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Community Gardens as Contexts for Science, Stewardship, and Civic Action Learning

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Abstract

Community gardens are heterogeneous environments that integrate environmental restoration, community activism, social interactions, cultural expression, and food security. As such, they provide a context for learning that addresses multiple societal goals, including a populace that is scientifically literate, practices environmental stewardship, and participates in civic life. Several theories are useful in describing the learning that occurs in community gardens, including those focusing on learning as acquisition of content by individuals, learning as interaction with other individuals and the environment and as increasingly skilled levels of participation in a community of practice, and social learning among groups of stakeholders leading to concerted action to enhance natural resources. In this paper, we use preliminary evidence from the Garden Mosaics intergenerational education program to suggest the potential for community gardens to foster multiple types of learning.

Keywords

Learning; education; community gardens; civic ecology

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INTRODUCTION

The word learning generally brings to mind students acquiring a set body of information or content that is generalisable rather than related to a specific environment or other learning context. So, for example, students who are ecologically literate should acquire content related to the fundamental principles of ecology, including how biotic and abiotic factors interact to influence species distributions, ecological processes at varying scales, ecological models, and evolutionary theory (Jordan et al. 2009).

Whereas such content may be learned in a classroom, interactive or socio-cultural theories suggest that science and other learning occurs through the participation of the learner in the social and bio-physical processes taking place in a particular environment or context (Bandura 1977; Sfard 1998; Rogoff et al. 2003; Wenger 2003; Gauvain 2005; Illeris 2007). Drawing from the work of Bandura (1977) and Wenger et al. (2002), interactive theories focus on imitation of and interaction with skilled practitioners, and moving from a novice to skilled participant in a community of practice. For example, a young person might become increasingly skilled as a member of a community gardening community of practice through interaction with the environment and with more experienced gardeners during the act of gardening. Such communities of practice are characterized by a "joint enterprise" (e.g., gardening and associated social and cultural practices), "mutual engagement" that binds members together, and a "shared repertoire" of tools, language, and stories (Wenger 1998).

Whereas both cognitive and interactive views of learning focus on changes in individual learners, researchers working within the context of natural resources management have used the term social learning to describe changes that transpire among a group of stakeholders engaged in adaptive co-management of watersheds and other social-ecological systems (Blackmore 2007). Thus, social learning is defined as a collaborative process among multiple stakeholders aimed at addressing management issues in complex systems (Schusler et al. 2003; Blackmore et al. 2007; Pahl-Wostl et al. 2007). Although Wenger and other socio-cultural theorists use the term *social learning* to refer to individual learning as a result of interaction or participation, for the purposes of this paper we use the term interactive to refer to theories emphasizing learning as interaction or participation focusing on individual learners, and *social learning* to refer to learning among a group of natural resources management stakeholders.

Community gardens are distinctive in their ability to integrate food production with environmental stewardship and civic engagement. Environmental stewardship takes the form of restoring neglected and degraded plots of land, and civic engagement includes building relationships, collaboratively mobilizing resources for advocacy and to promote neighborhood well-being, and coming together to share and celebrate cultural traditions (Saldivar and Krasny 2004; King 2008; Campbell and Wiesen 2009). From the perspective of learning, community gardening can be considered as a rich community of practice integrating multiple activities and skills, and thus presents unique opportunities for multiple types of learning. Such opportunities include learning as acquisition of science content, learning as interaction or participation in planting, social, and cultural practices, and social learning among a group of gardeners to address management and policy issues.

While recognizing that community gardening provides ongoing opportunities for learning among adult gardeners, our purpose in this article is to outline more specifically how educational programs designed around community gardening might foster multiple types of learning among youth. To accomplish this purpose, we first present a brief overview of the Garden Mosaics intergenerational community gardening education program and of the learning theory underlying this program. Next we examine evidence for multiple types of learning among youth in Garden Mosaics. We finish our discussion by showing the relationship of multiple forms of learning to the rich community gardening context and to the larger social-ecological system. At this time, our evidence for learning is based on surveys, interviews, and artefacts or products produced by participants (e.g., Gardener Stories and Action Project reports posted to the program website). Because our empirical evidence is limited, our intent is not to make definitive claims about the impacts of Garden Mosaics or other community gardening education programs. Rather our objective is to use learning theory and our own experience to stimulate thinking about community gardening educational strategies that may meet multiple learning, community, and environmental goals, and about how one might assess the outcomes of such programs.

GARDEN MOSAICS

Garden Mosaics is an intergenerational educational program taking place in urban community gardens across the United States (U.S.) and in other countries, which seeks to "connect youth and elders to investigate the mosaics of plants, people, and cultures in gardens." The youth participants, ranging in age from 9-18 years, engage in Garden Mosaics largely through out-of-school programs, including science enrichment, environmental education, youth action, gardening, and youth employment. These programs are sponsored by faith-based organizations, summer camps, community development corporations, half-way houses, 4-H, and community centers. Originally developed at Cornell University in collaboration with non-profit greening groups in cities across the U.S., Garden Mosaics is now housed with the American Community Gardening Association. The majority of funding for Garden Mosaics came from the National Science Foundation (NSF), although the U.S. Department of Agriculture and other agencies and foundations also contributed (Krasny et al. 2005).

The Garden Mosaics youth activities integrate learning from the "traditional" or practical knowledge of community gardeners with learning from science resources produced at Cornell University. Community gardeners in the U.S. come from all walks of life, and include immigrants from developing countries and African-Americans with roots in the rural southern states. Similarly in South Africa and other countries, community gardeners are often immigrants or internal migrants to cities with rural, agricultural backgrounds. Through Garden Mosaics, these gardeners share with youth the ways in which they have adapted agricultural practices from their homeland to highly urbanized settings. During their i·m·science investigations including the Gardener Story, Garden Inventory, Neighborhood Inventory, and Weed Watch, youth in Garden Mosaics interview gardeners and collect data on vegetables, weeds, soils, and the role of gardens in their community. Drawing on what they learn in these investigations, and in short-term learning activities outlined in the program's Science Pages, youth conduct Action Projects to enhance their community. Submitting the results of the i·m·science investigations and Action Projects to the program website provides opportunities for youth to share their learning. Thus the program activities are designed to facilitate science learning, intergenerational mentoring, cultural understanding, and community action (Textboxes 1 and 2). These goals are reflected in the multiple online and print resources, including illustrated Science Pages in English, Spanish, and other languages, a program manual, a training DVD for educators, and an interactive digital learning tool focusing on global agricultural biodiversity (www.gardenmosaics.org).

Over the first four years of the program, approximately 1200 educators, 14,000 youth, and 2500 elder gardeners from cities across the U.S. participated in Garden Mosaics activities. Currently the materials are available for free online and for purchase, and groups such as the American Community Gardening Association and Cornell Cooperative Extension continue to incorporate Garden Mosaics activities into new educator workshops and ongoing after-school youth and school programs. The overwhelming majority of Garden Mosaics participants are urban minority and immigrant youth and adults; more recently we also are conducting Garden Mosaics programs in communities impacted by military deployment.

Textbox 1. Garden Mosaics Learning Activities

i·m·science investigations, in which youth conduct research on gardens and their community.

- Neighborhood Exploration, in which youth explore the assets of their community using spatial images, interviews, and observations conducted while walking around their neighborhood;
- Gardener Story, which entails interviewing a gardener about the connections of planting practices to cultural traditions;
- Community Garden Inventory, in which participants list the activities and benefits community gardens provide for their neighborhood; and
- Weed Watch, designed to collect data about weed problems and control methods in urban gardens.

Action Projects, *in which youth apply what they have learned in their i·m·science investigations to enhancing their neighborhood or local gardens.* Example Action Projects include youth building a handicap-accessible raised bed, planning a neighborhood garden festival, donating produce to food kitchens, creating a plant sculpture in a garden, or sharing what they have learned with younger children.

Short-term inquiry and other learning activities ranging from jeopardy games focused on food crops to blog exchanges with youth overseas.

Textbox 2. Example Garden Mosaics Youth Program

Garden Mosaics Youth Program: Sacramento CA

In Sacramento, youth interviewed Hmong community gardeners about what they were growing and the cultural relevance of their plants. The youth compiled a list of insects in the gardens with both the English and Hmong names. They also learned that there was a long waiting list for plots at the community garden, so they designed a new community garden for elders and youth next to their high school.

Garden Mosaics Youth Program: Bronx, NY

In the Bronx, Abraham House provides housing and services for first-time offenders and their families. The youth in their summer program conducted an interview of “Pablo” at the nearby Bronx Cultural and Community Garden, and posted what they had learned on the Gardener Story database. Abraham House staff and Cornell graduate student Alexey Kudryavtsev worked together to guide the youth in inventorying weed problems, and entering their data on the Weed Watch database. The youth created a poster of their Weed Watch activities, which they presented at the annual meetings of the Weed Science Society of America. Later the youth used a blog to share their garden and neighborhood activities with youth conducting Garden Mosaics activities in Tomsk, Siberia.

LEARNING THEORY SUPPORTING COMMUNITY GARDENING EDUCATION

We initially designed the Garden Mosaics program based on science inquiry learning principles (National Research Council 1996; 2000) and on ideas about the importance of "free-choice" (Falk and Dierking 2002) or out-of-school settings for learning, such as community gardens. However, through our engagement in this and related civic ecology education programs (Krasny and Tidball 2009a), we developed a broader understanding of the potential role that learning theory may play in designing community gardening education programs. Underlying the science inquiry movement are individualist theories of learning, including behaviorist, cognitive, and constructivist psychology, which describe learning as an internal activity characterized by acquisition of knowledge and skills that may be transferred across contexts. However, community gardens, where there is an existing community of practice as well as a rich context for learning that integrates gardening, social interactions, advocacy, and cultural diversity, lend themselves to theories that describe learning as an outcome of interaction with the social and bio-physical environment (Illeris 2007). Such theories variously emphasize learning as moving from an inexperienced to skilled member of a community of practice (Lave and Wenger 1991; Wenger et al. 2002; Rogoff et al. 2003); the larger social, cultural and historical contexts of learning (sociocultural theory, Lemke 2001); learning as embedded in the more immediate social and environmental context (situated learning, Brown et al. 1989); the importance of reciprocal interactions among learners' behaviors, capabilities, and environment (social learning, Bandura 1977); and learning taking place through interactions of the learner with other components of an activity system (activity theory, Engestrom et al. 1999). However, all these interactive theories have in common their ability to help us think about alternatives to cognitive conceptions of learning as an individual activity with little reference to the social and environmental context.

In applying Lave and Wenger's (1991) notion of learning as changing participation in communities of practice to youth education, questions arise as to how to structure the learning experience to foster more skillful participation. In an empirical study comparing environmental learning among high school students in classrooms and community-based organizations, Hogan (2002) found that without proper mentoring and scaffolding by adults, students who were placed in a community environmental organization failed to achieve all the desired learning outcomes related to environmental stewardship and advocacy. In contrast, Bouillion and Gomez (2001) described a sequence of progressively more complex learning experiences for primary school students in Chicago focused on riverbank restoration, which resulted in both learning outcomes for the participants and improvements in the local community and ecosystem. Thus, rather than simply placing a young person in a community garden and expecting learning to transpire, this research suggests that opportunities for interacting with experienced adults who actively model the practices, coach novices, and provide scaffolding are needed to enable a young person to move from being an observer of a practice such as scientific research, gardening, or resource management, to a peripheral participant (someone who participates but has not yet mastered the practice), to a full or skilled participant (Brown et al. 1989; Rogoff et al. 2003; Gauvain 2005).

Much of the literature emphasizing learning as interaction has been in science education, suggesting that students learn science through participating in authentic science research communities (Brown et al. 1989). Citizen science programs, in which young people collect data that contribute to larger scientific studies, are one means of situating learning in authentic scientific practice (Krasny and Bonney 2005). Krasny and Tidball (2009a) have suggested that learning may also be situated in authentic natural resources management practices, such as community gardening, community forestry, and watershed restoration. These authors use the term *civic ecology* to refer to these small-scale, self-organized stewardship practices that integrate environmental and social values in cities and other peopled landscapes; this term also reflects the linked social and ecological systems implications of urban participatory environmental restoration and management initiatives (Tidball and Krasny 2007; Krasny and Tidball In Press). Community gardening and other civic ecology practices often emerge from the actions of local residents wanting to make a difference in the social and natural environment of their community, and is recognizable when both people and the environment benefit measurably and memorably from these actions. Thus, civic ecology practices can be considered as one form of adaptive co-management, which integrates the participatory processes of collaborative resource management, with ongoing learning through experimentation inherent to adaptive management (Plummer and FitzGibbon 2007; Armitage et al. 2008b). Whereas adaptive co-management often is imposed by state agencies or other organizations, in the case of community gardens, this management practice has a tradition of self-organization and emergence, or being initiated by stakeholders within the community (c.f., Ruitenbeek and Cartier 2001).

Situating learning in community gardening and other civic ecology practices has several potential positive outcomes related to environmental and science learning. First, concern has been raised about the negative tone of environmental education that focuses on pollution and other environmental problems, whereas civic ecology education situates learning in positive expressions of community engagement and environmental stewardship. Moreover, youth may be motivated by the opportunity to contribute as valued members of a community (Olitsky 2007) and by seeing how their actions lead to changes in their environment (Chawla 2008). Finally, Aikenhead (1996), Jegede and Aikenhead (1999), and Fakudze (2004) have suggested that integrating the knowledge of parents and other local adults into a science education program, such as is possible through a community gardening education program, may serve as a means for immigrant and other youth who may not be exposed to western scientific ways of thinking at home to “cross borders” between the subcultures of family/community and western science/science education. Through integrating the knowledge of community members, educational activities may become more relevant and more readily understood, and thus may reduce a feeling of alienation among minority and immigrant students (Moll et al. 1992; Aikenhead 1996).

Researchers working within the context of natural resources and adaptive co-management have expanded on the notion of individual learning as participation in a community of practice, to suggest that learning also may be an organizational or group process that is an outcome of specific forms of participation in resource management (Armitage et al. 2008b). They have described social learning as the process by which stakeholder interactions go beyond participation to concerted action that brings about policy change, or more generally a collaborative process among multiple stakeholders aimed at addressing management issues in complex systems (Schusler et al. 2003; Keen et al. 2005; Blackmore 2007; Ison et al. 2007; Mostert et al. 2007; Pahl-Wostl et al. 2007; Plummer and Armitage 2007; Plummer and FitzGibbon 2007; Fernandez-Gimenez et al. 2008). The ability to take concerted action depends on gaining adequate knowledge through experiential processes of learning-by-doing or more intentional experimentation directed at understanding the impact of a management practice or responding to changes in the social-ecological system, as well as through discussion and reflection (Armitage et al. 2008b). Thus social learning within adaptive co-management is characterized by inclusion and integration of multiple stakeholders, perspectives, and knowledge systems; experimentation and observation; a social-ecological systems orientation; interaction and negotiation; and reflection on and evaluation of results (Plummer and FitzGibbon 2007). Finally, evidence of social learning includes shared action (e.g., “experiments undertaken”), modifications in practice on the basis of knowledge gained and reflection, and questioning of management system routines, norms, and protocols (Armitage et al. 2008b).

In much of the adaptive co-management literature, social learning entails researchers and managers designing a specific set of participatory decision-making and learning experiences for stakeholders, such as simulation modeling (Pahl-Wostl and Hare 2004), participatory mapping (Ison et al. 2007), or search conferences (Schusler et al. 2003). In the community gardening context, social learning may emerge in concert with ongoing management and advocacy efforts among gardeners, such as when gardeners use their experiential knowledge of the outcomes of community gardening to collectively advocate for protection of their gardens against the threat of development. Other instances of social learning are focused more on resource management rather than advocacy, and include an adaptive learning component (Armitage et al. 2008a). For example, volunteer efforts to restore degraded prairie and savannah habitats in Chicago provide a case study of how, through a series of informal planting and land management experiments (e.g., controlled burns to suppress invasive species), lay people and scientists were able to continually improve upon means of managing their social and biophysical environment (Stevens 1995; Jordan 2003; Moskovits et al. 2004).

EVIDENCE OF LEARNING IN GARDEN MOSAICS PROGRAMS

We turn next to evidence from Garden Mosaics for learning related to science content, stewardship, and civic action, drawing from the three learning perspectives described above: learning as acquisition (cognitive or acquisition theories), learning as participation (socio-cultural or interactive theories), and learning among a group of stakeholders directed at changing management practice (social learning within a natural resources management context). In our initial attempts to directly measure science learning outcomes of Garden Mosaics programs, the program director (Krasny), her graduate student (Doyle), and the outside program evaluator (Thompson) encountered challenges related to limited literacy levels and range in age among participants, resistance to paper and pencil tests among youth in out-of-school educational settings, and wide variation in activities implemented among programs at different sites. We then turned to more active measures of youth learning (e.g., drawings) as well as to indirect measures such as interviews and surveys of educators, the methods and results for which are reported in the three sub-sections below. Thus the evidence we present is preliminary and more rigorous studies would be needed to justify further claims about the types of learning that occur through intergenerational community gardening education programs.

Science Learning: Learning as Acquisition and Interaction

Consistent with the goals of our funder (NSF), our original goal for Garden Mosaics was acquisition of science content and inquiry skills by youth through hands-on activities. These activities included taking measurements on social and bio-physical phenomena and interaction with knowledgeable adults within an urban, ethnically diverse, gardening context. We used post-program interviews with youth, pre/post-program drawings by youth and youth-generated lists of garden components, post-program educator surveys, and examination of reports of i·m·science investigations generated by youth to provide evidence of science learning.

During the pilot phase of Garden Mosaics, a graduate student conducted 30 open-ended interviews with a convenience sample of 28 participating youth from six cities, asking about how they benefited from the program. Although youth cited learning about soils, plants, and gardening as a benefit, this science learning outcome was mentioned less often than other benefits, ranking after gardening skills, learning from and developing relationships with elder gardeners, academic/research skills such as writing and measuring, and teamwork/ responsibility, and appreciation for the value of gardens (Krasny and Doyle 2002).

In the garden drawing activity also conducted during the early phases of the program, the outside program evaluator asked each youth in five different summer programs in low income, minority, urban neighborhoods in New York City and Pennsylvania to draw a garden before and after their involvement in Garden Mosaics summer programs. The evaluator then coded the drawings for presence of the following elements: trees, grass, flowers, fruits and vegetables, plant roots, soil, organized planting (beds, rows, etc.), row labels, paths, fences, watering mechanisms, weather elements, structures (casitas, sheds, etc.), animal life, people, and garden tools. Nineteen out of 23 youth who completed the pre- and post-drawings included at least one new element in their end of program drawing, with the mean number of new elements per drawing varying by site and ranging from 1.3 to 3.8. Fruits and vegetables were the most commonly included drawing element at both times. Grass, soil, weather, and flowers also frequently were included at both times, although there was a large decrease in the percent of drawings including flowers after the program, consistent with the fact that most of the gardens contained vegetables rather than flowers. Elements that tended to appear more frequently at the end of the program included water, organized planting, weather, grass, trees, and animals (Thompson 2004).

In an attempt to discern youth understanding of gardens as ecosystems, in particular garden inputs and outputs, the outside evaluator asked youth at the five sites who had completed the garden drawings the following questions before and after the program: “What does a garden need to grow and thrive?” and “What does a garden give back to you?” Eighty-eight and 94% of the lists completed after the program included at least one new input and output respectively, and 60% of the input and 75% of the output lists were longer following the program. There was little change in the frequency with which an item was listed at both times. Sun, water, soil, and air were the most frequently mentioned inputs, with seeds, care, and a person/gardener also common. On output lists, food and flowers were by far the most frequently listed garden items at both times; youth had difficulty imaging other garden outputs (Thompson 2004).

After several years of program implementation, a Cornell graduate student familiar with Garden Mosaics conducted an online survey of all educators for whom we had records of participation in Garden Mosaics training workshops or short Garden Mosaics presentations at professional conferences, and/or who had received the Garden Mosaics training DVD. Of the 696 email invitations mailed to educators, 105 were undeliverable, and 303 educators responded (response rate = 44%). Of educators who attended a workshop and received a DVD, 44% implemented the program, compared to 43% of those who only attended workshops, 20% who only received the DVD, and 13% who attended a short presentation of Garden Mosaics at professional conferences (Kudryavtsev 2006).

A subset of educators who responded to the online survey answered an open-ended question about what they felt was the greatest impact of the Garden Mosaics program on youth. Responses to this question were coded manually by the program director (Krasny). Given our original science learning focus in educator trainings and in the Garden Mosaics curricular materials, it is not surprising that science learning was listed most frequently as a program impact for youth. However, other impacts also were cited, including motivation to learn and awareness of the role of community gardens in the neighborhood (Table 1).

Table 1. Educator responses to open-ended survey question: "Briefly describe greatest impact of Garden Mosaics on Youth." (n = 66 educators, some educators reported multiple impacts)

Youth Impact	Number of Responses	Example Educator Response
Science concepts	13	Connecting broad ecological concepts with on-site school garden. Students saw a connection between the health of the soil (we examined organisms in soil and compost) and what can grow there. Participants were able to identify the garden plots in a better way, at the same time they learned and/or practiced their east, south, north and west in order to learn about directions.
Awareness of gardens and gardens' contributions to community	12	Made students more aware of gardens and how they can reflect culture and experiences. Greater awareness of role gardens can play in creating a sustainable urban environment .
General learning and exposure	11	New material for my kids. Hands-on, collaborative learning experience.
Motivation to learn	9	The look of learning and the fact that they get it. An excitement for science was developed.
Awareness of source of food	5	Understanding where food comes from.
Connection to nature	6	They experienced the satisfaction and calming influence of working in a garden.
Self-empowerment, sense of achievement	5	Sense of achievement in growing. Students felt empowered and successful. Recognition of power to control surroundings.
Contributions to community	4	Gave them an opportunity to beautify their community and learn about land caretaking. They learned that they are part of the community and whatever they do has an impact on it.
Learning from elders	4	Realize that scientist is a broad definition, includes elders w/ knowledge. Youth got a lot of learning from Gardeners.
Working together	2	The students have an appreciation for … working together as a team.
Multicultural understanding	1	Multicultural understanding.
Stayed out of trouble	1	They stayed out of trouble
Science inquiry	1	Enhanced learning into scientific inquiry.

Whereas not all participants in the i·m·science investigations posted reports on the Garden Mosaics website, and thus these reports do not provide evidence of the learning of a representative sample of Garden Mosaics participants, they do suggest the types of learning that may occur when a group leader guides youth in this aspect of the program. For example, Gardener Stories posted online suggest that youth in some programs learned about gardeners' planting practices, backgrounds, and cultural traditions; the Community Garden Inventory results suggest that youth learned about activities, plants, and structures that occur in the gardens, and thus what the garden contributes to the surrounding community; the Neighborhood Exploration results suggest that the youth learned about their community's assets and needs; and the Weed Watch data sheets suggest that youth learned about weed species, growth, problems, and control methods.

In short, through our program evaluation and online databases, we have evidence to suggest that community gardening education programs have the potential to enhance understanding of science content among youth participants and to engage youth in the process of data collection and presentation of results. Interactive learning theories would suggest that interaction with elders and with the garden environment was important to this learning, whereas cognitive theories would emphasize acquiring content through factual resources such as the Science Pages.

Stewardship: Learning as Participation in a Community Gardening Community of Practice

Through our work implementing Garden Mosaics in the United States, Canada, and South Africa, our vision expanded from community gardens as sites for science learning to encompass community gardening as a form of emergent, asset-based, resource management in cities (Tidball and Krasny 2007). This enabled us also to broaden our view of the educational potential of community gardens to encompass increasingly skilled levels of participation in urban resource management or stewardship, and to apply theories about interactive learning and adaptive co-management to a consideration of how youth might learn through participation in these stewardship communities of practice. Thus in addition to plant science and food security, which is the focus of many backyard and school gardening education programs, community gardening education programs may focus more broadly on the practice of coupled social-ecological resource management in urban systems.

Through participating in the ongoing community gardening activities under adult guidance, youth may have gained competence as members of the community gardening community of practice. Whereas our evaluation did not focus specifically on more skilled levels of participation, reports of accomplishments of individual programs written by our outside evaluator (Thompson 2004; Krasny 2007), and Action Project reports posted to the website (c.f., Textbox 2, www.gardenmosaics.org), provided some evidence of youth becoming engaged in such a community of practice. Activities of the community gardening community of practice in which youth participated included gardening alongside elders, social and cultural events, harvest festivals, and educational events for other youth and community members. The fact that the youth cited forming relationships with gardeners as a benefit of their participation in Garden Mosaics suggests that, in addition to the gardening "joint enterprise," mutual engagement characterized this community gardening community of practice. The Gardener Stories and Garden Inventories posted online indicate that youth and gardeners also may have developed a shared repertoire of gardening language and stories (Wenger 1998).

Further, evidence from two evaluation studies showed that forming relationships with youth was an important outcome of participation in the program for community gardeners, reinforcing the notion that mutual engagement was created through the Garden Mosaics activities. In the online educator survey conducted by Kudryavtsev (2006), 20 of the 53 educators who responded to an open-ended question about the greatest impact of the program for gardeners talked about gardeners engaging and sharing knowledge with youth (Table 2). Similarly, in open-ended interviews with four gardeners during the pilot phase of the program, common responses to questions about program outcomes included forming relationships with youth and interaction with youth and others (Krasny and Doyle 2002).

Table 2. Educator responses to open-ended survey question: "Briefly describe greatest impact of Garden Mosaics on Gardeners." (n = 52 educators, some educators reported multiple impacts)

Gardener Impact	Number of Responses	Example Educator Response
Opportunity to interact with youth	20	The one gardener involved in this project appeared happy to share his knowledge with students and he seemed proud to show the 'fruits' of his labor. Increased personal vitality due to interaction with youth and renewed sense of purpose. City kids are not scary to work with when everyone is interested in plants!
Share knowledge with/ teach youth	9	Sharing their knowledge with the students and helping the students in their research. Being able to share the how's and why's of gardening with youth.
New information/ skills	7	Learned new ways to create food source. New materials, new ideas.
Learn about science	5	Realization of the science involved in gardening. Understanding of basic science, composting, connections.
Practical	4	Brought food home to their families and friends.
Learn about youth	3	Understanding that children could grasp gardening concepts and enjoy it!
Personal growth	3	Feel valued and included.
Tie to nature	2	Nature and elderly. Environmental awareness.
Building community	1	Community building.

Concerted Action: Social Learning Among Groups

Through the Action Projects, young people also became part of stakeholder groups taking concerted action to enhance the environment, a process referred to as social learning by scholars of natural resources management (Blackmore 2007). Action Projects were described in reports posted by the youth groups online and in accomplishment reports completed by educators. These projects included New York City participants who worked with community leaders, gardeners and other adults to turn an abandoned lot into a new garden; former gang members in Harlem who launched a local foods awareness and environmental justice campaign; youth in Philadelphia who conducted soil tests, made recommendations to the gardeners for improving the soil, and arranged for delivery of free compost to the garden to improve the soil quality; and Boston youth who donated the harvest from their plots to a women's shelter and food kitchen (Krasny 2007). These projects tended to involve hands-on environmental stewardship and community actions, rather than advocacy for a particular resource management policy as has been described in the adaptive co-management social learning literature (Blackmore et al. 2007; Pahl-Wostl et al. 2007; Plummer and FitzGibbon 2007). Whereas the environmental education literature also has focused on engagement in the policy process through such approaches as action competence (Jensen and Schnack 1997), a recent study by Schusler et al. (2009) describes a broader suite of strategies for engaging youth in environmental action, encompassing both stewardship and policy activities.

According to Plummer and FitzGibbon (2007), social capital may be an outcome of the deliberation processes involved in social learning, and both social learning and social capital are linked to stakeholder engagement in adaptive co-management. The Garden Mosaics findings about the importance of the interactions with youth to the gardeners (Krasny and Doyle 2002; Krasny 2007) would suggest that youth and adults formed trusting relationships, which along with participation in civic activities such as community gardening, are aspects of social capital (Putnam 1995). In addition to their importance in adaptive co-management, social learning and social capital may enhance the resilience of a city neighborhood or other social-ecological system, or the capacity of such systems to respond to ongoing and catastrophic disturbances and conflict (Walker and Salt 2006).

COMMUNITY GARDENS AS SITES FOR LEARNING

Boyer and Roth (2006) have differentiated between school classrooms and out-of-school "heterogeneous" learning environments, which because of their variable and changing cultural, bio-physical and social environment, offer multiple opportunities for learning not available in classrooms. Community gardens, with their diversity of plants, cultures, and management and governance practices, can be considered as heterogeneous learning environments offering multiple possibilities for learning focused on science, stewardship, and advocacy. For example, the plants and insects offer opportunities for students to observe and perform experiments and thus acquire content knowledge related to pollination, whereas the community gardening practice, including planting, tending plants, and collaboratively developing rules related to plot allocation and pesticide use, allow opportunities for youth to become increasingly more skilled as members of a civic ecology community of practice (Krasny and Tidball 2009a). Further, through engaging with other gardeners in implementing and advocating for garden and neighborhood improvements, young people may become part of stakeholder groups engaging in concerted action.

Thus, our observations and evaluations of the Garden Mosaics program suggest that community gardens may provide opportunities for science content learning through both acquisitional and interactive processes, for learning as participation in communities of practice that integrate social, food security, and environmental outcomes, and for social learning as concerted action among a group of stakeholders. By providing opportunities to engage in multiple forms of learning, community gardens may expand on learning opportunities available in other informal science education settings such as museums and botanic gardens, which may focus more narrowly on science content. Further, community gardens are unique among both traditional (e.g., museum) and civic ecology (e.g., community forestry, wetland habitat restoration) learning contexts because of the cultural diversity represented by immigrant, minority, and other gardeners, and the related diversity of types of knowledge and planting practices.

Thus, community gardening provides opportunities for learning that addresses multiple societal goals, including creating a populace that is scientifically literate, that practices resource stewardship, and that is engaged in civic life. However, a number of challenges present themselves in facilitating such educational programs. These include providing the guidance and scaffolding that are necessary for youth to become more skilled members of community gardening communities of practice, and working within an informal educational infrastructure that includes myriad small, non-profit organizations and government agencies in which communication channels and networks are less clearly defined than in the formal, school educational system.

Although not covered here, community gardening education also has the potential to foster outcomes of interest to environmental educators and health practitioners. These include environmentally responsible behaviors, opportunities for unstructured time in nature, positive youth development, understanding of linkages between global and local food security, and gardening skills themselves (Krasny 2009). Recently, the National Forum on Children and Nature recognized community gardening as a best practice for connecting youth with nature (The Conservation Fund 2008).

CONCLUSION

Viewing learning as the result of interactions among individuals and the social and bio-physical components of their environment provides an opportunity to explore the role of education in a larger social-ecological system. Interestingly, both interactive and social learning theories borrow terms from ecology, including references to learning as an emergent property arising out of interactions that are only partially controlled by the facilitator or teacher, and as fostering changes in the learner and the environment through a series of feedback loops and other interactions (Boyer and Roth 2006; Chawla 2008; Tidball and Krasny, 2009). Thus, an understanding of interactive and social learning is useful in considering how a civic ecology practice, such as community gardening, might foster outcomes not only for individuals, but also for the larger social-ecological system. For example, youth engaged in a community gardening education program such as Garden Mosaics form connections with adults, and reinforce and enhance the contributions adult community gardeners make to their community. Such contributions can include fostering biological and cultural diversity and ecosystem services, such as food, pollination, and sites for reconnecting with nature. This suggests that, in addition to examining the outcomes of community gardening education programs for individual and groups of participants, further research could examine the role of such programs in the larger social-ecological system. In short, the question arises from the work described in this paper: What are the impacts of community gardening education not only on individual learning, but also on ecosystem services, social capital, and biological and cultural diversity, and thus on the sustainability and resilience of urban social-ecological systems (c.f., Folke et al. 2002)?

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