ASEE'S VIRTUAL CONFERENCE
At Home with Engineering Education
JUNE 22 - 26, 2020 #ASEEVC
Paper ID #31625

Work in Progress: An Exploratory Study of the Sustainability Mindset through a Citizen Science Project in a Vulnerable Latinx Community

Dr. Azadeh Bolhari P.E., Angelo State University

Dr. Bolhari is currently an Assistant Professor of Environmental Engineering at Angelo State University. Dr. Bolhari holds her PhD from Colorado State in Environmental Engineering. Her research interests include: sustainability mindset, resilient communities, citizen science, engineering identity, and retention of minorities in engineering.

Dr. Daniel Ivan Castaneda, James Madison University

Daniel I. Castaneda is an Assistant Professor at the Department of Engineering at James Madison University.

Daniel earned his PhD in 2016 and his Master's in 2010, both in civil engineering from the University of Illinois at Urbana-Champaign. He previously earned his Bachelor's in 2008 from the University of California, Berkeley. After graduating from Berkeley, Daniel worked as a Systems Analyst at ATAC Corporation – a Federal Aviation Administration subcontractor specializing in analytical software solutions – before enrolling at Illinois.

Daniel has research interests in alternative cements and concrete, fast-setting repair materials, freeze-thaw durability of concrete, instrumentation of infrastructure, residual stress modeling, rheology, and quantitative image analysis. He has taught a variety of courses including civil engineering materials, dynamics, engineering design, engineering economics, matrix analysis, mechanics, probability and risk in engineering, statics, and structural analysis.

Dr. Kenneth Stewart, Angelo State Univesity, Retired

Dr. Kenneth L. Stewart is retired professor of sociology at Angelo State University where he served on the faculty from 1975 through 2018. He was also among the founding faculty members of the Master of Public Health Degree at Texas Tech University Health Sciences Center.

Dr. Stewart's scholarly work has a distinctively interdisciplinary flavor overlapping the fields of sociology, history, political science, public health, and engineering. He is author or co-author of three scholarly books and two edited volumes. Sixteen of his scholarly articles have been published in refereed journals or as book chapters. He has delivered professional presentations in venues including the Cancer Prevention Research Institute of Texas, the Crossroads Conference on Rural Health, Texas State Historical Association, American Sociological Association, and the Oxford Round Table at England's Oxford University.

As director of Community Development Initiatives at ASU, Dr. Stewart implemented numerous community research, program evaluation, and community organizing projects. He continues to be an advocate for the vulnerable members of communities in West Texas.

Work in Progress:
An Exploratory Study of the Sustainability Mindset through a Citizen Science Project in a Vulnerable Latinx Community

Abstract

An initial exploratory study examined basic parameters of the sustainability mindset in an historically underrepresented group within engineering. An NSF water quality engineering research project engaged citizen scientists from vulnerable Latinx families in design, construction, and use of acrylic concrete structures for rainwater harvesting. During the start, middle, and end of the project, participants were asked to share their perceptions of sustainability through a series of exploratory focus groups questions: "How do you feel about droughts in the region; can you please tell me what you know about drought-resiliency; do you know ways a person might be able to conserve water during a drought; can you please tell me what you know about water quality testing?" Three coders (an environmental engineer, a civil engineer, and a sociologist) conducted a domain analysis of the focus group to determine emergent themes reflecting the sustainability mindset of the citizen scientists. Preliminary results show that between the onset and conclusion of the rainwater harvesting project, participants increasingly articulated their thoughts on sustainability in a future-oriented context requiring collective action in a broader, community sense. The preliminary findings have implications for sustainability-focused engineering outreach and crowdsourcing efforts.

Introduction & Background

A community's desired goals and future state are essential components in creating a shared vision. Such futuristic thinking by a community assists engineers in developing a sustainable design. To begin, a definition of the term 'sustainable community' is needed to identify the engineering skills needed to create them.

The Egan Review defines Sustainable Communities as "...[*meeting*] *the diverse needs of existing and future residents, their children and other users,* [*contributing*] *to a high quality of life and* [*providing*] *opportunity and choice. They achieve this in ways that make effective use of natural resources, enhance the environment, promote social cohesion and inclusion and strengthen economic prosperity*" [1]. Further, this framework describes 7 main components of sustainable communities as: 1) governance, 2) social & cultural, 3) housing & the built environment, 4) economy, 5) environmental, 6) services, and 7) transport & connectivity. In sum, the Egan Review is a visionary statement which brings together the time frames of sustainability by applying two types of vision: 1) the ability to see things clearly in the present and 2) the ability to envision a better future [2]. This future-oriented vision serves as the foundation of our research.

Engineers are one of the core occupations engaged in developing sustainable communities, mostly in their role of creating practical solutions that enable communities to thrive. Nevertheless, research in the mid-2000s identified a need to address inadequacies in the technical and generic skills of engineers needed to deliver sustainable communities. Generic engineering competencies in this context are defined as attributes, competencies, or skills that are important to graduates across all engineering disciplines. Communication and social skills are examples [3-4], but more broadly, the identified inadequacies represent gaps in project management and leadership skills needed to create and get buy-in for a community vision [5].

Our work-in-progress explores how engineers develop awareness of community's sustainability interests, and how they can help communities implement a sustainability mindset. Our starting point is to adopt the Egan Review as the framework used to categorize the sustainability mindset of the citizen scientist participants in a rainwater harvesting project conducted in a semi-arid region in the southwest United States supported by an NSF-EAGER grant [6]. The analysis focuses on present, self-oriented themes versus future, community-oriented themes in the mindsets of the citizen scientists.

We also focus on the development of futuristic 'sustainable community' views as the mindsets of citizen scientists changed during the rainwater harvesting project. 'Having a futuristic viewpoint' is used as an indicator of citizen scientists developing a more resilient sustainability mindset through participation in a community-based engineering project.

Context of the Study

The rainwater harvesting project used an exploratory qualitative research [7-8] approach to examine the sustainability mindset among citizen scientist participants. Exploratory qualitative research is usually focused on the local rather than the general [7,9]. Nevertheless, such exploratory research is useful to investigate human behavior without known parameters. Though not generalizable, knowledge gained about the parameters of a problem through exploratory research might later justify a quantitative study [7,9]. Exploratory research can be especially for analyzing ethnographic data expanding our understanding of cultural perspectives by describing the parameters of customs and ways of life [10].

Data generated by exploratory qualitative research is difficult to present to researchers who are more comfortable with quantitative data and large sample sizes [9], while in the field of engineering education this line of research is well justified. Still, some examples of exploratory research justifying its use in the field of engineering education include a study of Latinx social change in engineering with 15 participants [11], a service-learning project in Bolivia with 5 participants [12], and a study of faculty beliefs about entrepreneurship and design education with 26 participants [13].

Our study recruited five low-income Latinx families (nine total participants) from various community organizations and events to participate in this project, as citizen scientists (see Table 3). Recruiting focused on low-income, Latinx families because they represent a vulnerable population that does not often participate in citizen science projects. The families completed initial screening interviews to establish a baseline of their perceptions of drought, drought-resiliency, water conservation and water quality testing. The project required a commitment of approximately six months to construct an acrylic concrete rainwater harvesting tank at our engineering laboratory, adopt it for home use, document water usage, and collect rainwater samples for quality testing. The tanks were built with a metal frame covered with a commercially available fiberglass screen and coated with an acrylic concrete mixture which consisted of

Portland cement, acrylic paint, and siliceous sand (see Figure 1). Five families initiated this process. One family completed all project-related tasks (Household 4), and another family exited the project and opted to finish constructing the tank at home and then participate in an exit interview. The three other families exited the project at different stages and did not participate in an exit interview.

Table 1- Demographic Traits of Participating Households

Household Number	**1**	**2**	**3**	**4**	**5**
Age of householder	35	72	27	42	25
Gender of householder	F	M	F	F	F
Race/ethnicity	Black or African American	Latinx	Latinx	Latinx	Latinx
Education of householder	High School	Primary	High School	High School	Master's Degree
Primary language at home	English	Spanish	Spanish	Spanish	English
Child participants	1	2	0	1	0
Age of children	11	10, 8	N/A	16	n/a
Project completion	N	Y	N	Y	N

Figure 1- Building the acrylic concrete rainwater harvesting tank at the construction workshop phase of the project.

Data Sources

Data sources for this research include interviews with participants and field notes. The research team interviewed participants as the project progressed. Sessions included an entrance interview, focus groups after the construction and water workshops, and an exit interview. Interviews lasted between 45-90 minutes and were audio recorded. Citizen science participants talked about their rainwater harvesting designs, challenges, constraints, and potential solutions to solve problems. The data collected during these interviews highlighted how the citizen scientists engaged in critical analysis of their rainwater harvesting designs with their cultural contexts.

Data Analysis

All audio recordings were transcribed and coded by the research team consisting of a sociologist, a civil engineer, and an environmental engineer. The analysts used a domain analysis approach [14]. Predefined codes obtained from the literature review served as the basis for initial data analysis, but addition rounds included new codes based on Saldaña, 2013 [15]; Mejia *et al.,* 2017 [11]; Grubbs *et al.,* 2018 [16]; and Hsiao, 2019 [17]. The final round of coding included eight "Sustainability Mindset" domains: 1) Financial feasibility, 2) Social impacts, 3) Environmental impacts, 4) Resiliency, 5) Empathy, 6) Inclusion and diversity, 7) Indigenous worldview, 8) Other ethical considerations. Also, in the final coding round, the responses of the citizen scientist participants were classified as present-self-oriented, or future-community-oriented in accordance to the Egan Review.

Findings and Discussion

The initial coding data of this work-in-progress paper as of yet, are listed in Table 2. The word "artifact" is used to quantify the number of verbal exchanges expressing a sustainability mindset that were generated by the participants during interviews or focus groups. Citizen science participants from households 2 and 4 generated a total sub-sample of 19 artifacts across the entry interviews (green shaded cells), interim focus groups (yellow shaded cells), and exit interviews (blue shaded cells).

Table 2- Artifacts reflecting sustainability mindset categorized by present or future orientation.

Location of Artifacts	Artifacts	Household	Present	Future
Two Entry Interviews	4	Household 2	1	0
		Household 4	0	1
Four Interim Interviews or Focus Groups	2	Household 2	0	2
	10	Household 4	7	3
Two Exit Interviews	5	Household 2	0	0
		Household 4	1	4
Total artifacts	19		9	10

It is important to emphasize that the data illustrated in Table *2* is only a partial subset of the dataset. Additional artifacts from the rainwater harvesting project remain to be coded. The aim is to explore the basic parameter of present- versus future-oriented sustainability mindset expressions to establish a foundation elaborating additional parameters in additional research. The sub-sample of artifacts from households 2 and 4 were selected for preliminary analysis because the citizen scientists from these households provided feedback to the research team at the beginning, interim, and ending stages of the rainwater engineering project.

During the exit interviews, citizen scientists from Household 4 generated five artifacts about sustainability mindset. Four of them were future-oriented and all were generated by the adult participant from Household 4 (Table 2). This citizen scientist provided an example of a future-oriented sustainability mindset in response to a question about the force behind the household's recycling/reuse efforts:

> "For us I think we've read the consequences about if we don't take care of this now, their children or their grandchildren may not have what we have now, so that's just- … Generations, ah huh. And that's the only reason why we recycle you know, we used to, back when the City didn't have that, we used to have this big container of trash, and [person] would always tell me so many things we could recycle, but it's still going to go to the trash. So now they pass every two weeks and we have a lot of recycle, and our trash can, every week is maybe a third. Or just half. Little things like that."

In this artifact, actions target the future as the adult citizen scientist teaches the child ways of being more resourceful, thus passing down knowledge of sustainability intergenerationally [1,17].

In response to a question about the mechanism that the me household utilized to collect the rainwater for this project, the same adult citizen scientist responded:

> "Mh hmm. And the gutter we had, it was interesting because we didn't even have to buy it, the gutter we had by the doors in the garage, they weren't being used, so my husband said to my oldest son, why don't you move it up? and then you can use it for that. Cause there's no use for it in the back. Who cares if the cars get wet or whatever, so. Then it ended up [in the front], and it fits, not perfectly, but it fit-."

This artifact again articulates a future-oriented sustainability mindset by targeting the action of utilizing an underused gutter in the backyard for future collection of rainwater in the front yard harvesting tanks to meet household irrigation needs. The resourceful action leads to future water conservation [1,17].

Participants from Household 2 generated two artifacts about sustainability mindset during the focus group after construction of their rainwater harvesting tank (Table 2). One artifact was generated by the adult household participant and the other was offered by a child. The artifact generated by the child was a response to a question about what she learns while helping her father with projects. She responds to her father:

> "You help me with this, what I can do … you help me, well you don't help me. Rather you show me sometimes when the car leaks, well I watch how you do it, you help me ..."

This artifact expresses a value of self-sufficiency that the father passes on to the children so that they can invent or build things. In this household, making "inventions" together came up several times throughout the interviews. "Inventions" appear to be used by household members to convey a habitual sense of self-sufficiency. The father seems to use the "inventions" notion to set a foundation for developing resilient children. The artifact is future-oriented because its focus is on developing resilient individuals for the future [1,17]. The artifact is also an example of an individualistic focus rather than future-oriented community resilience [18-21].

In the entry interviews and interim focus groups, responses from Household 4 members were more reflective, a feature which may have influenced their mindset to be more future-oriented toward the end of the project [22]. The recursive habit observed in Household 4 illustrated the ability to connect reflections on action - retrospective reflection - to reflection for action - prospective reflection. According to Urzúa & Vásquez [22], such a recursive habit assists an individual to adapt more quickly than an individual who adopts a routine to undertake without reflection as observed in Household 2. Throughout the life of the project, father in Household 2 was the leader while the children competed for his approval or attention. This household decided that they did not need to attend the water workshop and to continue their water collection without guidance from the research team.

The future direction of our research in progress includes completing the data analysis for a more in-depth analysis of the application of the Egan Framework to our case to help understand the limits of this framework. The effort will assist us to redefine and adapt the assessment criteria through citizens' engagement [23]. Summaries of the Egan Framework's 7 main components of sustainable communities are listed in Table 3 and serve as the common goal for sustainable communities [1]. To measure the success of sustainability in communities through the Egan Framework, fifty sustainability indicators were developed for these seven components. For instance, under the Social & Cultural component, a sustainability indicator is 'percentage of respondents surveyed who feel they belong to the community.'

Table 3- The Egan Framework components of sustainable communities [1]

Component	Explanation
1. Governance	Effective and inclusive participation, representation and leadership
2. Social & Cultural	Vibrant, harmonious and inclusive communities
3. Housing & the Built Environment	A quality built and natural environment
4. Economy	A flourishing and diverse local economy
5. Environmental	Providing places for people to live in an environmentally friendly way
6. Services	A full range of appropriate, accessible public, private, community and voluntary services
7. Transport & Connectivity	Good transport services and communication linking people to jobs, schools, health and other services

Concluding Remarks and Final Observations

Qualitative studies that are open and exploratory can act as a catalyst for change to participants who can see the outcomes in a context that applies to them [9]. We did not intentionally elicit sustainability thinking in our original study. Yet, we observed its articulation by the participants. At the onset and conclusion of the citizen science project, participants articulated more of their thoughts on sustainability in a future-oriented context; with an understanding of why their actions had to be undertaken from a broader, community sense.

In engineering education, many students undertake curricular interventions in various forms. Based on our preliminary findings, we posit that reflective exercises before, during, and after a subset of those interventions can help students to draw out their thinking toward sustainability [22].

An example of a curricular change to foster a sustainability mindset is a first year "Sustainability Design in Engineering" course with a series of hands-on activities (e.g. materials life cycle assessment) are undertaken to foster a sustainability mindset in students [17]. Several reports and research suggest interventions incorporating cross-disciplinary learning from community-based organizations to bring direct experience from the field and to implement them in engineering design courses [24-25].

We propose that at least two types of measurements should be considered to judge the efficacy of any curricular effort in its ability to influence a student's sustainability mindset: a pre- and post-measurements to elicit students' future-oriented sustainability mindset by probing of what students think sustainability is and why it should be considered in engineering design. Also, an interim measurement should elicit students' present-oriented sustainability mindsets by probing what sustainability measures students think are best for accomplishing a particular engineering objective.

Acknowledgments

This study was funded by the National Science Foundation Award # 1744006. The authors are grateful to the help provided by the following research students at Angelo State University: Jesse Lee, Maria Ochoa, Austin Poole, Nicholas Manrique and Timmons (TJ) Spies.

References

[1] ODPM, 2004. The Egan Review: skills for sustainable communities. London: Office of the Deputy Prime Minister.

[2] AlWaer, H., R. Bickerton, and R. D. Kirk. 2014. Examining the Components Required for Assessing the Sustainability of Communities in the UK. *J Archit Plann Res.* 31 (1): 1–26.

[3] Male, S. A. 2010. Generic Engineering Competencies: A Review and Modelling Approach. *Education Research and Perspectives, 37*(1), 25-51.

[4] Ritchie, H., Sheppard, A., Croft, N., Peel, D. 2017. Planning education: exchanging approaches to teaching practice-based skills, Innovations in Education and Teaching International, 54:1, 3-11.

[5] Academy for Sustainable Communities. 2007. Mind the skills gap: The skills we need for sustainable communities. Leeds: ASC.

[6] NSF-EAGER - Early-Concept Grants for Exploratory Research. (2017). Developing Drought-Resilient Communities by Utilizing Acrylic Concrete Structures for Rainwater Harvesting. (NSF Award Number 1744006).

[7] Creswell, J. W. 2012. *Qualitative inquiry and research design: Choosing from among five approaches* (3rd ed.). Thousand Oaks, CA: Sage.

[8] Reeves, S., Peller, J., Goldman, J., Kitto. S. (2013) Ethnography in qualitative educational research: AMEE Guide No. 80, Medical Teacher, 35:8, e1365-e1379, DOI: 10.3109/0142159X.2013.804977

[9] Kelly, K., Bowe, B. 2011. *Qualitative research in engineering education: Proceedings of the 118th ASEE Annual Conference and Exposition,* Vancouver, Canada, June 26–29.

[10] Tedlock, B. 2000. Ethnography and ethnographic representation. In N.K. Denzin & Y. W. Lincoln (Eds.), *Handbook of Qualitative Research* (pp. 455-486). Thousand Oaks, CA: Sage.

[11] Mejia, J.A., Wilsom-Lopez, A., Eobledo, A., Revelo, R.A. (2017). Nepantleros and Nepantleras: How Latinx Adolescents Participate in Social Change in Engineering. In Proceedings of the ASEE Annual Conference and Exposition, Columbus, Ohio, 25-28 June 2017.

[12] Jeffers, A.E., Beata, P.A., Strassmann, B. I. (2014). *A Qualitative Study to Assess the Learning Outcomes of a Civil Engineering Service-Learning Project in Bolivia.* Paper presented at American Society of Engineering Education. Indianapolis, Indiana. https://peer.asee.org/19986

[13] Hochstedt, K., Zappe, S. E., Kisenwether, E., & Shartrand, A. 2010. A qualitative examination of faculty beliefs related to entrepreneurship education. Paper presented at the annual meeting of the American Society of Engineering Education. Louisville, KY.

[14] Spradley, J.P. 1979. *The ethnographic interview*. Fort Worth, TX: Holt, Rinehart and Winston.

[15] Saldaña, J. (2013). *The coding manual for qualitative researchers* (2nd ed.). Thousand Oaks, CA: Sage.

[16] Grubbs, M., Strimel, G., & Huffman, T. (2018). Engineering Education: A Clear Content Base for Standards. Technology and Engineering Teacher, 77(7), 32-38.

[17] Hsiao, A. 2019. Sustainability in Engineering Design. Canadian Engineering Education Association (CEEA- ACEG19) Conference. DOI: https://doi.org/10.24908/pceea.vi0.13877.

[18] Davidson, D.J. (2010). The applicability of the concept of resilience to social systems: Some sources of optimism and nagging doubts. *Society & Natural Resources, 23*, 1135–1149. doi:10.1080/08941921003652940

[19] Steiner, A., & Markantoni, M. (2014). Unpacking community resilience through Capacity for Change. *Community Development Journal, 49*, 407–425. doi:10.1093/cdj/bst042

[20] Turcu, C. (2013) Re-thinking sustainability indicators: local perspectives of urban sustainability, Journal of Environmental Planning and Management, 56:5, 695-719, DOI: 10.1080/09640568.2012.698984

[21] Vaneeckhaute, L.E., Vanwing, T., Jacquet, W., Abelshausen, B., Meurs, P. (2017) Community resilience 2.0: Toward a comprehensive conception of community-level resilience, Community Development, 48:5, 735-751, DOI: 10.1080/15575330.2017.1369443

[22] Urzúa, A., & Vásquez, C. (2008). Reflection and professional identity in teachers' future-oriented discourse. *Teaching and Teacher Education, 24,* 1935–1946

[23] Berardi, U. 2013. Sustainability assessment of urban communities through rating systems. *Environ Dev Sustain*. 15: 1573-1591. DOI: 10.1007/s10668-013-9462-0

[24] Urban Task Force. 1999. Towards an Urban Renaissance. Spon: London.

[25] Bagwell, S. 2007. Skills needs for regeneration professionals. *Journal of Urban Regeneration & Renewal*. 1(2), 191-204.