme is effectively spread and sets up a series of "water-loving" actions. The activities also have been playing an important role in motivating students to explore their academic and sustainability-related interests and laying a foundation for future inquiries. In addition, teachers update their own pedagogical understandings, thus enhancing the capacity for adapting and implementing curriculum reform.

School agroecology and community collaboration, Sant Cugat del Vallès, Catalonia, Spain

The Science Education Department at the Autonomous University of Barcelona and the Municipal Environment Department of Sant Cugat del Vallès in Catalonia, Spain collaborated for seven years to enhance the School Agenda 21 program in the city. Established in 2001, the program involved urban schools in the city's effort to promote sustainable development, and established links between schools and the community for the development of a new field of study called School Agroecology (Llerena, 2015). The program built an urban school network

involving all public urban schools from pre-K to secondary level, university researchers, local administrators, and environmental educators with the aim to empower students, teachers, and the community to develop agroecological food production and food consumption (Espinet and Llerena, 2014).

One of the collective projects was to transform school and community food gardens as places to grow endangered native plants (Figure 3). After consultation with a regional seed bank, each school chose a specific native plant to grow; students then harvested and preserved seeds, and shared seeds among different school and community actors to be grown in their own food gardens. Through a service-learning approach, secondary students visited primary students to teach seed preservation. Seed exchanges became an event where donor schools provided not only a sample of seeds but also storytelling, drama, or visualizations about growing practices. Once schools started

having seeds from several plants, they built seed banks inside their schools. In so doing, urban public schools with the help of the community became authentic urban agents of native plant preservation. One result of this urban environmental education project has been the creation of a new professional niche: the agro-environmental educator responsible for promoting and maintaining urban environmental education activities focused on the food system at the interface between the school and the city.

Conclusion

As demonstrated by our urban case studies, ongoing Green School actions—whether learning about lifecycles, monitoring water quality, or seed harvesting—guide students understanding their environment. Within the complex networks of urban settings, students also become directly engaged in urgent and interrelated global movements, for example pertaining to food security, as well as global initiatives such as Local Action for Biodiversity or BiodiverCities. Thus, socioecological refrains, involving place-based, curriculum-connected, community-engaged, collaborative practices, serve as effective frameworks for urban primary and secondary schools to provide students with rich, meaningful experiential learning opportunities fostering systems-thinking, stewardship, and sustainability.



Figure 3. Nurturing native plants in Sant Cugat del Vallès, Catalonia, Spain. Photo credit: Mariona Espinet and Lidia Bassons.

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3. Community environmental education

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Photo credit: Alex Russ

HIGHLIGHTS

- Community environmental education uses environmental learning and action to foster community wellness in cities and other settings.
- Social learning encompasses a diversity of learning theories, all of which focus on learning through interaction with others.
- Communities of practice and cultural historical activity theory are two social learning frameworks useful in understanding community environmental education.

Introduction

Community environmental education prioritizes community wellness above environmental outcomes. Rather than learning in, about, and for the environment being an end in itself, environmental learning becomes a means towards community wellness and healing. In this way, community environmental education is aligned with youth and community development, participatory, and resilience approaches in environmental education. Despite the priority being social rather than environmental, in reality community environmental education programs generally result in positive impacts for both communities and the environment.

Recognizing that community environmental education is an emerging field lacking a clear definition (Aguilar, in revision, Aguilar, Price and Krasny, 2015), here we use a definition developed in the US urban context (Price, Simmons and Krasny, 2014): “Community environmental education aims to enhance a community’s wellness through thoughtful environmental action. It fosters collaborative learning and action, taking into account the social, cultural, economic, and environmental conditions of a community.”

The term community also has multiple definitions, including those built around a common location, social connections or belonging, cultural identity, and interests (Delanty, 2003). Our use of the term integrates local (e.g., a neighborhood), common interests (e.g., youth development, organic food production), and relational or

belonging aspects of community, which is consistent with our focus on community wellness. We define community wellness as social, environmental, and economic conditions that support health and quality of life, including the presence of healthy green spaces, food and water, and opportunities to engage in healthy activities with others. Although environmental education focusing on community wellness can occur anywhere, much of our understanding of community environmental education comes from work in cities.

Because building connections among people is critical to achieving community wellness, a learning theory that emphasizes how learning occurs through interaction with others is useful in elucidating the learning process and outcomes of community environmental education. Social learning encompasses a group of theories that have in common a focus on learning through interactions with others and with the environment (Wals, 2007). Two social learning theories used in understanding environmental education include communities of practice and cultural historical activity theory. For example, Aguilar and Krasny (2011) applied communities of practice theory to understanding how learning occurs in environmental after-school programs in small cities in Texas, and Krasny and Roth (2010) applied cultural historical activity theory to watershed programs occurring near Victoria, British Columbia. Importantly, these two theories privilege not just the knowledge and

perspectives of professionals, but also of community members and of youth participants in environmental education programs. For the urban environmental educator, these theories enable understanding of how learning occurs in programs designed to foster individual and organizational transformations leading to community wellness.

In this essay, we apply community of practice theory to a youth program focusing on water quality in the U.S. and cultural historical activity theory to two programs in South Africa. —one involving organic agriculture and the other medical wastes. Although the South African cases may seem foreign to Western environmental educators who commonly work with youth audiences, lessons drawn from these cases about identifying and resolving contradictions through interactions among academic, professional, and practical knowledge holders, leading to transformations and outcomes consistent with community wellness, are relevant to community environmental education more broadly.

Communities of practice

Originally developed to understand how people learn a craft or skill through interactions with more skilled craftsmen, communities of practice theory examines individual and group identity formation and transformation as a learning process. According to Wenger (1998), a community of practice is a place where people with a

common interest or concern engage and become members, agree on and pursue a particular enterprise (e.g., community wellness), and cultivate a common repertoire (e.g., cultural values). The framework considers learning as a social process that occurs as individuals participate in groups associated with a specific physical, historical and cultural context, often resembling an apprenticeship focused around a common interest or concern (Lave and Wenger, 1991). Researchers have used this framework to identify apprenticeship-like approaches to learning, while others have examined individual identity and power differentials as a result of participation in communities of practice.

Water Watchers: An environmental education community of practice in Austin, Texas

Water Watchers (organization name changed to protect participants' privacy) is an environmental education program that engages low-income youth in Austin, Texas. Its mission is to: “advance personal and academic achievement through environmental monitoring, education, and adventure.” It provides an example of how program staff’s attention to multiple elements of a community of practice fosters youth engagement. During the academic year after the school-day ends, program staff transport students to test water quality at various sites, and then to program headquarters where students socialize, share food, and do homework with peers who tested a different

site. During the summer, staff transport students to their water monitoring sites, after which they go swimming or on a field trip. Through this process, Water Watchers has developed a community of practice, including membership, common enterprise, and shared culture (Aguilar, in revision).

A community of practice relies on consistent membership with multiple entry points for joining. Water Watchers offers meetings through the year, provides transportation and a stipend (thus encouraging attendance), offers multiple activities and volunteer opportunities, and brings in speakers and community members. This allows students to participate for different reasons: they like science, they want to be with friends, their teacher recommended them, or they simply want something to do after school.

The program common enterprise revolves around youth development—including academic achievement, social support, agency and empowerment—and around environmental stewardship, both of which foster community wellness. While students often identify the program enterprise as one of water-quality monitoring and socializing, they also acknowledge the program has given them a voice and feelings of respect and acceptance. The program leaders feel students should leave the program “prepared to create a life for themselves that will be better,” and thus ask students to develop goals not only for program participation, but also for their

school and family lives. Students work as mentees until they pass a test to become mentors. Mentors in turn develop confidence in their skills as they help newcomers with water testing procedures. Students also apply their water quality knowledge in new arenas, like canoeing and service-learning. Finally, the community of practice includes trajectories that enable members to expand their academic and social skills and bridge with other communities of practice.

Water Watchers also projects a shared culture of respect for each participant and of helping each other. This culture is reinforced when students depend on one another for a successful water test, and through overnight camping and trips to learn about colleges. For example, an African American male who had recently opened up about his homosexuality on an all-boys overnight trip found acceptance rather than ridicule in the Water Watchers community. Another student admitted that high school was a difficult place to feel accepted, but Water Watchers made it easier for her to find a sense of belonging.

In addition to consistent membership, common enterprise, and shared culture, Water Watchers provides for needs like food, financial assistance in the form of a stipend, and a base for homework and recreation. These services result in a “safe space” and enable a “sense of belonging” for students, many of whom come from unstable homes. In short, Water Watchers empowers participants by improving their social and

educational skills, and fosters community wellness through these youth development outcomes and monitoring water quality.

Cultural historical activity theory

Cultural historical activity theory is based on the idea that humans change or learn when they engage in productive activity within a particular cultural and historical context and environment, and in doing so, they change that environment. Productive activity occurs within an activity system, which is comprised of a goal or outcome for the activity, tools, rules, objects, subjects, community, and division of labor, as well as the interaction of these elements (Engeström, 1987). Learning occurs through interaction of the learner with other components of this system.

Learning also occurs when contradictions between different elements of the activity system generate conflicts, for example when rules specifying how to conduct an activity are not consistent with project goals. This can lead to transformations or expanding the activity to include new rules, tools, or goals. Further, one activity system may produce outcomes that are used by another activity system, such as when knowledge produced through a water monitoring activity system is used by policy makers in a legislative activity system. In short, a learning activity system is dynamic and has multiple interactions among its elements and with other activity systems,

which can lead to transformation of the activity system and related learning.

Expansive learning in organic agriculture learning system, Durban, South Africa

In 2008, Rhodes University, which has cultural knowledge that functions as activity system “tools,” and the South African Qualifications Authority, which makes educational policies and standards and thus provides “rules,” began implementing the Researching Work and Learning program in environmental education. The Isidore Organic Network and its marketing arm Earth Mother Organic constituted one research site (Mukute, 2010). In trying to address growing demand for organic produce in Durban, these organizations faced challenges meeting organic standards, getting certified as organic producers, and becoming profitable. Cultural historical activity theory, in particular its focus on collaborative learning, transformations of current practice, and contradictions, is useful in understanding how the organic farmer group and its stakeholders sought to overcome obstacles.

Through collaboration with Rhodes University researchers, members of the organic agriculture organizations used a series of steps to contribute to expansive social learning at the local level, and potentially to education nationally. They analyzed Isidore and Earth Mother Organic agriculture and agribusiness practices, which surfaced key challenges and their underlying causes (contradictions). Then they

collectively developed and implemented a solution to address the contradictions.

Over 20 organic farmers, trainers and marketers jointly defined key challenges, surfaced their causes, and developed solutions in an expansive learning process. They identified the goal of their collaborative learning as human health, profit, and environmental sustainability—which could only be enabled by a qualitatively new practice. The research participants decided to work on the contradiction between organic regulations (rules) and local social-ecological conditions (community). They concluded that this contradiction was caused by lack of collaborative linkages in the organic sector, which in turn was explained by: difficulties in making a profit, part of which would be used for collective learning and innovation; historically constructed cultural barriers among organic value chain actors and associated low levels of trust; strong culture of individualism fostered by past failures of cooperatives; and inadequate infrastructure to support the organic farming movement, including collection centers, training, inspection, and certification.

Responding to this contradiction, the project conducted a workshop that led to formation of a Green Growers Association consisting of organic farmers, trainers, marketers, certifiers, and the municipality, with the goal of linking and coordinating learning and actions of the Durban area organic farming community. The project also identified 11 stakeholder groups and accompanying activity systems that needed to be intentionally engaged, including agro-processors, suppliers of agricultural tools, consumer groups, funding partners, research organizations, universities, and colleges (Figure 1). The second model solution was the identification and adoption of the International Federation for Organic Agriculture Movements' Participatory Guarantee System, which would enable the local organic farming community to set, implement, monitor and certify local organic

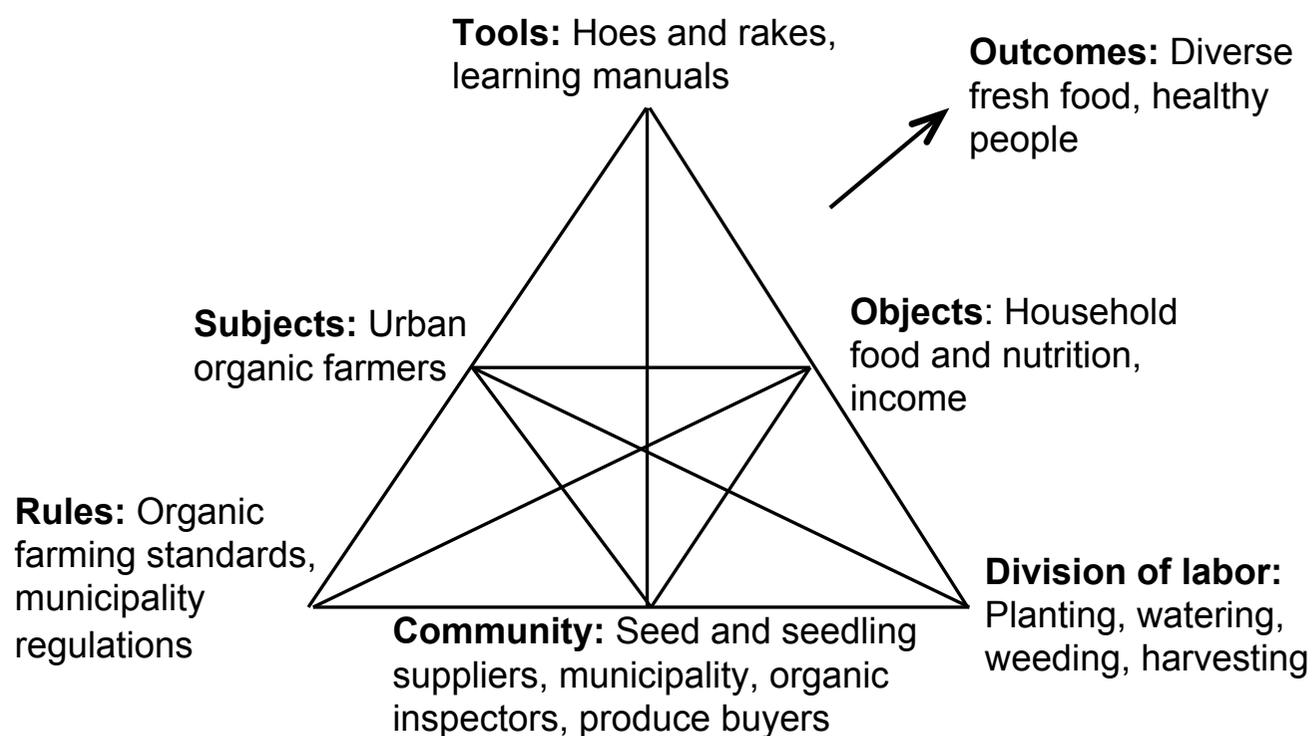


Figure 1. Urban organic farmers activity system, Durban, South Africa. Diagram adapted from Engeström, 1987.

production using agreed-upon criteria. The Green Growers Association recruited organic inspectors and an information technologies specialist to adapt international organic farming standards, communication, and marketing.

While the above process helped the Durban organic agriculture community learn jointly and generate solutions to agricultural challenges, it also revealed that organic trainers and mentors needed higher order skills to perform their tasks. In addition, the study concluded that agricultural cognition was comprised not just of the knowledge of trainers, but also of farmers, farmworkers, inspectors and marketers, which should be drawn on and developed (Mukute, 2010). Finally, it recommended the formation of local long-term collective learning, innovation and action structures. These insights were shared with the South African Qualifications Authority and Rhodes University, which influence education policy in South Africa. The insights and recommendations demonstrate a link between local and national level learning processes, which could strengthen environmental education impacts across multiple scales.

Knowledge-sharing practices in community home-based care, South Africa

Community home-based care in South Africa is in high demand due to the HIV/AIDS pandemic and related diseases, resulting in waste that poses a public health risk if not disposed of correctly. Typically, healthcare

waste includes swabs, adult diapers, and used dressings, needles, and surgical gloves. Young children have been seen playing with surgical gloves found dumped on a vacant plot, inflating them, filling them with water, and drinking out of them.

Different community players contribute toward achieving sustainable healthcare waste management. Some partners enforce waste management regulations, some produce healthcare waste, while others sort, manage, and dispose of waste. Cultural historical activity theory sees these players as interacting in activity systems that are dynamic and multi-voiced, and as individuals whose ideas and practices can be transformed through ongoing dialogue in expansive learning processes.

Research revealed that problematic waste management practices in home-based care facilities were linked to limited knowledge and knowledge-sharing (Masilela, 2015). It became clear that environmental education processes were needed to strengthen environmental management practices. For example, healthcare waste is commonly disposed of in domestic waste bins or illegally burned, but environmental health officers lack knowledge about such practices. Similarly, community home-based caregivers, despite extensive experience in nursing and palliative care, did not know how to dispose of waste generated outside of a clinic. Although senior managers seem to hold more detailed knowledge about healthcare waste management, channels to

disseminate this knowledge to environmental health officers or community home-based caregivers were non-existent. The result: impoverished waste pickers rummaging through piles of domestic garbage in search of items to recycle or resell faced risks of encountering healthcare waste.

Three workshops provided the basic framework for an expansive learning process in which the managers of home-based care facilities, environmental health officers, and waste inspectors identified their strengths and weaknesses and collaborated to seek long-term solutions. The voices of waste pickers and caregivers were brought into the workshops through interview transcripts and photographs, enabling stakeholders to develop a richer perspective on the complexity and contestation of the problem. The workshops created opportunities for people with diverse skills and backgrounds to build common knowledge and develop new practices around a shared outcome (i.e., improving waste management). Participants learned about daily practices related to healthcare waste management (“who does what”); gained insight into tensions and contradictions; and asked “why,” “how,” “where,” and “what” questions to clarify misconceptions.

The healthcare waste management activity system suggests lessons for community environmental education more broadly. Environmental sustainability challenges in urban settings require collaboration among multiple players who

need access to contextually relevant knowledge. Processes that stimulate dialogue and the production, circulation, and reflexive critique of knowledge within and across activity systems, such as the workshops addressing healthcare waste management, create opportunities for expansive learning leading to sustainability innovations.

Conclusion

The communities of practice framework allows us to examine social learning that occurs through participation in a community focused on a common enterprise. Cultural historical activity theory enables us to see how activities expand through encountering challenges or contradictions, resulting in learning at higher levels.

A focus on learning through interactions also suggests equitable knowledge sharing, which is important to urban environmental education. It reveals a subtle change in perspective from expanding existing outreach programs to simply be more inclusive of non-traditional audiences, such as low-income youth, farmers, or community healthcare workers. Instead, the focus is on the knowledge and experience youth, farmers, and healthcare workers, alongside university scientists and professional environmental educators, bring to the table. Recognizing and honoring each actor’s assets not only uncovers information and ideas potentially useful in addressing sustainability issues, it also empowers less powerful community

members. For these reasons, it is a critical component of social learning and of urban environmental education that seeks to foster community wellness and environmental sustainability.

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4. Sense of place

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Photo credit: Alex Russ

HIGHLIGHTS

- Sense of place—including place attachment and place meanings—can help people appreciate ecological aspects of cities.
- Sense of place is determined by personal experiences, social interactions, and identities.
- In cities, factors such as rapid development and gentrification, mobility, migration, and blurred boundaries between the natural and built environment complicate sense of place.
- Urban environmental education can leverage people's sense of place and foster ecological place meaning through direct experiences of places, social interactions in environmental programs, and nurturing residents' ecological identity.

Introduction

Different people perceive the same city or neighborhood in different ways. While one person may appreciate ecological and social aspects of a neighborhood, another may experience environmental and racialized injustice. A place may also conjure contradicting emotions—the warmth of community and home juxtaposed with the stress of dense urban living. Sense of place—the way we perceive places such as streets, communities, cities or ecoregions— influences our well-being, how we describe and interact with a place, what we value in a place, our respect for ecosystems and other species, how we perceive the affordances of a place, our desire to build more sustainable and just urban communities, and how we choose to improve cities. Our sense of place also reflects our historical and experiential knowledge of a place, and helps us imagine its more sustainable future. In this essay, we review scholarship about sense of place, including in cities. Then we explore how urban environmental education can help residents to strengthen their attachment to urban communities or entire cities, and to view urban places as ecologically valuable.

Sense of place

In general, sense of place describes our relationship with places, expressed in different dimensions of human life: emotions, biographies, imagination, stories, and personal experiences (Basso, 1996). In

environmental psychology, sense of place— how we perceive a place— includes place attachment and place meaning (Kudryavtsev, Stedman and Krasny, 2012). Place attachment reflects a bond between people and places, and place meaning reflects symbolic meanings people ascribe to places. In short, “sense of place is the lens through which people experience and make meaning of their experiences in and with place” (Adams, 2013). Sense of place varies among people, in history, and over the course of one’s lifetime (<http://www.placeness.com>). People may attribute various meanings to the same place in relation to its ecological, social, economic, cultural, aesthetic, historical, or other aspects. Sense of place evolves through personal experiences, and defines how people view, interpret and interact with their world (Russ et al., 2015). In cities, sense of place echoes the intersections of culture, environment, history, politics, and economics, and is impacted by global mobility, migration, and blurred boundaries between the natural and built environment.

Research and scholarship around the relationship between "place" and learning reflects diverse perspectives, many of which are relevant to urban environmental education. Education scholars point to the need for people to develop specific "practices of place" that reflect embodied (perceptual and conceptual) relationships with local landscapes (natural, built, and human). Further, some scholars and

researchers have used a lens of mobility—the globalized and networked flow of ideas, materials, and people—to build awareness of the relationship between the local and global in the construction of place in urban centers (Stedman and Ardoin, 2013). This suggests that understanding sense of place in the city generates an added set of situations and challenges, including dynamic demographics, migration narratives, and complex infrastructure networks, as well as contested definitions of natural environments (Heynen, Kaika and Swyngedouw, 2006). One critical question is how we think about sense of place in cities when places and people are constantly on the move. Given rural-urban migration, sense of place today includes where a person came from as much as where she now finds herself. In one study in a large, urban center in the U.S., Adams (2013) found that notions of “home” and identity for Caribbean-identified youth were largely constructed in the northeastern urban context in which they found themselves either through birth or immigration. Such dimensions of place relationships are vital for thinking about meaningful and relevant urban environmental education.

Understanding sense of place in the urban context would be incomplete without a critical consideration of cities as socially constructed places both inherited and created by those who live there. Critical geographers such as Edward Soja, David Harvey, and Doreen Massey draw on a Marxist analysis to describe cities as the

material consequence of particular political and ideological arrangements under global capitalism. Critical educators (e.g., Gruenewald, 2003; Haymes, 1995) have drawn upon critical geography to demonstrate how cities are social constructions imbued with contested race, class, and gender social relationships that make possible vastly different senses of place among their residents. For example, Stephen Haymes (1995) argued that against the historical backdrop of race relations in Western countries, “in the context of the inner city, a pedagogy of place must be linked to black urban struggle” (p. 129). Although Haymes was writing twenty years ago, his claim that place-responsive urban education must be linked to racial politics resonates today with the Black Lives Matter movement in the U.S. and ongoing need for environmental educators to be in tune with the political realities that so deeply inform a given individual’s sense of place. This also resonates with the notion that different people may ascribe different meanings to the same place. The complexity of meaning surrounding urban places and our understandings of such contested meanings make a powerful context for personal inquiry and collective learning.

In the U.S., Tzou and Bell (2012) used ethnographic approaches to examine the construction of place among urban young people of color. Their results suggest implications for equity and social justice in environmental education, such as the

damage that prevailing environmental education narratives could do to communities of color in terms of power and positioning. Further, Gruenewald (2005) suggests that traditional modes of assessment, such as standardized tests, are problematic in place-based education; instead, we need to redefine education and research as forms of inquiry that are identifiably place-responsive and afford a multiplicity of approaches to define and describe people's relationships to the environment.

Sense of place and urban environmental education

Although not always explicitly stated, sense of place is inherent to many environmental learning initiatives (Thomashow, 2002). A goal of such programs is nurturing ecological place meaning, defined as “viewing nature-related phenomena, including ecosystems and associated activities, as symbols” of a place (Kudryavtsev, Krasny and Stedman, 2012). This approach is prevalent in bioregionalism, the “no child left inside” movement, community gardening, sustainable agriculture, as well as in natural history, place-based, and other environmental education approaches. Place-based education has goals important to urban life, including raising awareness of place, of our relationship to place, and of how we may contribute positively to this constantly evolving relationship, as well as inspiring local actors to develop place-responsive

transformational learning experiences that contribute to community well-being.

Nurturing a sense of place

With the global population increasingly residing in cities, ecological urbanism requires new approaches to understanding place. How does sense of place contribute to human flourishing, ecological justice, and biological and cultural diversity? Using a theoretical basis from literature described above, we offer examples of activities to help readers construct field explorations that evoke, leverage, or influence sense of place. (Also, see a relevant diagram in Russ et al., 2015.) In practice, urban environmental education programs would combine different approaches to nurture sense of place, perhaps most prominently place-based approaches (Smith and Sobel, 2010), which teach respect for the local environment, including its other-than-human inhabitants, in any setting including cities.

Experiences of the urban environment

Making students more consciously aware of their taken-for-granted places is an important aspect of influencing sense of place. Focusing on places students frequent, educators can ask questions like: “What kind of place is this? What does this place mean to you? What does this place enable you to do?” Hands-on activities that allow students to experience, recreate in, and steward more natural ecosystems in cities could be one approach to nurture ecological place

meaning. Another activity could use conceptual mapping to highlight places and networks that are important to students, for example, related to commuting and transportation, the internet, food and energy sources, or recreation. Maps and drawings also might focus on sensory perceptions—sights, sounds and smells—or locate centers of urban sustainability. Such maps can help students learn about specific neighborhoods, investigate the relationship among neighborhoods, or create linkages between all the places they or their relatives have lived. Further, mapping activities may help students recognize how their own activities connect to the larger network of activities that create a city, as well as allow them to reflect on issues of power, access, and equity in relation to environmental concerns such as waste, air pollution, and access to green space.

Other observational and experiential activities to instill sense of place might include: (1) exploring boundaries or borders, for example, space under highways, transition zones between communities, fences and walls; (2) finding centers or gathering places and asking questions about where people congregate and why; (3) following the movements of pedestrians and comparing them to the movements of urban animals; (4) tracing the migratory flows of birds, insects and humans; (5) shadowing city workers who are engaged in garbage removal or other public services as they move around the city; (6) observing color and light at

different times of the day; (7) observing patterns of construction and demolition; and (8) working with street artists to create murals. All of these activities could serve to develop new meanings and attachments to places that may or may not be familiar to people. The activities build on seminal works related to urban design, including Christopher Alexander’s “Pattern Language,” Randolph T. Hexter’s “Design for Ecological Democracy,” Jane Jacobs “The Death and Life of Great American Cities,” Jan Gehl and Birgitte Svarre’s “How to Study Public Life,” and the rich material coming from *New Geographies*, the journal published by the Harvard University Graduate School of Design.

Social construction of place meanings

Activities that allow people to explore and interpret places together could contribute to developing a collective sense of place and corresponding place meanings. Participatory action research and other participatory approaches raise young people’s critical consciousness, influence how they see themselves in relation to places, and build collective understandings about what it means to be young in a rapidly changing city. For example, photo-voice and mental mapping used during a participatory urban environment course allowed students, many of them from marginalized racial and ethnic groups, to experience a shift from viewing a community as a fixed geographic place to a dynamic, socially constructed space, and to describe how they experience

and understand urban phenomena such as decay, gentrification, and access to green spaces (Bellino and Adams, 2014). These activities enabled students to expand their notions of what it means to be urban citizens, and to transform their ecological identities in ways that prompted them to take steps towards imagining environmentally, economically, and culturally sustainable futures.

Further, ecological place meaning can be constructed through storytelling, communication with environmental professionals, interpretation, learning from community members, and sharing students' own stories (Russ et al., 2015), as well as through representation of places through narratives, charts, music, poetry, photographs, or other forms that encourage dialogue and reflection about what places are and how they can be cared for (Wattchow and Brown, 2011). Other social activities, such as collective art-making, restoring local natural areas, or planting a community garden, could contribute to a collective sense of place that values green space and ecological aspects of place. New socially constructed place meanings can in turn help to promote community engagement in preserving, transforming, or creating places with unique ecological characteristics (e.g., fighting to keep a community garden safe from developers), and create opportunities to maintain these ecological characteristics (e.g., group-purchasing solar power). Environmental educators who are able to

engage with a community over time can watch these initiatives take root and grow, and can observe individual and collective changes in sense of place.

Developing an ecological identity

In addition to paying attention to social construction of place, environmental educators can nurture ecological identity, which fosters appreciation of the ecological aspects of cities. Humans have multiple identities, including ecological identity, which reflects the ecological perspectives or ecological lens through which they see the world. Ecological identity focuses one's attention on environmental activities, green infrastructure, ecosystems, and biodiversity, including in urban places. Ecological identity in cities can be manifested in realizing one's personal responsibility for urban sustainability, and feeling oneself empowered and competent to improve local places (Russ et al., 2015). Urban environmental education programs can influence ecological identity, for example, by involving students in long-term environmental restoration projects where they serve as experts on environmental topics, by valuing young people's contribution to environmental planning, respecting their viewpoint about future urban development, and recognizing young people's efforts as ambassadors of the local environment and environmental organizations (e.g., through work/volunteer titles, labels on t-shirts, or workshop certificates). Even involving students in projects that allow them to become more

familiar with their community from an ecological perspective goes a long way towards adding an ecological layer to their identity and perception of their city (Bellino and Adams, 2014).

Conclusion

The environmental education challenge presented in this essay is how to embed deeper meanings of place and identity in dynamic urban environments. Because urban settings tend to be diverse across multiple elements, ranging from types of green space and infrastructure to global migration, there are countless ways to proceed. In addition, while environmental educators can design and facilitate experiences to access and influence people's sense of place, it is also important for educators to have a strong notion of their own sense of place. This is especially critical for environmental educators who may not have spent their formative years in a city. Such persons may have a sense of place informed more by frequent and ready access to natural areas, and less by access to urban diversity and the density and diversity of people found in an urban environment. It is important for all urban environmental educators to engage in reflective activities that allow them to learn about their personal sense of place, including what they value about the natural, human, and built environment. Demonstrating one's own continued learning, and learning challenges, will greatly aid in the process of facilitating other learners developing sense of

place in diverse urban settings. Through sharing their own experiences with places, all learners can deepen our awareness of and sensitivity to our environment and to each other. Such awareness and receptivity to place can positively influence collective and individual actions that help create sustainable cities.

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5. Climate change education

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Photo credit: Alex Russ

HIGHLIGHTS

- Climate change education addresses immediate safety and risk reduction, as well as longer-term actions to enhance environmental quality.
- Education that focuses exclusively on reducing our carbon footprint, or mitigation, is no longer realistic given that changes in climate are already occurring and threatening livelihoods, communities, ecosystems, and biodiversity.
- Education for adaptation and transformation can foster healthy ecosystem and community processes, consistent with reducing carbon footprint.
- The “reclamation, resilience, and regeneration” climate education framework encompasses learning about mitigation, adaptation, and transformation.

Introduction

In October 2012, Hurricane Sandy slammed into the New York and New Jersey shoreline, with winds of 145 kilometers per hour and a storm surge 4.3 meters above mean low water. The superstorm flooded the city's subways, destroyed thousands of homes, washed away beaches and boardwalks, and caused at least 53 deaths and over \$18 billion in economic losses. On the other side of the world, between 2006 and 2014, Singapore experienced multiple 150-year record rainfalls and droughts. How can cities experiencing climate-related flooding and other disturbances protect their citizens now and into the future?

Environmental education—including school and public programs developed by universities and government agencies as well as initiatives that emerge from the efforts of grassroots organizations—can play a role in responding to and preparing for climate change and related disasters. But in so doing, environmental educators face a dilemma: how can we hold true to our foundational values of enhancing the environment, including efforts to mitigate climate change, while addressing the reality that climate change has already irreversibly changed our environment and that we need to adapt and transform? We address this question using examples of formal school curricula, engineered infrastructure development, and public outreach in Singapore, and through an exploratory “three Rs” approach to climate responsive

environmental and sustainability education in the U.S.

Formal curriculum and infrastructure approach

Singapore has responded to climate change through a combination of building infrastructure to ensure safety, implementing climate change requirements in the school curriculum, and public education (Figure 1). An example of infrastructure is engineering efficient drainage systems. Reflecting government directives, climate change has been incorporated into the grade 8 and 9 syllabus with a focus on “variable weather and changing climate” (Chang, 2014). Climate change education in Singapore seeks to help learners develop knowledge, skills, values and action to engage with and learn about the causes, impacts, and management of climate change. Students are



Figure 1. Like many coastal cities, most of Singapore is no more than a few meters above sea level; thus efficient drainage systems and education for public preparedness for floods are essential. Photo credit: Alex Russ.

expected to be proficient in climate change science, make informed judgements about climate change issues, convince others of their beliefs about the causes of climate change, and take personal action to reduce their carbon footprint. Complementing these infrastructure and school efforts is public education on floods, which is focused on public preparedness. For example, Singapore's Public Utilities Board communicates flood updates on the radio, Facebook, Twitter, and other websites. The public is actively engaged through crowd-sourced reporting of flood locations. In response to droughts, public education has focused on information dissemination and on providing an advisory to households to voluntarily manage water demand.

Whereas Singapore's multi-pronged efforts are impressive, Chang and Irvine (2014) recognize the need for a more integrated approach to prepare the public. For instance, they suggest developing a program to help the public prepare for precipitation extremes by identifying vulnerabilities and risks, creating an understanding of the notion of adaptive capacity (e.g., through improving drainage systems), and monitoring precipitation. They also promote a relief action program that describes what can be done for post-event recovery. In short, Singapore, which similar to many coastal cities around the world is highly vulnerable to sea level rise, has embarked on a comprehensive approach to protect and

educate its citizens and can be expected to take on even greater efforts in the future.

Climate-responsive environmental and sustainability education: Reclamation, resilience, and regeneration (three Rs)

In addition to efforts like those in Singapore that help residents prepare for and respond to the immediate threat of disasters, Hauk (2016) has called for more fundamental rethinking about how we address ongoing climate instability. She had proposed the three Rs approach to climate-responsive environmental and sustainability education. The Rs include reclamation, a form of mitigation or reducing our impact on and improving the environment; resilience, which incorporates notions of adaptation and adaptive capacity; and regeneration, which is most closely aligned with transformation or envisioning new social-ecological processes and systems. We suggest how environmental education can support each of these processes below.

Reclamation

Reclamation involves designing systems to reclaim lost ecological and social capacity. It can include ark-like preservation or conservation via sanctuaries, weather-proof libraries, seed banks, and reserves that maintain cultural lifeways. Whereas we often think of reclaiming in terms of mine reclamation, here we refer to reclaiming more complete sustainable living systems such as those incorporating indigenous ecological knowledge. Innovative technologies, including those informed by deep biomimicry

(Mathews 2011), can contribute to reclamation. Because reclamation is driven by an ethic of caring, and by political and social structures that allow for the expression of that caring, it depends on a culture's commitment to sustainability. Further, because it invites reconsideration of marginalized ecosystems and lifeways, reclamation also depends on the cultural commons, and the continuity and honoring of elder cultures that provide an alternative to practices with a high carbon footprint (Bowers, 2013). While this seemingly excludes the possibility of reclamation for many cities, remnants of social and ecological memories are often retained, for example, by farmers who have immigrated or migrated to urban centers and grow vegetables and herbs in community gardens. Cuba's permaculture and organic farming revolution and use of appropriate technologies following loss of Soviet support in the 1990s provides an example of reclamation. Such urban agriculture, as well as smaller-scale urban allotment and community gardens, bring together multiple generations and people with different skills, and thus create opportunities for environmental learning.

Resilience

A person, a community, an ecosystem, or a social-ecology system can be resilient. Thus, psychology, sociology, and ecology have developed definitions of resilience, all of which have in common notions of hardship, disturbance, recovery, adaptation, and in

cases where an individual, community, or system experiences "tipping point" changes, transformation (Table 1).

Table 1. Resilience definitions.

Type of resilience	Definition
Community	Ability of communities to cope with and recover from external stressors resulting from social, political and environmental change (CARRI, 2013)
Ecological	Magnitude of disturbance that a system can experience before it moves into a different state with different controls on structure and function (Holling, 1973)
Psychological	Processes of, capacity for, or patterns of positive adaptation during or following exposure to adverse experiences that have the potential to disrupt or destroy the successful functioning or development of the person (Masten and Obradovic, 2008)

Krasny, Lundholm, and Plummer (2010) suggest four ways in which environmental education programs can contribute to social-ecological and other forms of resilience.

- Environmental education can foster attributes of resilient social-ecological systems such as biological diversity, ecosystem services, and social capital (cf. Walker and Salt, 2006).

- Through collaboration with government agencies and nonprofit and community organizations, environmental education organizations can become part of polycentric governance systems, which offer options for adapting to and bouncing back from small disturbance and major disasters (cf. Ostrom, 2010, cited in Krasny et al. 2010).
- Resilience can help bridge the controversy over whether environmental education is an instrument to promote behavior change, or a means to foster critical thinking and emancipation, by showing that environmental education can foster social-ecological systems (instrumental) and psychological (emancipatory) resilience simultaneously.
- Parallels among concepts from learning theory and social-ecological resilience may contribute to badly needed cross-disciplinary approaches to address linked social and environmental problems. For example, learning theory suggests that discrepant or unexpected events foster transformational learning, and social-ecological systems resilience suggests that major disturbances spur new approaches to environmental management and environmental education.

A study of environmental educators who experienced Hurricane Sandy in New York City revealed that educators commonly used the term resilience to describe their programs. They drew on their environmental education practice to create working definitions of resilience, which roughly mirrored the academic definitions of psychological, community, and social-ecological resilience. A program emphasizing psychological resilience sought to equip participants with the skills to respond to future disturbances; programs designed to support community participation in planning reflected community resilience; and those that fostered engagement in civic ecology practices, such as oyster and dune restoration, reflected social-ecological resilience (DuBois and Krasny, 2016).

Although educators in the New York City study commonly did not make a distinction between resilience and adaptation, they spoke about resilience more often. Possible explanations include being influenced by resilience-focused funding and resilience-related city government reports. But an intriguing possibility is that the notion of resilience as a pathway forward in the face of personal hardship as well as larger systems disturbance made this term resonate with educators. Or, as one educator put it: “Adaptation—sometimes there is a, I don't want to use the word helplessness—but less of a proactive feeling than resiliency. Resiliency says it's a pathway and process—

the words adaptation and mitigation—not a lot of love in there.”

Regeneration

Regeneration involves creating more fundamental, transformational change, recognizing that climate change is altering ongoing social-ecological processes and that systems may lose the ability to adapt (Hauk, 2016). Such transformations are consistent with the reorganization phase following tipping point disruptions in the adaptive cycle, and with the emergence of entirely new processes at multiple scales (Gunderson and Holling, 2002; Krasny et al, 2010). Similar to resilient systems, regenerative systems are characterized by multiple and multi-scale feedback mechanisms, including feedbacks among social capital, empowerment, urban food production, justice, and knowledge-sharing networks. For example, students engaged in community gardens may build social capital, which in turn may foster willingness to engage in further action for the common good—including actions that require creating new systems for managing collective resources such as urban open space. Urban environmental education can play a role in regeneration not only by helping young people engage in activities such as creating and monitoring artificial algal systems designed to filter contaminants or produce energy, but also by reflecting on the human, community, and ecosystem processes that enable such systems to thrive. We can think of regeneration as “re-weaving living systems.” Williams and Brown

(2012, pp. 44-45) argue that these more radically transformative approaches “redesign the mindscape” while restructuring environmental and sustainability education through “the development of a regenerative metaphorical language to inform sustainability teaching and learning.” The learning is characterized by cooperation, mutual reciprocity, and vibrancy, and catalyzes transformations in the structure and pedagogy of learning contexts.

Summing-up

All three Rs—reclamation, resilience, and regeneration—can occur simultaneously. In fact, we may envision them as embedded processes, with reclamation occupying the more limited vision, followed by resilience and finally regeneration. Further, all three processes may depend on horizontal networks of nongovernmental organizations, scientists, government, and community groups that mobilize actions, and vertical integration of community action with larger political structures so as to effect larger changes (Soltesova et al., 2014).

Environmental education can incorporate reclamation, resilience, and regeneration. Environmental education for reclamation occurs when students become involved in preservation, conservation, and the establishment of sanctuaries of exemplar systems, including in small urban parks or gardens. Environmental education for social-ecological resilience focuses on building adaptive capacity, including through creating social networks to support collaboration and

learning, which are in turn applied to an ongoing process of collaborative and adaptive management or so-called “learning by experience.” Similar to environmental education for resilience, environmental education for regeneration incorporates an emphasis on feedback processes and nurtures participation in stewardship activities; however it adds a focus on learning through creating entirely new systems, like algal energy production, and on reflecting on how new types of complex systems operate.

Conclusion

Returning to our original question about the challenges environmental education faces in an age of climate change, we contend that environmental education can integrate mitigation and adaptation in cases where adaptation is grounded in processes that occur in healthy ecosystems and communities (Krasny and DuBois, in press). Examples of so-called “ecosystem-based adaptation” include restoring populations of oysters that provide filtering and other ecosystem services, and restoring dunes to serve as natural barriers for storm surges. Environmental education also can address adaptation in a manner consistent with its social values, including participation and equity, by incorporating “community-based adaptation” options. These include efforts to engage youth and adults in collaborative, hands-on stewardship and monitoring. Although many such initiatives may not sound like environmental education per se,

we propose a definition of urban environmental education that in addition to structured lessons, encompasses the learning that occurs through engagement in hands-on reclamation, restoration, and creating or monitoring regenerative systems. In some cases, this will mean that engagement in restoration and other forms of stewardship, normally considered a goal of environmental education, occurs prior to and creates a context for learning.

How might we integrate environmental education alongside mitigation, adaptation, and transformation, and the three Rs climate responsive education? We can start by drawing on a long-term tradition of environmental education that has focused on mitigation. When efforts to foster pro-environmental behaviors address conservation, environmental education is consistent with the first R, reclamation. Climate responsive environmental education expands to encompass ecosystem- and community-based adaptation, which is consistent with the second R, resilience. Finally, climate responsive environmental education encompasses transformation or regeneration, the third R (Table 2). Although we refer here to social-ecological resilience and transforming social-ecological systems, environmental education also fosters psychological resilience and transforms individual lives. Both individual and social-ecological systems resilience and transformation are critical to addressing climate change.

Table 2. Correspondence between three Rs and mitigation, adaptation and transformation.

Climate response categories	Three Rs	Examples
Mitigation	Reclamation	Preserves that incorporate indigenous knowledge, seed banks
Adaptation	Resilience	Ecosystem- and community-based adaptation (e.g., dune restoration)
Transformation	Regeneration	“Reweaving” new systems (e.g., algal energy production system)

In this essay, we present two paradigms for climate change education in cities. The first is based on the real-life experience of Singapore, a small, coastal city-state in constant risk of flooding whose options are limited by its size and location. Here, a more government-directed approach to ensure the safety of individuals and their water supply has been successful in saving lives.

The three Rs tries to move beyond existing ways of thinking and political structures that reinforce social and economic injustices and environmental degradation. It also suggest moving beyond top-down control strategies for emergency preparedness, despite the fact that such strategies may be desperately needed to save lives and infrastructure in the short run. Finding the balance between real-time responsiveness to ensure safety and save human lives, stewardship action coupled with reflection and integrated understandings of social-ecological systems, and long-term

capacity building to create transformed energy and social systems, is a critical challenge facing environmental education as we address social and ecological changes brought about by a warming and more erratic climate.

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6. Early childhood

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Photo credit: Alex Russ

HIGHLIGHTS

- Early childhood environmental education in cities draws on ideas of John Dewey, Reggio Emilia preschools, environment education in the built environment, and education for sustainability.
- Urban environmental education facilitates children's contact with and learning about urban nature and the built environment.
- Successful models for early childhood environmental education develop citizenship and promote sustainability.
- A variety of approaches, including participatory planning, forest kindergartens, mobile preschools, and school gardens, can be integrated into urban early childhood education.

Introduction

Early childhood—which is generally defined as ages three through eight—is a foundational period when children rapidly move through milestones in physical, cognitive, social, emotional and language development (McCartney and Phillips, 2006). Cities offer unique environments for learning because they present young children with high densities of people from different backgrounds and cultures, buildings and public spaces that may reflect hundreds or even thousands of years of human history, and political systems that regulate environmental behaviors and decision-making. In parks and along riverbanks, in vacant lots and gardens, the natural world weaves its presence. This essay begins by identifying successive schools of thought in early childhood education that have encouraged the exploration of urban environments with young children. These traditions have pursued similar aims: creative self-expression, democratic decision-making, collaborative learning among peers and multiple generations, communication skills, and a deepening of children’s experiential, place-based learning. This chapter illustrates diverse ways these aims can be achieved in cities, including participatory planning and design, mobile preschools, greening the grounds of schools and childcare centers, gardening, and forest and nature schools in metropolitan areas. It draws examples from both resourced and poorly resourced schools

and childcare centers in the global North and South.

Supportive teaching philosophies

In the 1890s, John Dewey’s progressive education sought to prepare children to adapt to an ever changing world through democratic processes of problem solving (Zilversmit, 1993). Central to this philosophy was the ideal of community—that children need opportunities to work with others in a spirit of empathy and service to the world. Dewey’s lab school demonstrated that essential skills like reading, writing and mathematics could be taught by following children’s own interests in communication, investigation, constructing things, and artistic expression. Dewey’s ideas encouraged project-based learning, which in some schools extended to explorations of local urban and natural environments.

The Reggio Emilia approach to preschool education, which grew out of the ruins of World War II in northern Italy, shared many goals of progressive education. It too sought to replace authoritarian systems of education with more tolerant, communal, equitable and child-centered values that nurture democracy (Hall and Rudkin, 2011). Adopted by all municipal preschools in the city of Reggio Emilia, its influence has spread worldwide.

Because progressive education and the Reggio Emilia approach encouraged community democratic processes and

projects that were motivated by children's own interests, they opened spaces for investigation of the urban environment. Learning about the city and shaping it through participatory processes of urban design and planning were central aims of the built environment education movement that arose in Great Britain in the 1960s and 1970s. In 1969, the Skeffington Report to government made community consultation an integral part of planning. The Town and Country Planning Association responded by launching the "Bulletin of Environmental Education," which advocated education to make people more aware, knowledgeable and responsible for their interactions with the environment "in a manner explicitly constructed to enable them to work with others to take greater control of the shaping and management of their own world" (Bishop, Kean and Adams, 1992, p. 51). In combination with progressive initiatives in British primary schools that included learning through direct experience, team teaching, and field trips into neighborhoods, built environment education led to systematic curricula that brought architects, planners, artists and other experts into classrooms and sent students into the city to investigate and give input on local issues.

Ideals of community and democracy that run through progressive education, the Reggio Emilia approach, and built environment education persist in current expressions of education for sustainability in

early childhood education. As Phillips (2014) observed in her discussion of education for sustainability, even very young children want to do "real things" that contribute to solving social and environmental problems. Integration of social and environmental systems, characteristic of education for sustainability, is also evident in the current international movement to naturalize grounds and plant gardens in schools and childcare centers as a means to bring nature into urban children's lives (Danks, 2010).

Taken together, these pedagogical approaches suggest a set of more specific strategies that can inform early childhood environmental education in cities (Table 1). We illustrate these approaches and strategies using case studies of participatory planning and design and garden education below.

Participation in planning and design of urban spaces

Growing Up Boulder is a child friendly city initiative that was formed in 2009 and is a formal partnership between the City of Boulder, Boulder Valley School District, and the University of Colorado's Program in Environmental Design. While the initiative engages children of all ages, its work with young children (ages 3-8) has included participatory design of city parks, playgrounds, large-scale public spaces, neighborhoods, and open space. Growing Up Boulder fosters creative self-expression and collaborative learning through its methods of engagement, from nicho boxes (multimedia

Table 1. Early childhood approaches, exemplified by case studies in this essay.

	Participatory planning and design	Garden education
Creative self-expression	Art-based methods, including murals, nicho boxes, videos, three-dimensional models	Songs, storytelling, cultural exchange
Collaborative learning	Peer-to-peer and multigenerational learning through dialogue with city leaders and designers	Multigenerational and multicultural exchanges
Experiential, place-based learning	Field trips and research about sites	Native plants and foods, ethnobotanic gardens
Development of empathy	Recommendations for wildlife habitat in urban spaces including butterfly gardens and creek restoration	Community service, cultural exchange
Sample recommendation	Tree houses near the library and creek to view and read about nature	Dissipation pond for rain catchment and water play

boxes inspired from Latin American folk art) and murals to three-dimensional models of recommended redesigns, which allow children to effectively express their ideas (Derr and Tarantini, 2016).

A critical aspect of Growing Up Boulder’s work with young children is developing partnerships in which teachers understand the value of participation in early childhood. One such partnership has been with the Boulder Journey School, a Reggio Emilia school. The school’s philosophies of honoring children’s own modes of expression, instilling a “pedagogy of listening,” and promoting children’s right to active citizenship (Hall and Rudkin, 2011) support participatory design and planning with ages 4-5. For example, Boulder Journey School students contributed to the redesign

of Boulder’s Civic Area, a public space in the city’s downtown, through field trips, drawings and photographs, a presentation to city council, and participation as jurors in the city’s design competition (Derr and Tarantini, 2016).

Growing Up Boulder has also partnered with third graders (ages 8-9) from an ethnically and economically diverse school that utilizes the International Baccalaureate curriculum. Projects have included neighborhood design for increased density as well as redesign of public space (Derr and Kovács, 2015). The most recent project focused on resilience in partnership with Mexico City, as part of the Rockefeller Foundation’s 100 Resilient Cities network. The project allowed creative self-expression and collaborative learning both within and

across schools, through video and mural exchange.

In Growing Up Boulder projects, children consistently consider the rights of others and show empathy toward other people and nature (Chawla and Rivkin, 2014; Derr and Tarantini, 2016). For example, in considering parks and open space, Boulder Journey School students researched physical features of insects and developed simple costumes of antennae and wings (Figure 1), and in the classroom, teachers projected large insect shadows on a wall so that children could experience the scale at which humans appear to insects. In their recommendations, students showed concern that insects might be hurt by visitors on trails and wanted to protect the insects and their homes. Growing Up Boulder has found that desires for nature protection and enhancement emerge across projects and ages, in early childhood and beyond (Chawla and Rivkin, 2014).

Children's access to nature in the city

Bringing children to nature

In an effort to increase young children's access to nature, many Canadian and European cities have established forest schools in which urban children walk to nearby forests or green spaces for some or all of their day (Elliott et al., 2014). Forest schools reach preschool through second grade and are integrated into both private and public school settings. In forest schools,



Figure 1. Children demonstrate empathy by dressing as insects on a field trip to a city park. Photo credit: Tina Briggs.

children visit the same place on a regular basis, thus coming to know it and its cycles intimately. Teachers respond to children's interests by listening to and writing down children's ideas and then deepening students' knowledge of nature and place. In Canada, forest schools also provide aboriginal specialists who integrate stories and cultural knowledge into place-based education (Elliott et al., 2014).

In response to shrinking school grounds that lack natural play areas, cities in Scandinavia and Australia have created mobile preschools, in which children ride a bus to natural areas and cultural places in the city. From their research with a mobile preschool in Sweden, Gustafson and van der Burgt (2015) caution that while this model may foster independence and increase children's access to urban places, such

programs face practical limitations from changes in weather conditions, the frequent need for outdoor toilets, and discussion of rules of behavior for different physical settings. This model provides a contrast to forest schools, which provide routine opportunities for learning through repeated visits to the same place.

Bringing nature to children

Naturalized childcare centers in North Carolina, U.S., are similar to forest schools in bringing nature to children where they learn and play. Moore and Cosco (2014) have found that community and ecosystem health fosters physical activity and a diversity of play types. Research comparing behaviors before and after naturalizing school grounds found children spent more time outdoors in all seasons; teachers created more vegetable gardens; children exhibited decreases in negative social behaviors, increases in imaginative play, and increases in play among peers with different abilities; and the community expressed increased pride about school grounds.

Perhaps the largest movement to increase children's access to nature within the city is school gardens. As the following examples illustrate, gardens embody a whole systems approach to understanding life's interconnections and involve children in interacting with plants and animals as they care for them. Tending a garden helps children to develop an ethic of caring, and to connect with themselves, the seasonal cycles, and the creatures that share the

garden (Noddings, 2005). Integrating stories about plants, insects and animals into environmental education engages children in life's wonders on a metaphorical and affective level. Songs tied to natural cycles deepen children's relationship with what they plant by allowing children to sing, dance, and act as part of their experience.

Gardens at daycare centers: Puebla, Mexico and Rocinha, Rio de Janeiro, Brazil

A small international organization, A Child's Garden of Peace, partnered with Casa Cuna, the only free daycare in Puebla, Mexico, to create a garden and nature education program on the daycare's grounds (Figure 2). Secondary schools and universities in Puebla (population 2 million) require several hundred hours of community service from their students. As a service project, about 60 youth prepared the Casa Cuna ground for planting. None had ever held a shovel or planted a garden. They worked with children, aged 2 to 5, to plant herbs, vegetables, flowers and fruit trees. Everyone learned together. The garden also includes a shade structure where children rest and participate in garden-inspired art and music activities. Children's senses lead their garden explorations. The youth and children water the garden daily, discover what has bloomed or become ripe for picking, and carry the harvest to the school kitchen.



Figure 2. Multigenerational planting at a daycare center in Puebla, Mexico. Photo credit: Illène Pevec.

When early childhood centers lack land for a garden, large pots filled with soil can provide planting space. In Rocinha, Brazil's largest favela where over 100,000 people live on a granite hillside, the Associação Social Padre Anchieta Daycare has no land except the building's footprint. The school's roof provides a small outdoor play area, and one 10-square-foot area bordered by a 6-inch raised edge became a small garden with the addition of compost donated by a local environmental group. Children used the small plot and large plastic pots to plant garlic, onions, beets, lettuce, collards, herbs and

flowers, which in turn enhanced nutrition and flavor of meals, attracted pollinators, and added color and life to the daycare, creating a sanctuary from street dangers.

Educational gardens: Vancouver, British Columbia, Canada

The "Spirit of Nature" garden was initiated by two University of British Columbia students at the Grandview/U'uquinakuh Elementary School and Grandview Daycare Center in 1998. Children, teachers and neighbors engaged in all phases of planning and implementation. Models created by children inspired a landscape architecture student's one-acre design including a butterfly garden, wild bird habitat, ethnobotanic garden, school vegetable garden, community garden, an outdoor classroom modeled after an indigenous longhouse building, and a dissipation pond. The dissipation pond—in which sand and crushed shells mimic a coastal beachfront and absorb falling rainwater—represents a compromise between children who wanted a pond and the school board who prohibited it for liability reasons (Bell, 2001). The rain catchment system provided a superb play space, affording opportunities for dam building and leaf sailing on rainy days. The Vancouver Coastal Health Authority has funded a garden coordinator/classroom educator since 2001. Lessons for early grades integrate science, culture, and math. For example, students make graphs to measure seedling growth and use an abacus fence to count harvests. The librarian also

hosts story times that thematically link garden eating with books about the plants being eaten.

Gardens can facilitate cross-cultural knowledge exchange in diverse urban communities. Elders who live adjacent to the garden in Grandview's public housing created a book titled "The Web of Life" to share their childhood garden experiences as indigenous peoples of Canada and as immigrants from other countries. The First Nations' school members also held a community-wide ceremony in which native chiefs, dancers and singers came in full regalia to bless the gardens and longhouse with its totem poles carved on site. As they play in the native maple tree's shade or under the longhouse roof on a rainy day, children experience wildlife attracted by the native plants and engage in a cultural environment honoring local heritage (Pevec, 2003).

Conclusion

This essay describes educational approaches that encourage children's exploration of built and natural settings in cities. These approaches provide opportunities for children to express empathy for other living beings and respect for diverse cultures. Through the participatory design of a playground, a garden space, or a public park, children develop a sense of agency and competence and increase their understanding of the processes that shape a city. Through field trips and gardening, they learn about natural cycles and systems.

These experiences lay a foundation for the development of environmental responsibility and stewardship. According to the ideas of John Dewey, Reggio Emilia preschools, and built environment education, social and environmental challenges cannot be solved through authoritarian, technocratic decision-making. Successful problem-solving requires the intelligence, creativity, and collaborative resourcefulness of all sectors of society, including young children. Early childhood is the time to begin teaching these skills. By bringing children out of their childcare centers and classrooms into the built and natural spaces of their cities, and by involving children in naturalizing built surroundings, urban environmental education contributes to cities where human constructions and natural processes can productively co-exist for all ages.

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7. Positive youth development

Tania M. Schusler, Jacqueline Davis-Manigaulte, Amy Cutter-Mackenzie



Photo credit: Alex Russ

HIGHLIGHTS

- Positive youth development is an assets-based approach for cultivating competencies essential to personal well-being.
- When environmental education enables children and youth to contribute to improving urban environments, it can not only increase cities' sustainability and resilience but also foster young people's personal growth.
- Participatory action research, peer education, and youth civic engagement are three educational approaches that can lead to positive change for both urban environments and youth living within them.

Introduction

Environmental education is often associated with environmental learning and pro-environmental behaviors. Some approaches to environmental education, however, also enable young people's personal growth through the development of confidence, self-efficacy, and other assets that support an individual's well-being. This essay explores the intersection of urban environmental education and positive youth development. It can inform teachers, environmental educators, science educators, youth workers, and others who want to advance environmental learning and a positive developmental trajectory for young people in varied educational settings, such as school classrooms, after-school programs, community organizations, youth development organizations, churches, camps, nature centers, science centers, museums, and gardens.

We begin by defining positive youth development and applying it to environmental education. We then describe three programs from the U.S. and Australia to illustrate different pedagogies for integrating positive youth development in environmental education aimed at urban sustainability. By "youth," we refer to the transitional period between childhood and adulthood, which varies across cultures. The United Nations defines youth as individuals age 15-24; however, others include children younger than 15 or young adults older than 24 in their

definitions. The programs we describe also included some children younger than 15.

Positive youth development in environmental education

A paradigm shift in the youth development field has occurred from a focus on reducing specific problems like unintended pregnancy or drug use to "positive youth development," which builds upon young people's strengths to develop competencies essential to well-being. Among multiple frameworks describing positive youth development, one of the most comprehensive describes four categories of personal assets promoting well-being: physical (e.g., good health habits); intellectual (e.g., critical thinking, good decision-making); psychological (e.g., positive self-regard, emotional self-regulation); and social (e.g., connectedness, commitment to civic engagement) (Eccles and Gootman, 2002). In addition to its emphasis on strengthening assets, positive youth development acknowledges that developmental experiences do not occur as isolated events, but throughout young people's daily lives as they interact with peers, family, and non-familial adults in schools, after-school programs, and their broader communities.

Settings that promote positive youth development in the U.S. have been found to share similar characteristics (Eccles and Gootman, 2002):

- Physical and psychological safety (e.g., safe facilities, safe peer interactions);

- Appropriate structure (e.g., clear and consistent expectations);
- Supportive relationships (e.g., good communication);
- Opportunities to belong (e.g., meaningful inclusion);
- Positive social norms (e.g., rules of behavior, values and morals);
- Support for efficacy and mattering (e.g., responsibility granting, meaningful challenge);
- Opportunities for skill building; and
- Integration of family, school, and community efforts.

The more of these features within an urban environmental education program, the more likely that positive youth development outcomes will result. However, all features need not be present and some might require adaptation to be culturally relevant in other countries.

Youths' physical and psychosocial development is also influenced by the quality of the urban environment, such as environmental toxins, noise, indoor air quality, and access to green space (Evans, 2006). Urban environmental education can enable young people to play a role in ameliorating environmental conditions that negatively impact well-being. Around the globe, youth have demonstrated their capacity to assess and act to improve

environmental conditions in cities (Hart, 1997, Chawla, 2002). When youth have genuine opportunity to address environmental concerns, they can develop valuable personal assets and also increase their own and others' well-being by enhancing urban environments (Figure 1). In short, urban environmental education can promote positive youth development and youth, in turn, can positively contribute to urban sustainability and resilience.

Studies suggest that when youth participate in programs where they act positively for the environment, they themselves grow positively in various ways (Schusler and Krasny, 2010). For example,

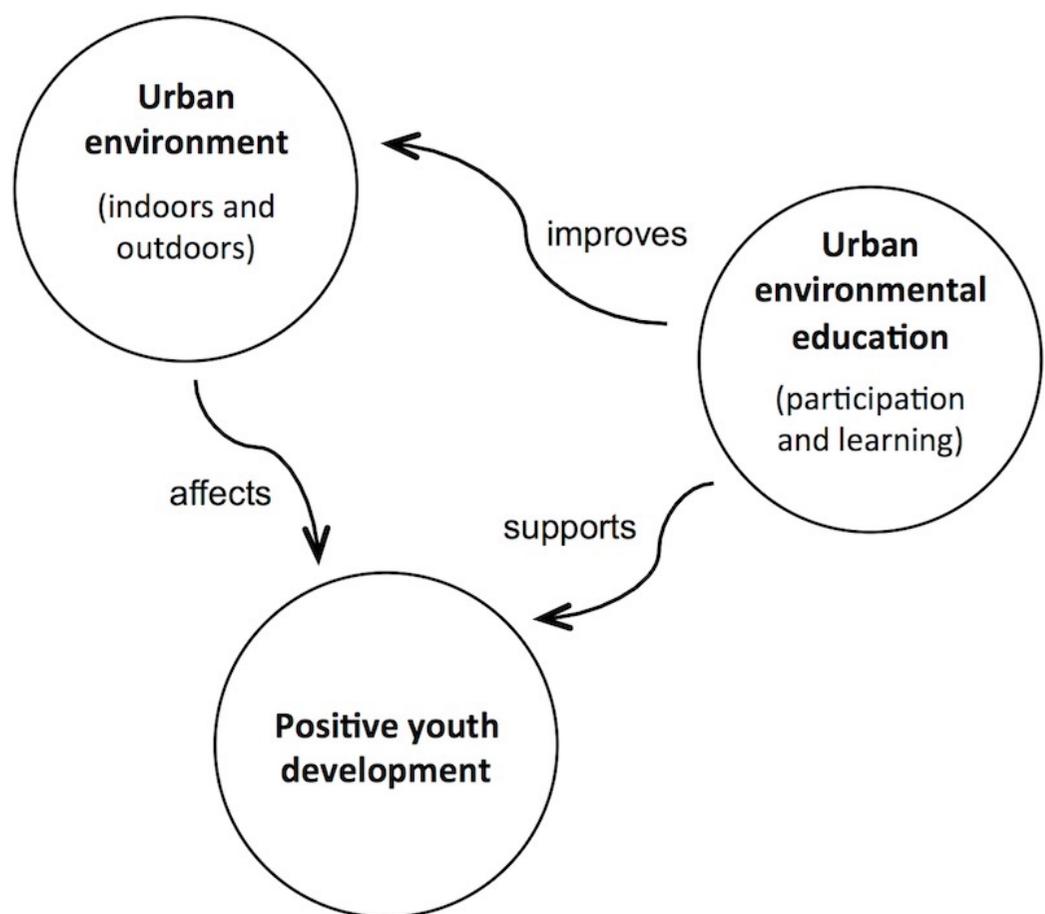


Figure 1. Urban environmental education that encompasses young people's participation in improving urban environments can also build assets promoting their well-being, while also changing environmental conditions that impact youth development.

Hawaiian students working together to select, investigate, and act on a local environmental issue improved their critical thinking; reading, writing, and oral communication skills; familiarity with technology; self-confidence; and citizenship competence (Volk and Cheak, 2003). A food justice education program in New York City proved a valuable developmental experience for youth because it offered somewhere to belong, be pushed toward developing one's potential, grapple with complexity, practice leadership, and become oneself (Delia, 2014). The evaluators of two environmental service-learning programs in East Africa, Roots & Shoots and Wildlife Clubs of Uganda, found that youth in both programs most valued forming relationships with club members, leaders, and community members as an outcome of environmental education (Johnson-Pynn and Johnson, 2010).

While more research is needed into the opportunities and barriers of integrating positive youth development with urban environmental education, the two can be synergistic when programs are intentionally designed with both in mind. To illustrate the synergy that arises between urban environmental education and positive youth development when youth are offered genuine opportunity to effect environmental change, we describe three programs below. The first involves young people in participatory action research through a child-framed approach. The second develops young people's leadership capacities as peer educators. And

the third facilitates youth civic engagement through local environmental action. In each urban environmental education example, young people were given the opportunity to understand and effect change in urban environments and, as a result, also developed assets promoting their own well-being (Figure 1).

Youth as co-researchers

Children and young people are experts on their own lives, yet research involving children is often conceived of and led by adults. Barratt Hacking, Cutter-Mackenzie and Barratt (2013) call for including children as researchers rather than objects of investigation. To that end, the project "Is 'Nature' Diminishing in Childhood? Implications for Children's Lives" engaged young people in Australia in research about childhood and nature from their own perspectives. The project used a child-framed methodology incorporating qualitative and quantitative research in five distinct stages. It involved 10 children ages 9-14 as co-researchers in each of two sites, one urban and the other an urban fringe suburb.

Stage 1 involved training sessions where the children and youth learned about qualitative research, specifically ethnography (participant observation, semi-structured interviews) and arts-based methods (photography, video, mapping), which enabled the children to study themselves and local culture (Cutter-Mackenzie, Edwards and Widdop Quinton, 2015). One child's

description of this experience was typical: “I am excited about being able to voice my opinion... There are lots of young people who are passionate to be heard, but this is the only project I have heard of or taken part in that allows them to do so.” Such opportunity to be heard may contribute to positive developmental assets, such as self-efficacy and a sense of social integration.

In Stage 2, children and youth conducted research over two months examining nature-deficit disorder within their own cultural settings. The children received a device with Wi-Fi and GPS for mapping everyday experiences, appropriate research protocols, and a secure dropbox for uploading data. The latter encouraged children and youth not only to take responsibility for their data but also begin

preliminary analysis (Barratt Hacking et al., 2013). Stage 3 involved children analyzing their data during research think tanks completed over one intensive session. Participants presented, discussed, mapped, and analyzed their findings. Focus group interviews with the children co-researchers and their parents or guardians also served to triangulate the research findings.

Stage 4 incorporated an online survey that the children co-researchers co-developed with researcher Cutter-Mackenzie. Finally, Stage 5 centered on disseminating the young people’s research to academics, practitioners, and other children. The young people prepared ways to communicate their findings including a documentary and photomontage (Figure 2)

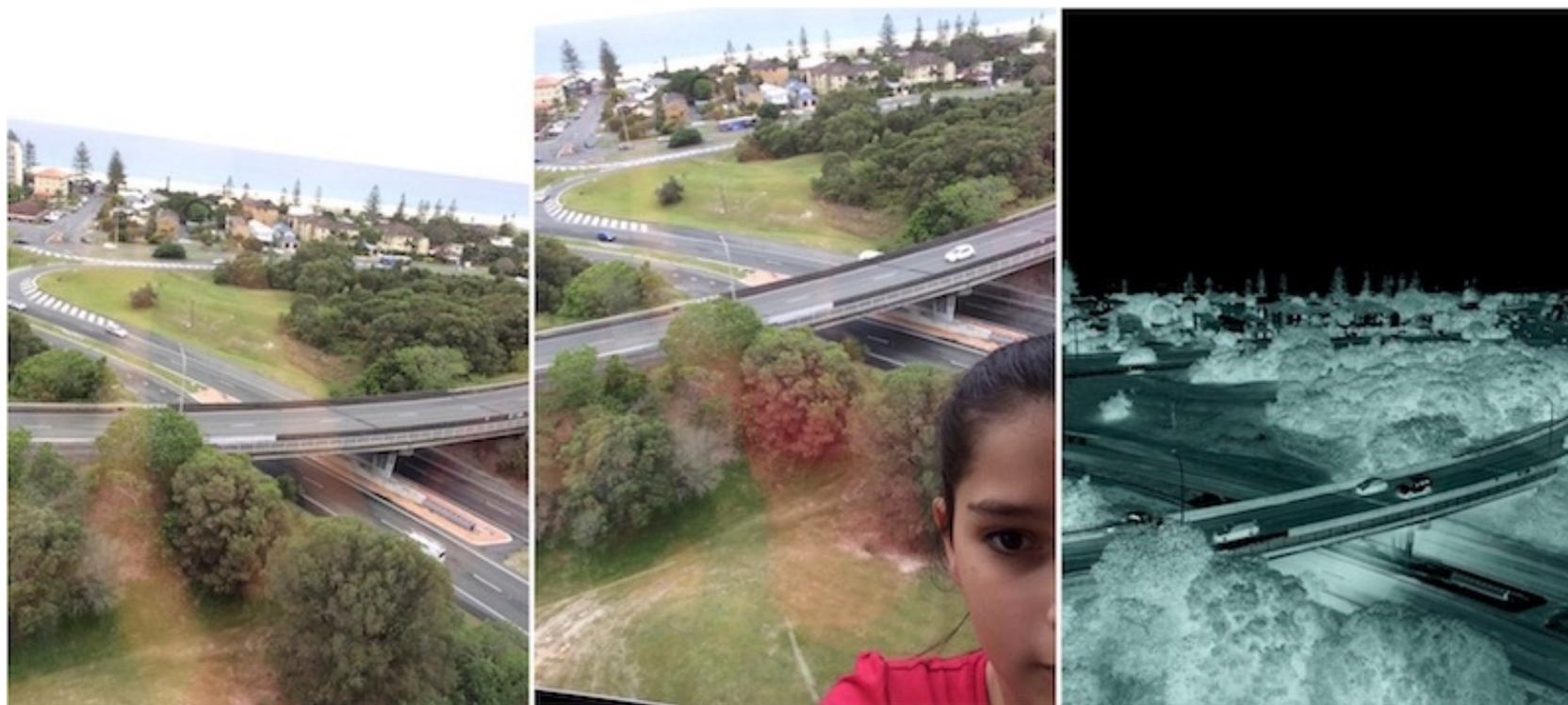


Figure 2. Photomontage designed and created by young co-researcher showing what she described as “nature by road” taken at different times throughout the day. She explained that roads in her community both connected (like “blood lines”) and disconnected children to nature. Photo credit: Graciella Mosqueira.

Together the stages of this child-framed methodology highlight how youth can genuinely engage as research collaborators. Through such experiences, children may develop positive developmental assets, such as self-efficacy, connectedness, and research, critical thinking, and communication skills. The results of children's research also may enhance understanding of children's experiences of nature in ways that can inform design and management of urban environments (Figure 1).

Youth as peer leaders

Peer education involves people with similar characteristics or experiences learning from each other. Used successfully in the health field, it also can be effective in other arenas, including environmental issues (de Vreede, Warner and Pitter, 2014). Evidence suggests that educating teens to facilitate learning experiences for younger youth can have positive developmental impacts for both younger program recipients and "teens as teachers" (Lee and Murdock, 2001). This strategy provides teens with ownership over the direction of program activities, leading to investment in the outcome of their work (Larson, Walker and Pearce, 2005).

A peer education or "teens as teachers" strategy was piloted in a 4-H environmental education initiative in New York City during the summer of 2015. 4-H is the youth development component of the Cooperative Extension System at many US public

universities. Twenty New York City 4-H teens attended the 4-H Career Exploration Conference at Cornell University, where they participated in science and leadership mini-courses led by faculty and staff. During the closing assembly, New York City 4-Hers engaged over 400 peers and adult volunteers in creating "Pollinator Seed Bombs" as part of the National Pollinator Initiative, a US presidential directive to conserve pollinators and thus protect the nation's food supply. Seed bombs are compressed bundles of clay, compost, and/or soil containing seeds that can be tossed into a bare patch of land to grow new plant life (kidsgardening.org). The 4-H teens and adult volunteers pledged to share their new knowledge and seed bombs with friends and 4-H clubs in their respective communities. One New York City 4-H Peer Educator reflected, "I could see action being taken to improve the world and I was proud to have been a part of it!" This illustrates how participating as an environmental peer educator contributed to this teen leader's self-efficacy and feelings of mattering, which are positive developmental assets.

When they returned home, the New York City 4-H teens also served as "teen teachers" for the 4-H Exploring Your Urban Environment summer day camp program (Figure 3). The teens were trained to implement a 5-week program with younger youth in eight community agencies in New York City. The teen leaders connected 392 youth to their communities through service-

learning opportunities that promoted environmental stewardship and community beautification. In a survey assessing program impacts, all 35 teen teachers agreed or strongly agreed with the statement: “I can make a difference in my community through community service;” commitment to community service is a social asset for positive youth development. Teens’ psychological assets were also enhanced as reflected by their agreement or strong agreement with the statement, “I am more confident in helping others.” These results align with our conceptual framework (Figure 1), highlighting the positive impact that connecting youth to their environment in meaningful ways can have for the youth as well as their environment and communities.

Youth as Civic Actors

Youth civic engagement refers to young people developing their civic capacities by actively collaborating with others to shape society. One form of youth civic engagement is environmental action, whereby learners collectively analyze a problem and act to solve it. Environmental action can involve directly improving the environment, such as planting native vegetation to restore habitat in a city park, or can indirectly influence others to act through education or policy advocacy. Critical to environmental action is shared decision-making; participants collaborate in defining a problem and then envision and enact solutions (Jensen and Schnack, 1997; Hart, 1997). Adults can experience tensions



Figure 3. In New York City, “teen teachers” in the 4-H Exploring Your Urban Environment program guided younger children releasing butterflies as part of their environmental stewardship project. Photo credit: Teishawn W. Florestal-Kevelier.

in sharing decision-making power; navigating these tensions is essential to ensuring genuine opportunity for youths’ participation and positive development (Schusler, Krasny and Decker, 2016).

A youth development specialist and an environmental educator collaborated in an after-school program to facilitate a project in which seven middle school students produced a documentary about “Green Homes” in the City of Ithaca and surrounding towns in upstate New York. The adult leaders

chose the project focus, i.e., producing a video about green building, and invited youth to participate. Youth then made decisions with educators' guidance throughout all facets of video production over seven months, from planning to filming, editing, and debuting to area residents their 18-minute documentary. The role of the adult leader and youth participants in decision-making in this project reflects results of a study on youth environmental action programs, in which educators spoke about striking a balance between providing needed guidance as well as opportunities for youth to assume decision-making and leadership (Schusler et al., 2016).

The students' video featured three local homes demonstrating building with natural materials, recycled materials, and renewable energy. It also included a "green home" for dogs and cats at the Tompkins County Society for the Prevention of Cruelty to Animals. The "pet home" highlighted the use of recycled materials, natural lighting, a geo-exchange heating and cooling system, and native landscaping.

Youth reported gaining knowledge about green building and being motivated to do more. As one youth said, "it's really inspired me to look more at our environment and what I can do to help." They also spoke of developing skills in video production, problem-solving, communication, teamwork, interacting with adults, persisting to complete a long-term project, and being patient. They valued the opportunity to contribute to their

community. As one reflected, "This is going to have an impact on how people build their homes. People that see [the video], at least they're going to do some of the minor things talked about. And maybe when they see that kids have done something like this, people will give the kids much more respect in the community." This form of indirect environmental action—youth acted to try to influence residents to make environmentally friendly choices—demonstrates one way that young people develop assets while educating others towards increased urban sustainability (Figure 1).

Conclusion

Participatory action research, peer education, and youth civic engagement are three approaches that have been used in urban environmental education to advance sustainability and foster positive youth development. These three approaches are not mutually exclusive; for example, youth environmental action often involves young people as researchers to understand a situation before proceeding in collective action to change it for the better, and thus integrates participatory action research and civic engagement. All three approaches value young people's capabilities, build upon their strengths, and offer opportunity for genuine, meaningful participation with the potential for impact on the environment and their communities. They also require adult leaders who provide a caring environment, as well as appropriate levels of guidance, expectations,

and freedom for youth to take on leadership and other responsibilities. Through such experiences, young people can contribute to creating more sustainable and resilient cities while developing valuable physical, intellectual, psychological, and social assets that enhance personal well-being.

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8. Intergenerational education

Shih-Tsen Nike Liu, Matthew S. Kaplan



Photo credit: Alex Russ

HIGHLIGHTS

- Adding an intergenerational component to environmental education programs enriches the learning experience for participants of all ages.
- Whereas multi-generational approaches to environmental education aim to include or accommodate different generations, intergenerational approaches seek to promote dialogue, collaborative learning, and mutual understanding.
- Across the globe, intergenerational environmental education programs are being implemented in diverse urban settings, including schools, parks, urban gardens, and community and environmental centers.

Introduction

In 1977, the Tbilisi intergovernmental conference on environmental education endorsed a set of guiding principles for environmental education. Some principles, including considering the environment in its totality, viewing environmental learning as a continuous lifelong process, and taking a historical perspective into account, lend support for intergenerational approaches to environmental education. This set of approaches to environmental education is particularly pertinent in cities, where working toward sustainable development involves addressing a host of complex environmental, historical, and social issues.

A child who has limited firsthand experience with the process of urbanization and accompanying economic, demographic, and environmental changes may have difficulty gaining a cognitive understanding and an emotional appreciation of the environmental challenges facing cities. Environmental education programs, resources, and materials certainly contribute to such learning. However, learning is enhanced when the child has direct access to the living experience and perceptions of older people who can share their experiences of changes in the urban environment over time. At the root of an intergenerational paradigm for environmental education is activating environmental learning through facilitating interactions between generations.

Background

Intergenerational programs have been defined broadly as social vehicles that create purposeful and ongoing exchange of resources and learning among older and younger generations (Kaplan, Henkin and Kusano, 2002). With regard to urban environmental education, the focus of intergenerational programs turns to ways in which young people, older adults, and the generations in the middle can work together to explore, build awareness, gain understanding, and improve the urban environment.

Environmental education funding, research, and program design tend to target young people as the primary audience (Kaplan and Liu, 2004). One of the most significant social changes of our time, however, is the rapidly expanding number of older adults. In countries experiencing rapid urban-development, such as Taiwan, Japan, and the U.S., older adults will soon become the largest segment of the population.

This demographic shift can be viewed positively. Contrary to negative age-related stereotypes, many older adults living in cities are healthy, lively, and actively engaged in civic affairs, including in volunteer initiatives aimed at protecting the urban environment. There are some notable accounts of environmental initiatives aimed at reaching and involving the older adult population (Ingman, Benjamin and Lusky, 1999; Benson, 2000), including older adult environmental volunteerism found in the U.S. (Bushway et

al. 2016) and in Australia (Warburton and Gooch, 2007). However, the level of engagement of older adults in environmental education initiatives targeting younger generations still has room to grow. The relative disconnection of older adults from schools, environmental centers, and other settings that educate people about the environment represents a missed opportunity for strengthening community relationships in urban communities and instilling in children and youth a deeper sense of environmental awareness and connection.

Scholars have documented the potential benefits of intergenerational environmental education (Ballantyne, Fien and Packer, 2001; Vaughan et al., 2003). However, the adults in some studies were passive learners who were not utilized as educators or co-learners during the learning process. The intergenerational initiatives highlighted in this essay go beyond the goal of multi-generational inclusion or simply including members of different generations. An ideal intergenerational program creates opportunities for people of different age groups to learn about each other's knowledge, experiences, skills, and perceptions. As participants learn about the impact of the environment in each other's lives, they gain an awareness of common concerns. This contributes to an understanding of the interrelationships among people and the environment and a sense of how to work collaboratively to

influence environmental policies and practices (Kaplan and Liu, 2004).

Why consider intergenerational environmental education?

Benefits for environmental education

In cities, the teacher-student ratio is commonly high and the teachers' workload is heavy. In many countries, particularly in urban areas, the proportion of older adults in the population is growing. Well-designed intergenerational programs provide an institutional anchor and vehicle for taking advantage of this demographic trend; educated, civically engaged older adults who care about future generations and wish to make a contribution to their environmental learning can be recruited, trained, and engaged as human resources in support of environmental education programs (Kaplan and Liu, 2004).

Benefits for children

Many urban children do not live near their grandparents and have limited contact with older adults. Older adults in an intergenerational activity can serve as role models for younger participants to observe and imitate, which are important forms of learning (Bandura, 1977). Older adults also have life experiences that can make environmental content in textbooks more relevant and meaningful to young learners. For instance, older adults can readily share how they use natural resources with children in a community festival. Children learn things

such as how to conserve water by using remaining bathwater to water flowers. As another example, while teaching topics such as chemical pollution hazards, an older adult who used to work as a toxics prevention agent or suffered from past pollution accidents can share his or her own experiences. Such conversation helps children to relate to environmental issues and to view environmental health risks from a lifespan perspective (Schettler et al., 1999). Environmental educators can structure intergenerational dialogue to nurture such long-term environmental perspectives (cf. Wright and Lund, 2000).

Benefits for older adults

Intergenerational programs provide older adults with opportunities to stay active, expand their social networks, and make valued contributions to society (Kaplan, Henkin and Kusano, 2002). A powerful motivation for older adults to volunteer for environmental stewardship activities is wanting to leave a legacy—both for the earth and for their grandchildren (Warburton and Gooch, 2007); a desire to leave a legacy could also motivate older adults to volunteer in environmental education programs.

Benefits for the city

Intergenerational programs tend to involve a broad spectrum of organizational partners and collaborators, thereby extending the reach and influence of environmental education and action messages across cities. The Lincoln Place “Futures Festival” event

held in Pittsburgh provides an example of how a collaborative planning process involving residents of all ages, and representatives of local community organizations and agencies from multiple sectors, can broaden the visioning process to encompass the natural as well as the built environment. The process of having to reach consensus and integrate their diverse ideas into large murals encouraged participants to work together to create age-inclusive, economically vibrant, and ecologically sustainable visions for the future of Lincoln Place (Kaplan et al., 2004).

What do intergenerational environmental education initiatives look like?

Intergenerational environmental education initiatives can take place in multiple urban settings including schools, environmental education centers, parks, playgrounds, community centers, retirement centers, city streets, community gardens, and even vacant lots. Such educational initiatives can also be launched by different organizations and inter-organizational partnerships. A school that wants to let students know about the history of a local urban forest, for example, can partner with a local historical society whose members include older adult residents willing to share the history of the site and discuss factors that influenced changes. An urban environmental center wanting to hold an air pollution monitoring fair that attracts residents of all

ages can work with youth service and senior volunteer organizations to establish intergenerational teams working together to develop, set up, and staff interactive exhibits at the fair.

Educators across the globe are creating models to stimulate intergenerational dialogue and co-learning about the natural environment. For example, Tanaka (2007) describes a school-based project in Japan in which students and adult volunteers developed a miniature biosphere to heighten their environmental awareness and appreciation. Chand and Shukla (2003) describe an intergenerational biodiversity contest in India designed to enhance learning about plants and promote values of conservation and respect for traditional ecological knowledge. Garden Mosaics is a science education and national outreach program developed by Cornell University that combines community action and intergenerational learning. Through interviewing elder gardeners, youth ages 10-18 learn about the mosaic of plants, planting practices, and cultures in urban community and other gardens (Figure 1). Youth participants balance what they learn from elder gardeners with learning from “Science Pages” developed at Cornell, which explain key science principles behind the practices youth observe and learn about from elders in the gardens (Kaplan and Liu, 2004).

Two additional examples, one from a formal education in Taiwan and the other from non-formal education in the U.S.,



Figure 1. Young people and an educator in Abraham House, the Bronx, New York City, learn from an elderly gardener (right) in a community garden. Photo credit: Alex Russ.

illustrate elements of intergenerational urban environmental education programs (Table 1). The first program took place at He-cuo Elementary School in Taichung, Taiwan’s third largest city. The teachers and principals invited senior adults from the community to participate in a series of intergenerational activities. The senior volunteers’ opinions were taken into account throughout the planning process. Over the ten years of the program, new activities and volunteer recruits were continually integrated. On a city tour, children learned about old trees in the He-cuo community and listened to the elders’ stories about the trees. In other activities, participants observed juxtaposed old and new photos to learn about environmental changes over time, and students learned about differences between rural and city lifestyles through displays of traditional farmers’ equipment. These and other

Table 1. Urban intergenerational environmental education programs in Taiwan and the U.S.

	He-cuo Elementary School	Shaver's Creek Environmental Center
Country	Taichung, Taiwan	Pennsylvania, USA
Organization	School	Environmental education center
Setting	Downtown area	Suburban recreation area
Program approaches	Subject class, extracurricular activity, community family fair, and special day event	4-day summer camp for children from urban areas
Elderly participants	Community senior residents	Members of retirement centers
Young participants	Elementary school students	Fifth grade students signed up by their teachers
Main subject	Community environment and traditional artistry	Nature conservation and urban development
Examples of urban resources	Plants and animals, life style, and community changes over time	Traditional living style and urban development issues

activities combined to have an impact on student, teacher, and even nearby residents' awareness of community changes associated with urbanization. The program also helped students weave this historical context into their sense of local identity.

The second example is a 4-day-residential program located at the Shaver's Creek Environmental Center, approximately 14 miles south of downtown State College, Pennsylvania. The researchers conducted an experimental study to determine the effectiveness of an intergenerational program versus a mono-generational program (Liu and Kaplan, 2006). In the intergenerational condition, a group of older adult volunteers participated in the program as co-learners and assistant instructors working with students to teach about traditional tools, such as darning eggs (an egg-shaped piece of wood inserted into the toe or heel of a

sock during mending), and to share environment friendly living habits. In another activity, the students were asked to discuss the possibility of converting the Environmental Center into a shopping mall. Students recognized that the development would have negative environmental consequences. At that point one of the senior volunteers shared a pertinent example from personal experience; residents of her childhood community successfully organized against a massive development plan that entailed replacing natural woodland with an airport. Such real life stories helped students to better understand the process of community change and the potential influence of local residents.

How to implement intergenerational environmental education initiatives?

Beyond program activities per se, organizational partnerships have a bearing on program structure and success. The critical step is to invite local leaders, stakeholders, and senior volunteers to join the planning process of the environmental education program. In the above example, the He-cuo Elementary School recruited older adult participants from local organizations including a Salvation Army center, a Taoism temple, a women's club, a traditional orchestra, and a puppet performance museum. These organizations have had a long-term relationship with the He-cuo school starting at the beginning of the environmental education activities. They also help with school functions, such as student enrollment, holiday festivals, and student club advising, thereby broadening the school-community partnership beyond the environmental education program. Other organizations in urban areas can make good partners for helping to recruit local youth as well as older adults, such as 4-H clubs, scout troops, after-school programs, universities, animal shelters, and senior and community centers.

In order to build partnerships, environmental educators can seek out organizations with similar or complementary interests and objectives. For instance, a university may hold a class for elders about urban plants, and the adult students can

partner with an elementary school's nature class. Or the older members of a community photography club can be invited to play a role in an intergenerational activity aimed to enhance environmental awareness.

Integration of an intergenerational component into environmental education activities also introduces complexities and considerations with regard to program design. The following principles contribute to productive group dynamics and learning effectiveness in intergenerational programs (Kaplan and Liu, 2004).

1. Prepare participants of both generations before the program begins.
2. Draw upon both the youth's and adults' experiences and talents.
3. Promote extensive dialogue and sharing among participants.
4. Focus on the relationship among participants as well as the task.
5. Pay attention to safety for different age groups.
6. Design tasks that require the active participation of both generations to be completed.

Conclusion

Sustainability is an intergenerational concept. Meadows, Meadows, and Randers (1993) define a "sustainable society" as "one that can persist over generations; one that is far-seeing enough, flexible enough, and wise enough not to undermine either its physical or its social system of support." When

considering how natural resources are used/misused over time, as well as strategies to preserve and enhance the environment, it is important to engage in long-term thinking and strategic policy making. Environmental educators can structure intergenerational dialogue to nurture such a long-term environmental perspective of the environment (cf. Wright and Lund, 2000). At the same time, older adults who volunteer in such programs gain opportunities to stay active, contribute, and connect meaningfully with young people in their communities.

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9. Environmental arts

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Photo credit: Alex Russ

HIGHLIGHTS

- Environmental arts catalyze environmental learning and action in cities worldwide.
- Environmental arts cultivate imagination and provoke reflection, helping citizens to think critically and creatively about environmental issues.
- Environmental arts help to bring about cultural shifts towards sustainability.

Introduction

Cities around the world are using the arts to enhance urban aesthetic experiences and motivate innovative environmental activism. Manifesting as flash mobs, immersive street theatre, bike parades, pop-up installations, zero-carbon concerts, and participatory storytelling, artists are using their creativity and ingenuity to draw attention to and propose solutions for the environmental challenges of the 21st century city. Often referred to as creative or artistic activism, environmental arts are becoming part of the curriculum in schools, universities, colleges, museums, and community centers, and are being woven into the fabric of the city in unexpected spaces like parks, city streets, alleyways, and rooftops. This essay provides an overview of some of the ways that the arts —visual arts, drama, dance and music— are transforming environmental education in urban centers, and helping bring about cultural shifts towards sustainability.

Imagining a more sustainable world through the arts

As part of the development of the environmental arts movement over the past several decades, artists, musicians, playwrights, dancers and filmmakers have revealed critical insights about urban places and spaces. McKibben (2009) describes their cultural sway: “Artists, in a sense, are the antibodies of the cultural bloodstream. They sense trouble early, and rally to isolate and

expose and defeat it, to bring to bear the human power for love and beauty and meaning against the worst results of carelessness and greed and stupidity” (n.p.).

As one of the founders of the 350.org campaign, McKibben draws on the power of the arts to catalyze action on climate change in cities around the world. Using media as diverse as comics, music videos, documentary photography, spoken word poetry, reverse graffiti, performance, puppetry, and aerial art, 350.org is harnessing the energy of artists in unique ways. In Istanbul, activists created a giant inflatable sculpture of lungs, inspired by the art of Artur von Balen, to highlight the effects of CO₂ emissions on human health. Working with artists in Lima, Peru, activists designed “Casa Activa,” an arts and activism center that exemplifies what a sustainable future could look like. These and other projects are demonstrating that cities can be used for artistic activism in multiple ways, as inspiration, as material, and as exhibition site.

By cultivating imagination, engagement, connection, and reflection, artists help us to think critically and creatively about ecological degradation, resource extraction, climate change, and other environmental issues. They explore, analyze, and critique the complex materiality and social contexts of urban centers, often leading to innovative sustainability solutions. They demonstrate that the arts make for powerful and personal learning experiences that transcend age and life-stage, inviting citizens to engage with

their cities through emotional and creative lenses, and helping to shift attitudinal change into action about and for sustainability.

Greene (1995) referred to this power as “social imagination,” that is, the capacity “to invent visions of what should be and what might be in our deficit society, on the streets where we live, [and] in our schools” (p. 5). Eisner (2002) recognized the similarity between the arts and sciences: “this is what the scientists and artists do; they perceive what is, but imagine what might be, and then use their knowledge, their technical skills, and their sensibilities to pursue what they have imagined” (p. 199). For many then, the arts are a form of research in their own right; they “provide a special way of coming to understand something and how it represents what we know about the world” (Sullivan, 2004, p. 61).

For urban dwellers, opportunities abound for becoming involved in arts-based creation, research, and activism. For example, student teachers at the University of Toronto regularly engage with its public eco-art collection; inspired by what they experience, many join the eco-art club looking to contribute to the next installation. For some, this is the start of engagement with the creative process or their own form of artistic activism; for others, it provides insights about how to do an environmental art project with their own students.

Engaging with environmental education through art-making

Visual artists have been creatively addressing environmental issues in cities for decades, inspiring teaching and learning across multiple educational settings. Alan Sonfist recreated the history of nature in urban spaces (“Time Landscape,” 1978); Agnes Denes planted a brownfield with wheat to raise questions about food security (“Wheatfield: A Confrontation,” 1982); and Joseph Beuys invited citizens to collaboratively combat urban deforestation (“7000 Oaks Project,” 1982). These early efforts led to aesthetic experiments that design and implement sustainability solutions. Mel Chin used hyper-accumulator plants to leach heavy metals from soil in an art installation intended to reclaim toxic land (“Revival Field,” 1990). Noel Harding’s “Elevated Wetlands” (1997) sculpture project showed indigenous plant species could be grown to cleanse water from a polluted urban river. And JR’s large-scale photographs (“Women are Heroes/Kenya,” 2009) raised issues of eco-justice in a Kenyan shanty town.

These environmental art pioneers led the way for a new generation of artists, photographers, filmmakers, and architects to combine traditional and digital media to maximize the reach and power of their work. The “Beehive Design Collective” uses techniques drawn from popular education, storytelling, and advertising to collaboratively

design large-scale, narrative drawings that illustrate and mobilize support for citizens' social and eco-justice struggles. "No. 9," a community-based nonprofit that installs eco-art in urban parks and rivers to encourage citizens to explore their city and environmental issues simultaneously; artist Ian Baxter's ECOARTVAN was one such project that took learning to city streets. Additionally, artists and scientists of the "Cape Farewell" project bring their explorations of the Arctic, manifested in photography, sculptural installations, and light projections, to urban settings to draw attention to the effects of climate change. Finally, Maya Lin's "What is Missing" uses permanent sound and media sculptures, travelling exhibits, a Times Square video billboard, and an interactive website that displays videos and stories contributed by people around the globe, to create awareness of the current sixth mass extinction and what we can do to reduce carbon emissions and protect habitats. These forms of artistic activism have opened up critical dialogue between curators, critics and the public focused on instigating environmental learning through art (Spaid, 2002; Weintraub, 2012).

Introducing children to the works of environmental artists can inspire them to learn about the issues the artists raise, as well as about the artistic processes itself. It can also spur children to experiment on their own, finding ways to address local environmental issues in their communities.

Children at Runnymede Public School in Toronto created a series of imaginative art installations in their schoolyard to address local environmental problems including habitat destruction, air pollution from idling cars, and invasive species in their schoolyard. Their projects ranged from painted fence murals, to large-scale stencils on the asphalted playground, to a knitted sweater for a favorite oak tree. The art projects created opportunities for cross-curricular learning, raised awareness about environmental issues, and inspired other schools to create their own eco-artworks, all age-appropriate forms of eco-activism (Figure 1).

Drama as a tool for environmental learning

Theater has long been used as political commentary, social instruction, cultural normalization, and calls to action. In environmental education, theatre is used to communicate educational messages, challenge political positions on environmental issues, and engage people in policy-setting at the community level. Theatre's role in urban environmental learning grew out of the Environmental Theatre movement, which broke down physical and psychological walls between performers and audience, engaged in full use of indoor and outdoor performance spaces, and forced audiences to consider themselves within the intention and meaning of the play (Schechner, 1971). Creating theatre is a pedagogical approach (Reed and



Figure 1. (a) Fence paintings by grade six students aimed to bring about positive environmental change in Toronto. Credit: Hilary Inwood. (b) A bird parade during the “Celebrate Urban Birds” event in Central Park, New York City, educates residents about local avifauna. Photo credit: Alex Russ.

Loughran, 1984) that leads learners to challenge their assumptions about environmental issues and explore their local environments. In the town of Samadang, Turkey, theatre performances were used with middle school students living near beaches where threatened sea turtles nest; a comparative study showed the theatre performance had a significantly higher cognitive recall than did traditional classroom teaching (Okur-Berberoglu et al., 2014).

Theatre provides fertile ground for engaging audiences in local environmental issues. The “Theatre of the Oppressed” was used to achieve transformative learning (including environmental) by allowing audiences to see the structure of oppression, and to inspire action by engaging them in finding solutions. Inspired by this work, the

nongovernmental organization Ecologistas en Acción (Ecologists in Action) in Madrid uses social theatre to address issues of water privatization and engages the audience in discussions with the characters following performances. Similarly in Forum Theatre, the Protagonist is oppressed, does not know how to fight, and fails. The audience is invited to replace the

Protagonist and act out on stage all possible solutions, ideas, and strategies. These uses of theatre for social change led to its use as a tool for multiple environmental purposes: entertainment conveying messages to low literate communities around environmental justice issues; performances engaging residents in environmental design and policy-making; and theatre companies researching local issues, incorporating community members’ words into presentations, and conducting talk-backs after the performance. Theatre is also used for consciousness-raising and as a tool for confrontation by environmental protesters and activists.

The use of theatre as entertainment that conveys a message remains its most common use in schools and communities. In informal educational settings, environmental,

heritage, and museum theatre often uses educational entertainment around environmental issues, such as a sustainability theatre performance in a science center or the conservation messages contained in a bird show at a zoo. In these settings, hundreds of thousands of individuals each year are exposed to environmental messages.

Embodying urban process and experience through dance

Dance has long been an expression of people's connections to their natural and built environments. It is an outward expression of humans' embodied knowledge, allowing us to both learn about and act on our relationship with the environment. In urban settings, Harvie noted that dance not only "demonstrate[s] urban processes" but is also a "part of urban processes, producing urban experiences and thereby producing the city itself" (as cited in Rogers, 2012, p. 68).

As with visual arts and theatre, environmental dance refers to choreography that is informed by environmental issues. Stewart (2010) described environmental dance as an eco-phenomenological method that is "concerned with the human body's relationship to landscape and the environment, including the other-than-human world of animals and plants" (p. 32). Artists usually work in non-traditional dance spaces, and use the natural and built environment to inform movement. As part of iMAP, choreographer Jennifer Monson used an

interdisciplinary approach, drawing on history, geography, and hydrology, to study water resources and the urban environment, resulting in a site-based performance that highlighted the relationship between human intervention and natural processes in a neglected urban park in Brooklyn, New York City. In another effort, the Ananya Dance Theatre, a group of women artists of color in Minneapolis created works that address environmental justice issues in marginalized communities around the world, highlighting grassroots advocacy work being done by women to address these issues. In Austin, Texas, choreographer Allison Orr engaged municipal garbage collectors in choreography that juxtaposed their own collection movements with those of their massive garbage trucks. A crowd gathered to watch the final production on an abandoned airport runway. The entire process, from the creation to the public performance, was captured in the documentary "Trash Dance." This project moved the largely unseen collectors to an aesthetic center allowing the audience to appreciate their vital roles in the environmental health and sanitation of the city.

The environmental dance movement is slowly filtering into urban schools. The Council of Ontario Drama and Dance Educators developed a unit plan where teachers and students "explore the environment through dance composition" (CODE, 2009) and address larger questions about using dance to

address social issues and advocate for environmental change. In another example, the Interdisciplinary Laboratory for Art, Nature and Dance created BIRD BRAIN to engage urban elementary students in learning about bird migration through cityscapes. Dance connected to the environment is a dialogue between humans and nature that emphasizes the shared agency of humans, nonhumans, and their physical setting (Kramer, 2012). By integrating dance into environmental education, learners are encouraged to share and create their own kinesthetic and embodied understandings of their environment.

Place, identity, and sustainability through music

Humans have used music as a means for environmental expression for thousands of years—to convey the beauty of the natural and built world, celebrate the features of local communities, or protest against the exploitation of people and places. From Vivaldi’s “Four Seasons,” where the beauty of seasonal environmental changes come to life, to Paul Kelly’s “Sydney from a 747,” where the sparkle of Sydney’s city lights seen from an airplane are the focus, we have always sung about our places in a manner that imbues them with human connection and cultural significance. Indeed, it is this affective impact of music that makes it so powerful.

The protest song is not new, but highlights the ways in which human beings

use music to engage with issues of exploitation and inequality. Songs such as “Simple Song of Freedom” by Bobby Darin and “The Day After Tomorrow” by Tom Waits protest against the futility of war, while eco-activist songs aim to raise awareness as well as call for change. In Australia, the band Midnight Oil sings about injustice for Indigenous people in “Beds are Burning” and about corporate environmental vandalism in “Blue Sky Mine;” Gurrumul sings about the disappearing land in “Galupa;” and Christine Anu about “My Island Home” and the sense of belonging we have to our place of origin.

Similar trends are appearing in music education in schools. In an exploration of place, four participating pre-schools in “The Living Curriculum” project (Ward, 2010) researched the flora and fauna of local suburban environments, and reflected their habitats, interspecies relationships, and coexistence with humans through story, verse and song. These songs became the students’ “Sydney Songs,” representing the intersection of the human and non-human in the places where the children lived. This musical mapping of place is akin to what Somerville (2013) called “a post modern emergence” (p. 56) where a place becomes known through story, drawing, singing and mapping. Knowing and caring about places that are meaningful to us are precursors to developing stewardship dispositions.

In 2012, teacher education mentors from Antofagasta, Chile visited Western Sydney University and engaged in master

classes on representing their local natural and built environment using visual arts and music. The songs written for this occasion focused on the kamanchaca, a weather phenomenon in Antofagasta, and the vischaca, a chinchilla type animal common in the Antofagasta community and surrounding mountains. This project highlighted the multiple uses of environmental or place-based music for understanding community and environmental relationships, for investigating human and other-than-human worlds, and for building interwoven musical bridges between them.

Conclusion

As demonstrated by the examples above, the arts play a crucial role in environmental learning in urban centers. They do this by raising awareness about environmental degradation, by introducing a new means to voice dissension, and by proposing imaginative sustainability solutions. The arts involve the public in creative forms of activism, helping them to bring about positive environmental change in unique and personal ways through music, dance, drama, and other art. By engaging those in urban centers in memorable arts experiences that connect them to the places and spaces in which they live, artists in all media are demonstrating an inclusive and innovative approach to environmental education. The arts reach learners who may not be reached in other ways, and ensure that a broad audience can be involved in

making the cultural shifts needed to move urban communities toward sustainability.

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10. Green infrastructure

Laura B. Cole, Timon McPhearson, Cecilia P. Herzog, Alex Russ



Photo credit: Alex Russ

HIGHLIGHTS

- Green infrastructure, such as urban parks, community gardens, green buildings and green roofs, represents a network of human-managed and natural ecosystems that together enhance ecosystem health and climate change resilience, contribute to biodiversity, and benefit human populations through the maintenance and enhancement of ecosystem services.
- Environmental education *in, of, and for* green infrastructure provides significant opportunities for improving human-nature connections in the city.
- Environmental education *in* green infrastructure entails formal and informal place-based learning in built and natural green infrastructure settings.
- Environmental education *of* green infrastructure offers a framework for teaching about the benefits of urban green infrastructure, such as ecosystem services.
- Environmental education *for* green infrastructure provides opportunities for promoting urban environmental stewardship by engaging residents in the planning, maintenance, and use of green infrastructure projects.

Introduction

The term “sustainable city” evokes images of green roofs, energy-efficient buildings, bioswales, bike lanes, urban forests, and other types of green infrastructure. These urban features clearly have value for ecosystem and human health, but they also have great educational potential. Green infrastructure can help urban residents improve their understanding of complex sustainability issues, provide opportunities for residents to interact with urban nature, and potentially encourage citizens to take actions to enhance the environment in cities.

Green infrastructure can be defined as a network of human-managed and natural ecosystems that together enhance ecosystem health and resilience, contribute to biodiversity, and benefit human populations through the maintenance and enhancement of ecosystem services (Gómez-Baggethun et al., 2013; McPhearson et al., 2016; Novotny, Ahern and Brown, 2010). Green infrastructure projects provide a broad array of human and ecosystem services in areas such as food, energy, security, climate regulation, water management, education, and aesthetics. The field of urban ecology has advanced a conceptual framework that considers the ecology in, of, and for cities (McPhearson et al., 2016). This framing reflects ecological research taking place in cities; a systems approach to study the ecology of cities that considers the complexity and dynamic interactions of

social, ecological, economic, and built components; and how the field can be positioned for advancing urban sustainability and resilience (Childers et al., 2015; Grimm et al., 2008; Pickett et al., 2008).

In this essay, we adopt a similar lexicon to consider how environmental education in cities and urban regions can be advanced *in*, *of*, and *for* urban green infrastructure (Figure 1). Put another way, we address three questions related to green infrastructure education: Where and how do we learn? What do we learn? and Why do we learn?

Education in green infrastructure refers to the rich opportunities for place-based education in cities. Here we discuss opportunities for using green infrastructure in classroom and after-school activities and deepening student contact with and attachment to their local environment. Education of green infrastructure refers to the vast learning opportunities provided by infrastructure projects in cities, where ecosystem services are entangled with human development and can teach fundamental lessons about systems thinking, sustainability and resilience. Finally, education for green infrastructure focuses on the need for increased public education regarding the benefits of green infrastructure, which could increase public support, management, and stewardship of present and future green infrastructure projects.

These ideas and the discussion of education in, of, and for green infrastructure below parallel the work of Lucas (1972) who

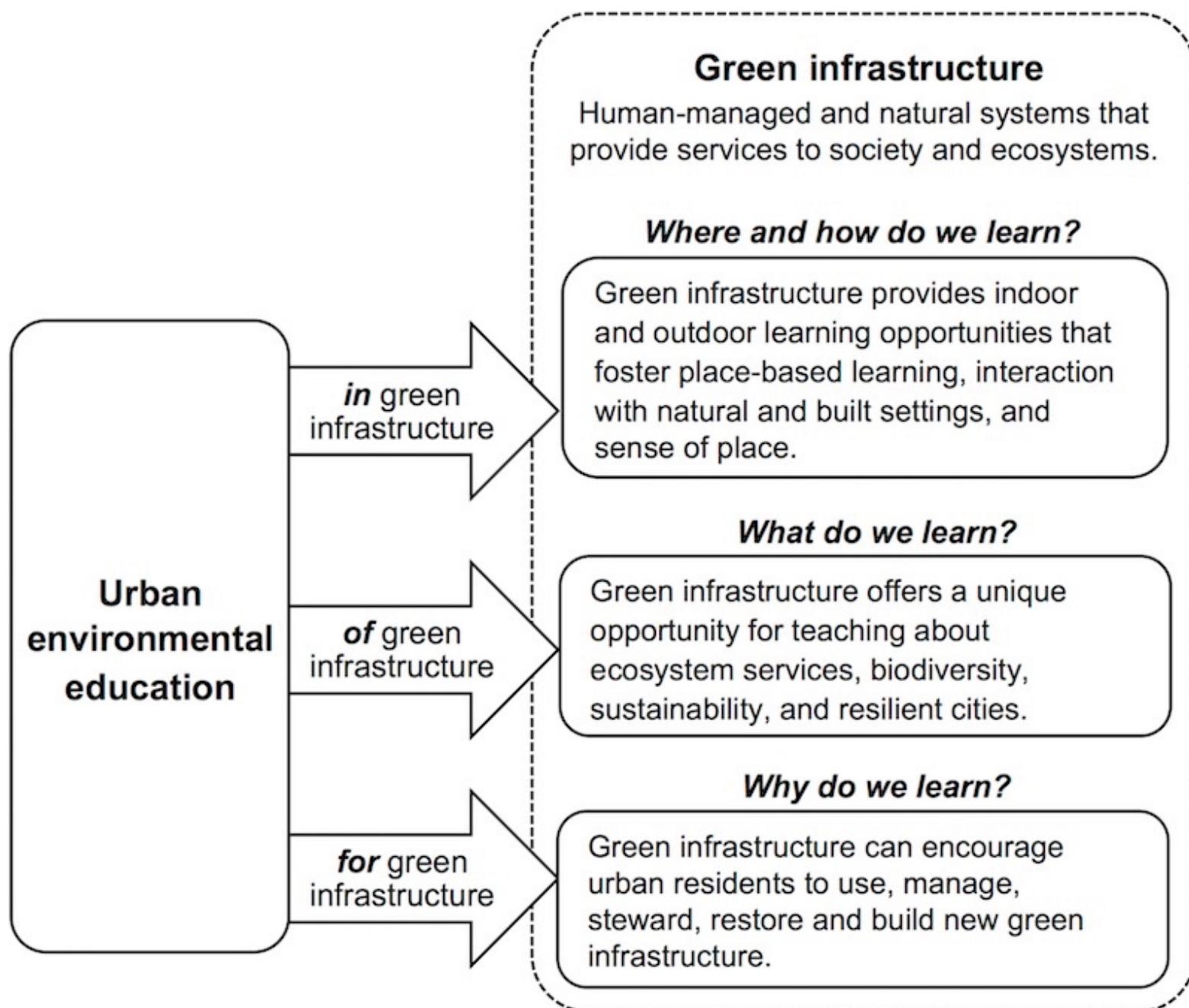


Figure 1. Urban environmental education in, of, and for green infrastructure.

proposed an education in, about, and for the environment. Throughout this exploration of education in, of, and for green infrastructure, we bring these themes to life by sharing case examples used by educators in urbanized areas around the world.

Environmental education *in* green infrastructure

Environmental education in green infrastructure is concerned with rooting education in place. If green infrastructure in

cities can be used for environmental education, then the lessons learned are necessarily about the local environment where learning occurs. In the words of Geertz (1996), "[N]o one lives in the world in general" (p. 259). Place-based education in green infrastructure can make abstract ecological principles concrete.

Demonstration projects can illuminate the potential for environmental education in green infrastructure. For example, the Center for Sustainable Building Research at the University of Minnesota in the U.S. initiated a



Figure 2. The Riverside Park branch of the Urban Ecology Center, Milwaukee, Wisconsin, U.S. Photo credit: Urban Ecology Center.

demonstration project entitled “Art, Story, and Infrastructure: A Model for Experiential Interconnection in Environmental Education.” This project takes kindergarten students on a tour of the urban water cycle using water infrastructure from the Minnesota landscape, from treatment facilities to the school building sink, all the while incorporating place-based environmental education and participatory art. Another example is the Urban Ecology Center at Riverside Park in Milwaukee Wisconsin (Figure 2). This center showcases a green building, solar power station, public art, urban wasteland being transformed into a park, riparian habitats, classrooms, and a climbing wall, all of which are intended to improve visitors’ environmental experiences and knowledge. Educational efforts such as these are rich in their ability to string together disciplines like civil engineering, landscape architecture, and building design to trace both ecological and human processes—all grounded in the learners’ lived environment.

Despite the potential to use place-conscious education and systems thinking to advance sustainability education, current public educational models are challenged to use these approaches. Such strategies may require additional financial resources and time from school districts and teachers. Moreover, some green infrastructure projects lack access and educational interpretation, making them difficult destinations for classroom field trips. Further, the place-based nature of education in green infrastructure may not align with more abstract, place-neutral methods of educational assessment that emphasize measurement and accountability. Examples around the world illustrate the potential of environmental education in green infrastructure, though neighborhoods and cities may need to invest additional resources to unleash this potential.

Environmental education of green infrastructure

Urban environmental education provides opportunities to teach the benefits of green infrastructure and therefore improve urban residents’ understanding of the impact that green infrastructure has on their own health and well-being. This approach includes lessons about planning and designing multifunctional and inclusive urban green infrastructure. Teaching about green infrastructure can borrow ideas from urban ecology to increase public understanding of high-performing social, ecological, and



Figure 3. At the California Academy of Sciences in San Francisco, California, U.S., a docent educates visitors about ecosystem services provided by the green roof, including insulation, stormwater control, and fresh air, which help the Academy and surrounding parkland thrive. Photo credit: Alex Russ.

biophilic landscapes (Beatley, 2011; Novotny, Ahern and Brown, 2010). In particular, the concept of ecosystem services, a widely used term in urban ecology (Elmqvist et al., 2013), can be used to frame the benefits of green infrastructure and ecosystems for human health and well-being. For example, in San Francisco, the California Academy of Sciences provides tours of its Leadership in Energy and Environmental Design-certified (LEED) green building to teach visitors about using green infrastructure to reduce waste, save energy, reuse materials, provide healthy indoor environments, create rooftop habitats for birds and insects, and other ecosystem services (Figure 3).

In general, ecosystem services refer to those ecosystem functions of green infrastructure that are used, enjoyed, or consumed by humans. Ecosystem services

can be categorized into four types: provisioning services (e.g., drinking water, raw materials, and medicinal plants); regulating services (e.g., pollination, water purification, carbon sequestration, flood control, climate regulation); habitat and supporting services (e.g., nutrient cycling, soil formation, photosynthesis, habitat for species); and cultural services (e.g., recreational, educational, and spiritual experiences) (Gómez-Baggethun et al., 2013; Millennium Ecosystem Assessment, 2005; TEEB, 2011). Urban residents, whether they know it or not, rely on ecosystem services produced by green infrastructure both within and outside the city. Urban green infrastructure is especially important in providing services with direct impact on human health and security such as air purification, noise reduction, urban cooling, and stormwater runoff mitigation, but also provides places for social cohesion and connection, recreation, and development of sense of place. Further, green infrastructure is being increasingly used as a nature-based solution for climate change adaptation and mitigation in cities (McPhearson et al., 2016). For example, cities are investing in green infrastructure as a specific management tool for combining engineered and ecological systems (e.g., bioswales) in place of engineered non-ecological systems (e.g., concrete sewer drains) to provide ecosystem services such as cooling, stormwater management, urban heat island reduction,

carbon storage, flood protection, and recreation (Novotny, Ahern and Brown, 2010).

Environmental education of green infrastructure is about the ways in which cities provide opportunities for complex and interdisciplinary sustainability lessons. Green infrastructure offers lessons in science, mathematics, art, design, history, social studies, and beyond. From stormwater pathways to pocket parks with bird habitat to plazas with permeable surfaces, green infrastructure in cities provides endless venues for lessons about how human settlements interact with ecosystems. In urban environmental education, green infrastructure gives visibility to processes such as water flowing through cities, sunlight converted to heat and electricity, food being grown, species migration using greenway trails, and urban forests that support biodiversity and recreation.

Cities are complex and best studied as an entanglement of systems that are social, cultural, technical, and ecological in nature (e.g., Grimm et al., 2008; McPhearson et al., 2016; Pickett et al., 2008). By focusing on the multiple functions of green infrastructure, urban environmental education teaches about systems thinking. For example, urban community gardens provide food, absorb excess stormwater, mitigate microclimate fluctuations, support urban biodiversity, and provide aesthetic benefits. These gardens become places for recreation, reflection, social bonding, and cohesion. Similarly, green roofs and vegetated areas, including trees,

can increase rainwater infiltration and reduce peak flood discharge and associated water pollution while also delivering mental and physical health benefits such as providing spaces for recreation, relaxation, and reducing stress. These kinds of green infrastructure projects are critical for building community resilience, and simultaneously offer rich contexts for urban environmental education.

Environmental education for green infrastructure

Environmental education can amplify public support for green infrastructure. Urban environmental educators can play a critical role in fostering support for current and future green infrastructure projects, helping cities push toward a community-based form of urban land management that has been described as urban ecological or civic ecology stewardship (Krasny and Tidball, 2015; Svendsen and Campbell, 2008). Environmental education can help to promote, create, and maintain green infrastructure in multiple ways.

First, educators can involve adults and children in the planning and maintenance of green infrastructure. Such projects may require deep and sustained partnerships between local governments, grassroots, nonprofits, businesses and schools. For example, in the Bronx, New York City, community-based organizations such as the Bronx River Alliance, Youth Ministries for Peace and Justice, and The POINT

Community Development Corporation involved high school students and other urban residents in designing a concept plan for greenways along urban rivers and streets. As another example, the 1.2 hectare Grands-Moulins – Abbé-Pierre garden in Paris offers an inspiring instance of how residents actively manage green spaces and rediscover nature in the city. These examples show that diverse members of urban communities can play a role in decision-making about green infrastructure development.

Second, urban environmental education can involve people in using green infrastructure. With bike lanes, gardens ready for growing vegetables, and green buildings open for tours, cities are providing green infrastructure projects that become dynamic examples of sustainability woven into the daily life of citizens. In this way, green infrastructure acts as a stage for informal environmental education as people spontaneously engage “hands-on” with green infrastructure projects. For example, many community-based education/restoration organizations in the U.S. offer free canoeing in restored urban waterways for residents to rediscover local recreational opportunities, potentially raising

public support for urban open space.

Third, education related to green infrastructure may inspire interest and future action to expand green infrastructure in cities. Berlin offers an example of how citizens knowledgeable about the benefits of open and multi-functional spaces engaged in supporting the revitalization of an urban green space. In the 1980s, local residents formed a nonprofit organization to protect an 18-hectare railyard. The former railyard had been abandoned for five decades during Berlin’s separation of East and West, a circumstance that allowed the landscape to regenerate while untouched by development. Despite the area’s proximity to a densely populated neighborhood, civic activists and professional planners influenced policy makers to protect it. Their efforts, along with ecological research, helped transform the area into the Natur-Park Südgelände, opened in 2000 (Kowarik and Langer, 2005) (Figure 4).



Figure 4. Natur-Park Südgelände in Berlin resulted from the efforts of civically engaged residents. Photo credit: Cecilia Herzog.

The park offers a model for green infrastructure that fosters a strong sense of place for residents by nurturing cultural values related to art, education and sport. In this way, it also provides opportunities for education in and of green infrastructure.

Conclusion

Urban environmental educators working *in, of and for* green infrastructure offer a unique voice as cities design, build, and promote ecologically- and socially-conscious infrastructure. In particular, we suggest that environmental education in green infrastructure can offer nature-based opportunities for place-based environmental education, help to build sense of place, and use spaces that otherwise may not be perceived as educational (e.g., waste management facilities, mechanical rooms of green buildings, and bioswales). Advancing environmental education of green infrastructure can help to showcase the social and ecological benefits of urban green infrastructure to residents' everyday lives, thus increasing awareness of the value of urban nature. Finally, we suggest that environmental education can be employed for encouraging hands-on stewardship or restoration of green infrastructure, as well as programs that encourage cities to build new and better manage existing green infrastructure.

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