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Sharing Science Knowledge across Generations: Do Children Tell Caregivers What They Learn in School about Water Conservation?

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Abstract

Children often learn more contemporary information in school about topics such as water conservation than their caregivers did. As such, intergenerational learning from child to caregiver may occur, especially when children learn information with practical applications. Forty-six fifth-graders had a water conservation lesson at school. Afterward, their caregivers (n = 46) completed a survey about home water conservation, family activities, and intergenerational learning. Caregivers reported acquiring information from their children through direct communication and during ongoing activities. Child self-efficacy also showed a marginal association with intergenerational learning. Implications for future research and for formal and informal science learning are discussed.

Keywords: intergenerational learning, informal learning, science education, self-efficacy, water conservation

Intergenerational learning, acquiring knowledge across generations, is usually conceptualized as older individuals teaching younger ones (Pinazo-Hernandis, 2011). However, children often learn more contemporary science knowledge in school than what their caregivers know, for instance new information about water conservation. When children communicate this knowledge to caregivers, it provides an opportunity for science learning to reach beyond the classroom and may help to promote pro-environmental household practices. Research has shown that it is possible for caregivers to increase their environmental science knowledge after children participate in lessons on the topic (Duvall & Zint, 2007; Istead & Shapiro, 2014), however the findings are equivocal. It is also not known how children themselves contribute to this process. In this research, we investigate whether children share recently learned environmental science knowledge about water conservation with their caregivers and, if so, the social contexts in which the exchange occurs. We also explore a psychological factor, child self-efficacy (Bandura, 1997), that has been linked to children's environmental engagement (Chawla & Heft, 2002) and may relate to whether children share new science information with caregivers.

We focus on environmental science knowledge concerning freshwater conservation because many regions in the United States are experiencing severe water crises that are expected to persist for the foreseeable future (Corral-Verdugo, Frías-Armenta, Tapia-Fonllem, & Fraijo-Sing, 2012; Cook, Ault, & Smerdon, 2015). To conserve water, many communities are encouraging sustainable behaviors in the public (Gober & Kirkwood, 2009). However, such behavior change is difficult to achieve (Duvall & Zint, 2007). Educational media campaigns have been inconsistently effective (Corral-Verdugo et al., 2012). Some campaigns have increased pro-environmental attitudes (Dolnicar, Hulrimann, & Grün, 2011), such as those that utilize trusted community members to spread the information or that let people try out new conservation behaviors (e.g., using recycled water to water lawns or fill public pools). In contrast, information-only campaigns, such as those that rely on pamphlets with conservation tips mailed directly to homes, are often ineffective and may even lead to increased wasteful water behaviors (Seyranian, Sinatra, & Polikoff, 2015). Although some of these results are encouraging, conservationists continue to seek alternative methods of behavior change. One proposal is to focus on younger community members as agents of change (Istead & Shapiro, 2014). Children learn a significant amount of new environmental science knowledge in school that may affect their attitudes and behaviors (Chawla & Derr, 2012). When children convey this knowledge to caregivers, it may stimulate pro-conservation attitudes and behaviors at home.

This study aims to shed more light on whether caregivers report learning new science-based water conservation knowledge from their children and how children's self-efficacy regarding intergenerational learning relates to sharing this knowledge. In addition, to learn more about the social context of this information sharing, we investigated whether it occurs during ongoing activities, a common context of informal learning (Weisner, 2002), or in more explicit, didactic conversations mirroring formal school learning (Rogoff, Moore, Correa-Chávez, & Dexter, 2015). As background, we review research on out-of-school or informal science learning, intergenerational learning, and the potential role of child self-efficacy in bridging school and home learning.

Informal Science Learning

Informal science learning occurs outside of the formal learning context of school. It is valuable for reaching society's goals of capacity building in science, technology, engineering, and mathematics (STEM) and for advancing public science literacy. Informal science learning can reinforce knowledge learned in school and promote deeper understanding of it (Chawla & Derr, 2012). It can illustrate how science is a way of thinking about and approaching the world and not merely a school subject (Callanan, Shrager, & Moore, 1995; Gleason & Schauble, 1999). It may also help motivate a lifelong interest in science by showing how scientific knowledge and methods apply to many practical problems (Hall & Schaverien, 2001; Renninger & Hidi, 2011).

Much of the research on informal science learning focuses on settings dedicated to this purpose, such as museums and organized out-of-school programs (Dierking & Falk, 1994; Mohr-Schroeder et al., 2014; National Research Council, 2015). Yet, informal science learning may also occur during less-organized pursuits including daily activities, interactions with friends and family, and experience with media (Bell, Lewenstein, Shouse, & Feder, 2009). In these situations, children can acquire new science knowledge and have the opportunity to relate this information to their everyday experiences, which may make the contribution of science to children's lives more vivid (Chawla, 2009; Luebke, Clayton, Kelly, & Grajal, 2015). Informal learning may extend scientific information learned in the classroom to the family setting, a connection that could motivate household behavioral change (Wals, 2012).

An important feature of informal science learning is that it occurs during activities where the intention is not to teach about science, but to communicate something considered important to the people involved (Farver, 1999). This learning can occur during routine activities (e.g., shopping; Toth, Little, Read, Fitton, & Horton, 2013), explicit conversations about what happened in school (Forrester, 2013), and when caregivers or children observe each other's behaviors (e.g., recycling; Leeming, Porter, Dwyer, Cobern, & Oliver, 1997). These activity settings afford opportunities for children and caregivers to explore and exchange information about scientific ideas and to learn from one another. A common assumption about informal learning is that adults, and sometimes older children, provide knowledge to young children. However, some prior research suggests that children will share information they learn in school with older family members, including caregivers (Duvall & Zint, 2007). However, this research has identified some barriers to children sharing information with adults including caregivers, such as adults' or children's perception of children as potential experts and the extent to which caregivers engage with the child's schoolwork.

As these examples suggest, formal and informal learning are not really separate from one another. Knowledge learned in one context often enriches or influences activities and knowledge learned in the other (Eshach, 2007; Hofstein & Rosenfeld, 1996). Formal learning intersects with informal learning in various ways, including through objects or projects children take home from school, which may include exploration of local environments and even household activities (Zimmerman, Gamrat, & Hooper, 2014). Prior research has related informal science learning to increased interest and understanding of STEM concepts at school (National Research Council, 2015; Rennie, 2014). Thus, to understand children's science learning fully, it is important to examine connections between formal and informal learning. How, then, do children and caregivers share new science information at home?

Intergenerational Learning

Informal learning can often be intergenerational, with knowledge shared across people of different ages or generations (Pinazo-Hernandis, 2011). Adults often pass information onto children during daily activities such as chores (e.g., cooking), play (e.g., swimming), and conversation (Patrick, Johnson, Mantzicopolous, & Gray, 2015; Rogoff et al., 2015). The transmission of knowledge from more- to less-experienced community members helps young people learn and develop the skills needed to succeed in their environment along with many other behaviors valued in the community (Boyd, Richerson, & Henrich, 2011).

Prior research shows that families share knowledge and engage in scientific discussions in many non-school activities, such as visiting nature trails and science museums. During these activities, children can share knowledge they learned in school with family members in real-world situations (Forrester, 2013; Jewett & Clark, 1979; McClain & Zimmerman, 2014). Interactions between children and caregivers during daily routines and household activities can provide an especially rich learning context because the practical utility of the knowledge is evident. Also, in these situations, children may have the opportunity to direct the activity themselves and bring up unique knowledge to share (e.g., that storm water can be reused in the garden; Zimmerman, Reeve, & Bell, 2008), which can deepen children's science knowledge along with their skills at sharing this type of knowledge with others.

Few studies have investigated child-to-caregiver intergenerational learning and results are inconsistent (Duvall & Zint, 2007). Although some studies report little sharing of information, including information about the environment (Ballantyne, Connell, & Fien, 1998; Legault & Pelletier, 2000), other studies report that children convey large amounts of information learned in school to caregivers (Damerell, Howe, & Milner-Gulland, 2013; Istead & Shapiro, 2014). Research indicates that children convey newly learned science knowledge in various family contexts, such as working on homework, accompanying caregivers when they shop for appliances, and discussing household recycling habits (Istead & Shapiro, 2014; Uzzell, 1994). Some research suggests that child-caregiver interactions following children's participation in environmental education influences caregivers' self-reported conservation behaviors (Damerell et al., 2013). Such exchanges are not unique to caregivers and children living in industrialized societies. Research conducted in Kenya found that children convey health-related information learned in school to caregivers during home activities (Onyango-Ouma, Aagaard-Hansen, & Jensen, 2005).

Research suggests that learning science informally may proceed differently across contexts. For instance, caregivers support children's learning about mathematics differently during homework than during a game (Bjorklund, Hubertz, & Reubens, 2004). Similarly, research suggests that children differ in how they share knowledge with caregivers. Some children directly recount the science learned in school to caregivers in an instructive or didactic manner resembling school lessons (Boyd et al., 2011; Istead & Shapiro, 2014), whereas other children transmit science information learned in school to caregivers during relevant activities (McClain & Zimmerman, 2014). For example, when brushing teeth, children may tell caregivers that turning off the faucet while brushing saves water. Whether children pass this type of information on instructively or during an activity may depend on various factors. Because intergenerational learning requires children to assume the role of more-knowledgeable participant, characteristics such as the child's sense of self-efficacy may affect the frequency and settings in which child-to-caregiver intergenerational learning occurs.

Child Self-Efficacy and Intergenerational Learning

Self-efficacy is the perceived ability to accomplish a behavior and effect change (Bandura, 1997). Self-efficacy is related to an individual's identification with the environment and sense of competence in caring for it (Chawla, 2009; Clayton & Opotow, 2003). Children with higher self-efficacy exhibit more pro-environmental behaviors following environmental education (Chawla & Heft, 2002). Some research suggests that children with higher self-efficacy are more likely than children with lower self-efficacy to impart new knowledge to caregivers (Knafo & Galansky, 2008). Child self-efficacy may be promoted by teachers and parents who endorse a growth mindset, which enhances the potential to learn and may help children develop confidence in their own knowledge and ability to pass it onto others (Haimovitz & Dweck, 2017).

Child self-efficacy may also relate to the way children share science knowledge learned in school with their caregivers (Istead & Shapiro, 2014; Patrick et al., 2015). Children with higher self-efficacy may be more likely to share this information didactically. Alternatively, children with lower self-efficacy may be more likely to share this information during an ongoing activity (Vaughan, Gack, Solorazano, & Ray, 2003). To explore these questions, we examine the relation of child self-efficacy to the frequency with which children share science knowledge learned in school with their caregivers and the contexts in which such exchanges occur.

Research Questions

This study investigates child-to-caregiver intergenerational learning of environmental science knowledge about water conservation following a lesson in which children learned new knowledge on this topic at school. It examines three research questions. First, do caregivers report learning new science knowledge from their children that was learned in school? Second, in what activity settings do families report children share this information? Third, will children who learn more in the science lesson be more likely to share the knowledge with caregivers? For this study, we test two hypotheses. One, children will share information learned from a water conservation lesson with their parents. Two, children will share this information in various social contexts, including direct, or more didactic, conversations and during ongoing activities. We also explore whether child self-efficacy is related to children's sharing of newly learned water conservation information with their caregivers.

Method

Participants

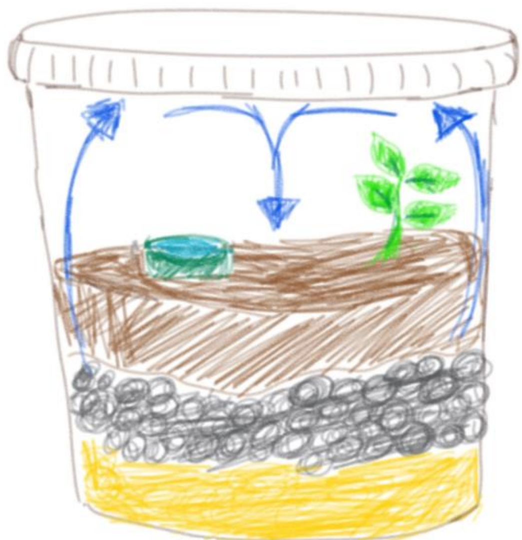
Forty-six fifth-grade children (17 male; *M* age = 10.61 years, *SD* = 3.64 months) and their caregivers (32 mothers, two grandmothers, three fathers, nine unspecified caregivers) participated. They were recruited from nine classrooms in four schools located in an urban region of Southern California. The schools were in lower- to lower-middle-income neighborhoods with an average of 75 percent of the children across the participating schools receiving free/reduced lunches. The schools have a diverse ethnic population reflecting the community at large, with rates of 61-80 percent Hispanic American, 10-25 percent European American, 3-5 percent African American, and 3-8 percent Other across the four schools.

Procedure

Data collection for children occurred before and after an in-class 90-minute lesson on water conservation led by a trained science educator from the local public utilities office. Before the lesson began, children completed a brief questionnaire, *Water in the World Today*. The water lesson consisted of a 60-minute presentation about the water cycle, water pollution, current water sanitation methods, and water sustainability. The presentation conveyed environmental science information about water waste, water cycle, and pollution with particular effort to contextualize the information in everyday situations (e.g., that the water used on your lawns during the day evaporates quickly because of the sun). While the lesson connected the science information to real-world and at-home contexts, there was no explicit instruction to share this information with caregivers following the lesson. During the presentation students participated in a dance that demonstrated the water cycle, from evaporation to resupply of aquifers. A 30-minute activity followed the presentation in which children constructed a small terrarium, a plant enclosed in a jar that was used to illustrate the water cycle in a self-contained ecosystem (see Figure 1). Materials for the activity included a plastic container, rocks, sand, soil, a drought-tolerant flower, and water. Children were given their terrariums to keep at the end of instruction. Following the terrarium activity, children completed another brief questionnaire, *Today's Water Uses*.

For both questionnaires, the experimenter read each question aloud. Children were instructed to respond on their own and not to share their answers with others. After completing the second questionnaire, children were given human research review board-approved consent forms and caregiver surveys, which they brought home for their caregivers to complete. The completed take-home surveys and consent forms were returned by participants to the university by mail in a postage-paid envelope. After receiving this information, the researchers sent the family a $10 gift card for a local merchant in appreciation of their participation.

Figure 1. An illustration of the terrariums used during the environmental education lesson.



Measures

Children completed two questionnaires, *Water in the World Today* and *Today's Water Uses*, and caregivers completed the *Caregiver Environmental Survey*. These measures were created for this study and were available in English and Spanish. The Spanish versions were translated by local research assistants fluent in Spanish. Two child-caregiver pairs completed the measures in Spanish, while all the other pairs completed them in English.

Water in the World Today

This 14-item paper-and-pencil questionnaire measures water-related knowledge and conservation behaviors; it includes 10 yes-no items (see Appendix A) and four open-response questions. Two of the four open-response questions asked if the child endorsed the conservation behaviors described in the scenario and to explain why. The scenario questions were:

1. *Your school is getting brand new water fountains and the students are asked to vote on whether the fountains should use recycled wastewater or desalinated water. Recycled wastewater is water that was used before for another purpose and has been cleaned to make it safe to drink. Desalinated water is ocean water that has had the salt taken out of it, it is more expensive than recycled wastewater. Which water would you choose? Why?*
2. *There is a big rainstorm in your town and after it was over you found some buckets outside your house that filled up with storm water. What will you do with the water in these buckets? Why?*

The other two questions asked about conservation behaviors: *Do you try to conserve water? Do you think conserving water at home helps the environment?* First, the child answered yes or no to the question and then explained the response (prompted by "Why or why not?").

Today's Water Uses

This 13-item questionnaire measures water knowledge, water-related behaviors, intergenerational learning, and child self-efficacy. Nine yes/no items that mirror questions in *Water in the World Today* assessed water knowledge following the lesson (see Appendix B). Two additional items asked about water-related behaviors. One used a four-point Likert scale (*How often do you actively do things to save water?*; responses: 1 = daily, 2 = often, 3 = rarely, 4 = never) and the other was an open-response question (*What are some of the things you do to save water at home?*).

Two other items, adapted from prior research on intergenerational learning (Istead & Shapiro, 2014), assessed children's experience telling caregivers what they learned in school and their self-efficacy related to this practice. A yes/no question asked whether the child tells their caregiver(s) about school learning in general: *Do you tell your parents interesting things you do in school?* The second question was a four-point Likert scale item assessing child self-efficacy that asked about the frequency with which children believe they impart newly learned school information to their caregivers: *How often do you think you teach something new to your parents that you learned from school?* (choices: every day, few times a week, few times a month, rarely). This item was used as an index of child self-efficacy regarding child-to-caregiver intergenerational learning.

Caregiver Environmental Survey

Caregivers reported on their environmental attitudes, behaviors, and instances of child-to-caregiver intergenerational learning on a 16-item survey. It included four yes/no questions (see Appendix C) followed by two open-response questions based on a scenario similar to one in the child survey. The scenario and questions were as follows:

All the water faucets in your house will soon have recycled water in them. Recycled waste water is waste water cleaned until it is safe to drink, and then returned straight to your pipes.

1. *Would you drink this water or switch to other water like bottled water? Why or why not?*
2. *Would your answer change if water fountains at your child's school used recycled water? Why or why not?*

The survey also contained 10 other open-response questions (see Appendix C); three asked about home water conservation behaviors, three asked about child-caregiver interactions, and two asked whether their child tells the caregiver things the child learned in school—with one focusing on general information and the other on water information. Each question about children sharing information learned in school had a follow-up question that requested specific examples about when caregivers learned such information from their children.

Coding and Reliability

The measures included forced-choice and narrative responses. The first author and a trained research assistant independently coded the narrative responses for 37 participants (80 percent of the sample) for interrater reliability purposes and achieved very good reliability; *Cohen's Kappa* ranged from .73-.86. When reliability was less than complete agreement, the first author's coding was used in the analyses.

Yes/No Questions

Items were coded 1 if the response supported water conservation or sustainable behaviors, and 0 if the response did not represent water conservation or represented misconceptions about water (e.g., it is impossible to waste water because it is in a continuing water cycle). Scores represented the total number of responses supporting water conservation (a possible total of 10 for *Water in the World Today* and 9 for *Today's Water Uses*).

Intergenerational Learning

Intergenerational learning was coded from two items that asked caregivers about the frequency and content of interactions in which their children shared knowledge they learned at school with the caregiver. For frequency, we counted the number of specific examples of intergenerational learning in the responses to two questions: *Can you name a time where you learned something about water from your children?* and *Could you tell us about a time where you changed your water use habits because of something your child taught you about water?* For the analysis, the total number of responses was identified as either low (0), medium (1), or high (≥ 2). When participants reported the same situation in response to both items, they were counted as one instance.

Activity Settings

Responses to the three open-ended questions (one on *Today's Water Uses* completed by the child and two on the *Caregiver Environmental Survey*) that respondents provided as examples of intergenerational learning were coded as: *observation*, *conversation*, *ongoing activity*, or *not occurring*. *Observation* refers to caregivers acquiring new knowledge by observing their children's behaviors without any direct interaction between child and caregiver (e.g., caregiver turns faucets off during an activity after having seen the child doing so). *Conversation* refers to when a caregiver gains information after talking with their child about it (e.g., child tells caregiver about what was learned in school). *Ongoing activity* refers to instances when caregivers learn new information from their children during a shared activity (e.g., gardening, cooking), while using an object or form of technology in the home to carry out a behavior (e.g., an egg timer to time showers), or when the child suggests the caregiver modify his or behavior during an activity (e.g., child tells caregiver to turn off a running faucet when brushing teeth). *Not occurring* was used when no specific instances of intergenerational learning were reported. Reliability was acceptable for the activity setting coding, *Kappa* = .73.

Child Self-Efficacy
Child self-efficacy was coded using the child's response to the question: *How often do you think you teach something new to your parents that you learned from school?* As self-efficacy relates to children's perceived ability to complete a task, children's perception of themselves as successfully sharing new and novel information was used to measure self-efficacy. Responses were coded on a four-point Likert scale reflecting the frequency of the behavior, with higher scores indicating greater frequency (every day= 4, few times a week = 3, few times a month = 2, rarely = 1).

Plan of Analysis
Paired-sample *t*-tests were used to assess children's environmental knowledge before and after the science lesson to determine if children acquired new information from the classroom visit. To test the first hypothesis, we computed a one-sample *t*-test to determine if caregivers' reported learning of new science information from their children was above chance. To test the second the second hypothesis, chi-square goodness of fit tests compared the frequency of intergenerational learning across activity settings. We used polychoric correlations to explore the relations of child-reported self-efficacy and children's science learning to caregiver-reported intergenerational learning and the contexts in which this learning occurred.

Results
Results showed an increase in children's water conservation knowledge following the 90-minute lesson, $t(45) = 6.77$, $p < .001$, $d = 1.02$ Children, on average, had pro-conservation responses in 55 percent of the 10 questions ($M = 5.56$, $SD = 1.68$) before the environmental lesson, and in 79 percent of the nine questions ($M = 7.17$, $SD = 1.48$) after the lesson. No gender differences were found in pretest scores, $t(44) = 0.25$, $p = .80$, $r = .038$, post-test scores, $t(44) = 0.83$., $p = .41$, $r = .12$, or when examining differences between pre-test and post-test scores, $t(44) = 0.49$, $p = .50$, $r = .073$.

The first hypothesis was confirmed. Thirty-eight of 46 caregivers (83 percent) reported learning new water-saving information or attitudes from their children, significantly more than would be expected by chance, $t(45) = 14.62$, $p < .001$, $d = 4.36$. Caregivers reported a mean number of 1.30 distinct instances ($SD = .76$, range 0 – 2) of intergenerational learning. Eight caregivers (17.4 percent) reported no instances of intergenerational learning, 16 (34.8 percent) reported one instance, and 22 (47.8 percent) reported two instances. There were no differences for child gender in caregiver-reported intergenerational learning. The amount of learning by children in the class lesson, measured by difference scores between pre- and post-assessments, was marginally correlated with frequency of intergenerational learning reported by caregivers, r (44) = .25, p =.093.

The second hypothesis was also supported. There was a total of 38 reported instances of intergenerational learning during explicit conversations (M = 0.83, SD = 0.8) and 39 reported instances during ongoing activities (M = 0.85, SD = 0.7); observational learning occurred in only one case and is not examined further. Intergenerational learning occurred at similar rates across the two settings, $\chi^2(1)$ = .013, p = 0.91, r = .01. Eighteen families (39.1 percent) reported no specific instances of learning during conversations, 19 families (41.3 percent) reported one instance, eight (17.4 percent) reported two instances, and one (2.2 percent) reported three specific instances. Fifteen families (32 percent) reported no instances during ongoing activities, 23 (50 percent) families provided one specific instance, and eight families (17.4 percent) reported two specific instances. There were no gender differences; boys and girls shared science knowledge in conversation, $t(44)$ = 0.36, p = .72, r = .05, and during ongoing activities, $t(44)$ = 0.69, p = .49, r = .10, at similar rates.

Children reported a mean response of 2.76 (SD = 0.97) out of a maximum of 4 (share information everyday) on the self-efficacy item, which indicates that, on average, they shared newly learned science knowledge with caregivers on a regular, but not daily, basis. There was no gender difference in this response, $t(44)$ = 0.30, p = .76, r = .046. A marginally positive relation appeared between child-reported self-efficacy and frequency of caregiver-reported intergenerational learning, $r(44)$ = .28, p = .057. Polychoric correlations revealed no relation between child self-efficacy and communicating science knowledge to caregivers in conversation, $r(44)$ = .18, p =.23 or during ongoing activities, $r(44)$ = .14, p = .35.

Discussion

Most children in this study, after learning new water conservation knowledge in a one-time classroom lesson, conveyed this knowledge to their caregivers. Children shared this knowledge with caregivers in different social contexts, mainly during conversations and ongoing activities. These findings are consistent with research showing caregivers increase their knowledge about environmental science when their children participate in science-oriented extracurricular programs (Damerell et al., 2013). The present study adds to this finding by showing that this type of intergenerational learning may occur after a one-time environmental education lesson at school about water conservation.

More generally, the results support the idea that children's learning about science-based water conservation may contribute to adults' environmental science knowledge. Children and their caregivers, with whom many children have their closest relationships, interact regularly (Bronfenbrenner & Morris, 2006). A significant amount of knowledge, particularly concerning everyday behaviors (e.g., cooking, hygiene), is passed on during these interactions as part of the socialization process (Weisner, 2002). Thus, a potentially effective way to impart contemporary scientific knowledge about water conservation to adults may be to teach children this knowledge through school lessons that are clearly connected to real-world experiences.

Our investigation into the different contexts of these child-caregiver interactions showed that children shared newly learned science knowledge with caregivers during ongoing activities and in conversations at similar rates. These findings are consistent with prior research that identified family activities of many types as important for intergenerational and informal learning (Cristancho & Vining, 2009; Rogoff et al., 2015; Weisner, 2002). Ongoing activities may be a common setting for intergenerational learning in the home because they provide real-world contexts in which children can apply their newly learned knowledge. Prior research showed that children more often share learned information when they can refer to an object or activity related to that information (Zimmerman et al., 2014). Conversations that refer to school lessons that are relevant to home life, as was the case here, may be especially likely to be recounted by children. Future study might include home observations of these different types of interactions to learn more about them and to determine if they influence behavior change.

Child self-efficacy and children's learning during a one-time science lesson were marginally related positively to sharing this information with caregivers, which suggests a potential connection between child self-efficacy, children's science learning, and child-to-caregiver intergenerational learning. Contrary to expectations, child self-efficacy showed no relation to the context in which children shared this knowledge with caregivers. These findings suggest that self-efficacy may be pertinent to the amount of knowledge children share, but not to the social context in which it is shared. Yet, the current study used limited measures for self-efficacy, so the relation between self-efficacy and intergenerational learning requires further study.

This study has several limitations. It was a naturalistic study without a control condition or experimental manipulation and, therefore, causal relations are unknown. Students in the participating classrooms were not required to partake in the study, and some selection bias may have occurred. Although the data were from two sources (children and caregivers), all data used self-report measures; more objective home observations would increase understanding of child-to-caregiver intergenerational learning. The lesson that was the focus of the research deviated from the normal curriculum and may have been more interesting to children than usual class lessons, which may have increased the likelihood of the lesson being shared with caregivers. The sample size was small, which may have limited our ability to detect certain effects of interest, in particular the relation of child self-efficacy to child-to-caregiver intergenerational learning. Finally, the data were collected in a geographic region experiencing severe drought. This situation may have increased the likelihood that children would share water-related information with caregivers and raises questions about the generalizability of the results.

This study has several benefits. Results are consistent with prior findings showing that children can impart new knowledge to caregivers about environmental science and conservation. They also provide insight into the everyday situations of child-to-caregiver intergenerational learning and, more generally, about informal learning. In the present study, instances of intergenerational sharing were reported even after a brief, one-time lesson, which is useful for designing educational interventions aimed at promoting community-wide pro-conservation behaviors regarding water. A brief lesson that connects school curricula to at-home situations may be more acceptable to teachers and school administrators who are often hesitant to include longer lessons that deviate from the planned curriculum.

An important feature of the water conservation lesson was constructing terrariums that the children could take home (see Figure 1). The terrariums may have helped spark caregiver-child interaction about the lesson (Zimmerman et al., 2014). Given that this activity was low in cost as well as fun and engaging for the children, it may be useful to incorporate such activities in one-time lessons as a way of facilitating intergenerational learning. Additionally, although one-time lessons are often considered limited for behavioral change, when lessons reinforce broader societal messages, their potential may be enhanced. At the present time, people's concerns about the environment are on the rise and better understanding of the potential of brief pro-environmental lessons for children's learning and behavioral change is needed. Developmental scientists and educators can play an important role by assessing the contributions of these lessons, which may, in turn, lead to recommendations for best practices in this area (Clayton et al., 2016). Lastly, this study shows a marginal link between self-efficacy and child-to-caregiver intergenerational learning, which suggests a need for further study of this connection. If such relations hold, the inclusion of more directed self-efficacy interventions, such as lessons in which children can provide or create solutions to water conservation problems, during brief pro-environmental lessons might increase the frequency and extent to which child-to-caregiver intergenerational learning occurs.

In conclusion, the current water crisis has raised awareness of the need for widespread behavioral change in the use of this precious resource. Intergenerational learning may help in this effort. This study extended current knowledge of child-to-caregiver intergenerational learning by examining caregivers' self-reported learning of this sort and the contexts in which it occurred. Results showed that caregivers report acquiring new environmental science information about water conservation from children in various informal learning contexts. The findings suggest that instructing children in environmental science issues can be a potentially valuable way of increasing adult environmental science knowledge and may have implications for household behavioral change. The study also explored how self-efficacy related to child-to-caregiver intergenerational learning and there was some indication that child self-efficacy may contribute to this process. However, this analysis was exploratory, with limited measurement of self-efficacy. In terms of new research directions, future study might investigate the skills children need to share science knowledge effectively with caregivers, if child-to-caregiver intergenerational learning raises children's interest in or motivation to engage in science learning, and whether this type of intergenerational learning has the potential to increase pro-environmental behaviors in the home.

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Appendix A

Water in the World Today

All responses were in a yes/no format.

1. Is bottled water healthier to drink than water from the faucet or a water fountain?
2. If you saw a pipe leaking, would you let someone know about it?
3. Is it OK to reuse water that has already been used to take a shower or for other things?
4. Do water bottles that get thrown away after they are empty harm the environment?
5. Would you drink recycled water that has been used before for things like bathing and washing dishes?
6. Do you think you need to take long showers (8 minutes or longer) to get really clean?
7. Would you use recycled water that was used before and then cleaned if you were told it was safe?
8. Do you believe that waste water, even after it gets cleaned, has germs in it that can make you sick?
9. Is saving water an important issue in the world today?
10. Would you be embarrassed if people knew you drank recycled water?

Appendix B

Today's Water Uses

All responses were in a yes/no format.

1. Do you need to worry about conserving water even though the water you use will stay in the water cycle?
2. Do you have a problem reusing water that has been used before if it is cleaned afterwards?
3. Is bottled water healthier for you than water from the water fountains or your faucet at home?
4. Can the way you use water change the amount of available water in your area?
5. If you saw a pipe leaking water, would you let someone know about it?
6. Is recycled water that has been used before and cleaned to be safe again, OK to drink?
7. Would you be embarrassed if people knew you drank recycled water?
8. Are we in danger of not having water in the future if we don't try to save it today?
9. Do water bottles you use then throw away do harm to the environment?

Appendix C

Caregiver Environmental Survey

Yes/No Questions:

1. Are bottles of water healthier for you to drink than water from the faucet or drinking from water fountains? (Yes/No)
2. Would you drink recycled water (water that has been used and cleaned) if you knew it was safe? (Yes/No)
3. Is water sustainability currently an important issue to you? (Yes/No)
4. Do disposable water bottles have a huge impact on the environment? (Yes/No)

Open-Response Questions:

1. How important is it to you to conserve water?
2. Do you take any extra actions to save water at your home? If so, what are they? If not, why not?
3. What are some things you do to save water at home?
4. Does your child (who completed the surveys) participate in any community activities (play on a sports team, acting, Cub/Girl Scouts, etc.)?
5. Did you choose these community activities, or was it your child's idea?
6. Do you often do activities with your child you both consider fun? What are they?
7. Does your child share things they've learned in school with you?
8. Has your child shared anything they learned in school about water with you? If so, what did they tell you?
9. How often, if ever, do you feel you change your habits or behaviors regarding water because of something your child told you?
10. Could you tell us about a time where you changed your water use habits because of something your child taught you about water?