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Citizen Science as a REAL Environment for Authentic Scientific Inquiry

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Abstract

Citizen science projects can serve as constructivist learning environments for programming focused on science, technology, engineering, and math (STEM) for youth. Attributes of *rich environments for active learning* (REALs) provide a framework for design of Extension STEM learning environments. Guiding principles and design strategies for the University of Minnesota Extension's Driven to Discover: Enabling Authentic Inquiry through Citizen Science project demonstrate how education and investigations grounded in real-world citizen science projects can capitalize on REAL environments to generate meaningful STEM learning. Positive evaluation results support the efficacy of the design for enhancing youth science identity and practice.

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Introduction

Preparing a workforce literate in science, technology, engineering, and math (STEM) is critical to maintaining viability of the United States in global markets. Rothwell (2013) concluded that around 20% of all jobs require STEM aptitudes. But the nation's school systems fall short of addressing this challenge (Hanushek, Peterson, & Woessmann, 2012). STEM education in informal settings is critical (Bell, Lewenstein, Shouse, & Feder, 2009; Falk & Dierking, 2010). Extension, therefore, has a vital role to play in reform that excites and trains a diverse, next-generation STEM literate workforce (Heck, Carlos, Barnett, & Smith, 2012; Kraft, 1999).

Extension programs are particularly well-suited to provide rich opportunities to understand and practice science, as evidenced by several successful program models (Blair, Meyer, Rager, Ostlie, Montgomery, & Carlson, 2004; Bordeau, 2004; Clarke, 2010; Skelton, Seevers, Dormody, & Hodnett, 2012; Stevenson, 2013), and volunteer and teacher training strategies (DePriest, & Krasny, 2004; Konen, & Horton, 2000; Larson Nippolt, 2012; Smith, 2008; Smith, Meehan, Enfield, George, & Young, 2004). However, previous publications on these programs have not included detailed descriptions of effective learning environments for Extension STEM programming.

Extension STEM Learning Environments

The learning environment, or the setting and situation in which learning takes place, is a critical element to consider for Extension STEM program design (Kolb, 1984; Meyer, Bevan, & Garza, 2010; Worker, 2013). Kolb (1984) asserted that learning is a process of transactions between a person and her or his environment. Worker (2013) suggested that meaningful STEM education must be situated in the authentic environments of scientific communities of practice. Summarizing findings from the *Museums Afterschool: Principles, Data, and Design* research project, Meyer, Bevan, and Garza (2010) subsequently described the learning environment as one of three critical design factors for informal STEM programs.

Grabinger and Dunlap's (1995) *rich environments for active learning* (REALs) provide one useful framework to assess learning potential of Extension STEM environments. Grabinger and Dunlap argue that REALs are comprehensive instructional environments that "engage students in a continuous collaborative process of building and reshaping understanding as a natural consequence of their experiences and interactions within learning environments that authentically reflect the world around them." REALs are grounded in three characteristics of constructivism: collaboration and social negotiation of meaning, active knowledge construction and evolution, and indexed knowledge acquisition (Table 1). Extension programs that employ REAL design strategies intentionally address instructional factors for meaningful, experiential STEM education.

Citizen Science as STEM Learning Environments

The University of Minnesota's Driven to Discover: Enabling Authentic Inquiry through Citizen Science project (D2D), funded by the National Science Foundation, demonstrates the use of citizen science in REALs for Extension STEM programming. Citizen science projects provide authentic experiences for participants (e.g., Ferry, 1995; Kountoupes, & Oberhauser, 2008; National Research Council, 2000; Trumbull, Bonney, Bascom, & Cabral, 2000), and lead to increased science knowledge (Brossard, Lewenstein, & Bonney, 2005). Typically, citizen science—or public participation in science—involves the public in collecting data to be analyzed and interpreted by professional scientists. D2D carries citizen science a step further, using participation in these projects to scaffold middle-school aged youth as they design, carry out, and report on original research questions under the mentorship of adult volunteers. An evaluation of this project is focused on the premise that youth gain a greater understanding and appreciation for science practice and will grow to see themselves as scientists by having the freedom, responsibility, and support to design their own investigations.

D2D program design exemplifies all attributes of REALs (Table 1). Extensive curricular materials outline recommended program structures and provide teaching resources to help volunteer leaders of youth groups (4-H, scouts, community centers, nature centers, etc.) develop constructivist learning environments. Specifically designed for non-school settings, the materials support leaders in channeling young participants' personal engagement in real, nationally recognized citizen science projects, with the ultimate goal of mentoring them as they initiate and carry out their own scientific studies. For example, the curriculum provides scaffolding strategies, such as collecting data alongside adult leaders and working with teammates through a guided investigation, then supporting small group or individual research projects. Specific guidance is provided to help leaders identify authentic settings, such as parks and nature centers with woodlands and fields rich for investigation. Throughout the program, youth participants work closely with team members, adult leaders, and professional mentors as they carry out independent investigations.

Table 1.

Description of D2D Program Guiding Principles and Strategies That Address Grabinger and Dunlap's (1995) REAL attributes, and Characteristics of Constructivist Learning

Characteristics of Constructivist Learning	REAL Environment Attributes	D2D Program Principles & Strategies
Active knowledge construction and evolution	**1. Student responsibility and initiative in learning** through activities that initiate high-order thinking, reflection, action, and transfer of knowledge	**Principle:** Scientific investigations emerge from personal observations and questions. **Strategies:** Youth draw on their experience with the citizen science programs to instigate and carry out scientific investigations; document science thinking using reflection tools; and take responsibility for data accuracy by checking each others' work.
	2. Generative learning strategies that involve processes like argumentation and cognitive apprenticeship	**Principle:** Science practice develops through experience, trial and error, and mentorship. **Strategies:** Youth start the program by participating in collecting and inputting accurate citizen scientific data with team members. Youth co-create and complete an example investigation under the guidance adult mentors. Later, they design and rationalize for peers and adult leaders their own scientific investigation, while also arguing the merits of projects conducted by their peers. Mentors continuously encourage youth to assess their decisions to encourage clarity of thinking and high quality investigation design. Supplemental

		learning exercises foster science skills such as observing, predicting, and explaining.
Indexed knowledge acquisition	**3. Authentic learning contexts** that anchor learning in situations resembling real-world application	**Principle:** Scientific investigations are sparked by immersion and structured observation in authentic settings. **Strategies:** Research teams meet in authentic natural settings, collect and input data for nationally recognized citizen science projects and conduct research on actual phenomena. Contributed citizen science data are used by youth and professional scientists to understand real world conditions and issues.
	4. Authentic assessments that measure performance in realistic situations	**Principle:** Science practices are assessed through real research projects and feedback from peers and mentors. **Strategies:** Science investigations serve as capstone projects through which youth demonstrate knowledge and skills gained when doing citizen science. Youth are invited to create and present a poster summary of their investigations to be presented through an interview process conducted by mixed groups of peers and professional scientists. Many youth also choose to enter their studies in school science fairs and county/state fairs, and often give presentations on their projects in community settings.
Collaboration and social negotiation of meaning	**5. Co-operative support** that involve team- and problem-based learning	**Principle:** Science knowledge and skills are refined and improved through interaction and collaboration with peers. **Strategies:** Youth and adult leaders work together to accurately collect and input citizen science data. Youth participate in activities to document and expand on individual observations; co-create a safe, supportive community of learners by reflecting on their experiences together; participate in research roundtables to share observations and questions, generate and refine investigation design ideas, support analysis, and address challenges of collecting and managing data in dynamic natural conditions. Adult leaders often connect youth with professional scientists to guide their science practices.

Four years into the 5-year project, evaluation results are positive, suggesting promise for REAL citizen science-based STEM learning in Extension. Participant numbers have doubled from the first to the third year—increasing from 76 youth to 157 youth. In the third year, almost 25% of youth were returning for the second or third time. Seventy-four percent of youth reported enjoying the program "a lot" (the highest ranking), and 72% of youth were interested in participating again. Participants reported improved science and inquiry skills. For example, on a post-assessment youth were asked on a variety of questions to rate their science (i.e., "identifying bird or butterfly larvae (eggs) or pond organisms") and inquiry skills (i.e., "Developing testable hypotheses") before and after the program on a five-point scale. Results show that youth report statistically significant better skills after the program (for each question, $p<0.01$, and the means increase between 0.7 and 1.0). In addition, youth are meaningfully extending their knowledge into their communities. For example, one research team wrote a letter to the editor of their local newspaper to educate the public about the danger for butterflies of spraying forest tent caterpillars. Youth are also building positive science identities. In the words of one adult leader: "At another point as we walked [YOUTH] remarked that 'maybe when we grow up we can be scientists.' Her Mom happily laughed and agreed whole-heartedly."

Implications for Extension

In conclusion, the REAL framework (Grabinger & Dunlap, 1995) is one useful guide to assess potential for learning environments, in which Extension can support a next-generation STEM workforce. D2D exemplifies how citizen science-based REALs can promote meaningful learning. The focus on existing citizen science projects that use participant data to better understand and conserve species, and the focus on individual research, mean that participants are engaged in authentic research at multiple levels. This authentic research is deliberately conducted in the context of social settings that are both appropriate for the developmental stages of the youth participants and mimic the social context in which science is often conducted. Participants enjoy and learn from the experience and enact meaningful change in their communities and personal identities.

References

Bell, P.B., Lewenstein, Shouse, A. W., & Feder, M. A. (2009). *Learning science in informal environments: People, places, and pursuits.* Washington D.C.: The National Academies Press.

Blair, R. B., Meyer, N., Rager, A. B., Ostlie, K., Montgomery, K. L., & Carlson, S. (2004). Best practices for environmental field days: Structuring your event for fun and learning. *Journal of Extension* [On-line], 42(5) Article 5TOT4. Available at: http://www.joe.org/joe/2004october/tt4.php

Bordeau, V. D. (2004). 4-H experiential education—A model for 4-H science as inquiry. *Journal of Extension* [On-line], 42(5). Article 5TOT3. Available at: http://www.joe.org/joe/2004october/tt3.php

Brossard, D., Lewenstein, B., & Bonney, R. (2005). Scientific knowledge and attitude change: The impact of a citizen science project. *International Journal of Science Education*, 27, 1099–1121.

Clarke, K. C. (2010). A science, engineering and technology (SET) approach improves science process skills in 4-H animal science participants. *Journal of Extension* [On-line], 48(1) Article 1IAW3. Available at: http://www.joe.org/joe/2010february/iw3.php

DePriest T., & Krasny, M. (2004). Engaging county educators in science education reform: The New York 4-H environmental inquiry program. *Journal of Extension* [On-line], 42(2). Article 2RIB4. Available at: http://www.joe.org/joe/2004april/rb4.php.

Falk, J.H., & Dierking, L.D. (2010). The 95% Solution: School is not where most Americans learn most of their science. *American Scientist*, 98, 486–493.

Ferry, B. (1995). Enhancing environmental experiences through effective partnership among teacher educators, field study centers and schools. *Journal of Experiential Education*, 18, 133-137.

Grabinger, R., & Dunlap, J. (1995). Rich environments for active learning: A definition. Association for *Learning Technology Journal* (ALT-J), 3(2), 5-34.

Hanushek, E. A., Peterson, P. E., & Woessmann, L. (2012). *Achievement growth: International and U.S. state trends in student performance.* PEPG Report No. 12-03. Cambridge, MA: Harvard's Program on Education Policy & Governance.

Heck, K. E., Carlos, R. M., Barnett, C., & Smith, M. H. (2012). 4-H participation and science interest in youth. *Journal of Extension* [On-line], 50(2). Article 2FEA5. Available at: http://www.joe.org/joe/2012april/a5.php

Konen, J., & Horton, R.L. (2000). Beneficial science teacher training. *Journal of Extension* [On-line], 38(2). Article 2RIB1. Available at: http://www.joe.org/joe/2000april/rb1.php

Kolb, D.A. (1984). *Experiential learning: Experience as the source of learning and development.* Englewood Cliffs, NJ: Prentice Hall, Inc.

Kountoupes, D., & Oberhauser, K.S. (2008). Citizen science and youth audiences: Educational outcomes of the Monarch Larva Monitoring Project. *Journal of Community Engagement and Scholarship*, 1(1), 10-20.

Kraft, G. (1999). Education reform as public policy: A role for Extension. *Journal of Extension* [On-line], 37(3). Article 3COM1. Available at: http://www.joe.org/joe/1999june/comm1.html.

Larson Nippolt, P. (2012). 4-H science: Evaluating across sites to critically examine training of adult facilitators. *Journal of Youth Development*, 7(4), 5-24. Article 120704FA001. Retrieved from: http://nae4a.memberclicks.net/assets/documents/jyd_0704final.pdf

Meyer, R. L., Bevan, B., & Garza, P. (2010). *Museums afterschool: Principles, data, and design.* Poster presented at University of Minnesota Extension Fall Program Conference. St Paul: Regents of the University of Minnesota.

National Research Council. (2000). *Inquiry and the National Science Education Standards: A guide for teaching and learning.* Washington, DC: National Academy Press.

Rothwell, J. (2013). *The hidden STEM economy.* Metropolitan Policy Program at Brookings. Washington D.C.: Brookings Institution.

Skelton, P., Seevers, B., Dormody, T., & Hodnett, F. (2012). A conceptual process model for improving youth science comprehension. *Journal of Extension* [On-line], 50(3). Article 3IAW1. Available at: http://www.joe.org/joe/2012june/iw1.php

Smith, M. H. (2008). Volunteer development in 4-H: Constructivist considerations to improve youth science literacy in urban areas. *Journal of Extension* [On-line], 46(4). Article 4IAW2. Available at: http://www.joe.org/joe/2008august/iw2.php

Smith, M. H., Meehan C. L., Enfield, R. P., George, J. L., & Young, J. C. (2004). Improving county-based science programs: Bringing out the science teacher in your volunteer leaders. *Journal of Extension* [On-line], 42(6). Article 6FEA5. Available at: http://www.joe.org/joe/2004december/a5.php

Stevenson, A. (2013). I wonder... I wonder boards serve as a springboard for scientific investigations. *Science and Children*, 50(6), 74-79.

Trumbull, D. J., Bonney, R., Bascom, D., & Cabral, A. (2000). Thinking scientifically during participation in a citizen-science project. *Science Education*, 84, 265-275.

Worker, S. M. (2013). Embracing scientific and engineering practices in 4-H. *Journal of Extension* [On-line], 51(3). Article 3IAW3. Available at: http://www.joe.org/joe/2013june/iw3.php

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