



Motives for Citizen Science Program Participation and the Role of the Organization: Lessons from Water Quality Monitors in Texas

RESEARCH PAPER

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ABSTRACT

Citizen science (CS) programs often question what motivates their volunteers and how volunteer participation can be sustained. Using a case study of citizen scientist volunteers (CSVs) who monitor water quality in Texas, I apply here a novel approach—the Dispositional-Organizational Interactions Framework (DOIF)—that provides a nuanced understanding of CSVs. The DOIF allows for consideration of how dispositional variables, such as sociodemographic characteristics and motivations for participation, may relate to organizational variables (e.g., program efficacy, results, and recognition); both overarching variables relate to indicators of commitment. The purpose of this study is to examine interactions among different aspects of a CS program and CSVs—observations that can improve CSV satisfaction and possibly retention. In a community geography partnership, volunteers of a statewide CS program were surveyed ($n = 327$). Results of exploratory factor analyses and a series of nonparametric tests indicate the DOIF offers insights into five major motivational factors; it uncovers between-group differences in how CSVs value organizational variables and indicate a commitment to volunteerism. This study contributes to the broader literature by incorporating the role of the organization in assessments of motivations through the creation of a novel framework and through empirical findings. The paper considers implications of results for CS programs and practice, then concludes with suggestions for future research.

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INTRODUCTION

Citizen science (CS) is the “participation of the general public or volunteers in research activities such as data collection and analysis” (Herodotou et al. 2020, p. 1). The data collected and/or analyzed by citizen scientist volunteers (CSVs) are invaluable for scientific advancement (Bonney et al. 2014; Domroese and Johnson 2017; Riesch, Potter, and Davies 2013; Ries and Oberhauser 2015). Although CS has increased in popularity and consequently gained momentum recently in the United States (US), the practice has existed since 1900 (Land-Zandstra et al. 2016). Most CS programs are housed at nonprofit organizations; therefore, they may face challenges such as funding and volunteer recruitment and retention (Bloom and Crowder 2020; Alender 2016; Hidayat and Stoecker 2018). CSV recruitment and (sustained) participation are the “forces driving the engine” behind successful CS programs, and while CSV motivations have been examined, an understanding of how motivations are related to and influenced by attributes of an organization is lacking (Larson et al. 2020; Phillips et al. 2019; Johnson et al. 2018; Domroese and Johnson 2017).

To conduct this study, a community geography collaborative research partnership was created to assist a CS nonprofit organization in better identifying and understanding their CSVs (Lopez 2020a; Robinson 2010). The purpose of this study is to survey CSV water quality monitors who work in subgroups in watersheds across the state of Texas to understand how dispositional variables (sociodemographic characteristics and motivations) interact with one another, as well as how they interact with organizational variables. In addition, this article explores how dispositional and organizational variables relate to indicators of commitment that would lead to sustained participation. Toward that end, this study contributes to the broader literature on how dispositional and organizational variables interact to promote or restrict CSV participation and delivers practical information and insights that CS organizations may implement to improve volunteer satisfaction, which is crucial for CSV retention.

BACKGROUND

The data collected by CSVs are known to be valuable for conservation research efforts (Larson et al. 2020) because they are collected on a scale that wouldn't otherwise be possible (e.g., larger data sets, greater spatial coverage) because of the larger number of participants (Davis, Ramirez-Andreotta, and Buxner 2020; Bonney et al. 2014; Domroese and Johnson 2017; Riesch, Potter, and Davies 2013). Further, data are comparable in quality to professional data

collection. For example, in one study, the data collected by CSV water quality monitors, when compared with professional water quality monitoring, had an agreement of 80% for all test parameters (Albus et al. 2020).

Though CS data are highly valuable, CS programs may face challenges such as funding, volunteer recruitment, and sustained participation (Bloom and Crowder 2020; Alender 2016; Conard and Hilchey 2011; Hidayat and Stoecker 2018). These challenges work in a cyclical fashion, meaning funding is necessary to recruit volunteers, and in turn, volunteer participation is necessary to attract funding (Louv and Fitzpatrick 2012). CSV participation can be measured by both quantity (the number of participants and hours/frequency of volunteerism) and quality (volunteer experience that is relevant and meets motivational needs) (Shirk et al. 2012). When motivations are understood and implemented in program and project design, CSVs are more likely to be satisfied with their participation in the program and continue or even expand their roles (Nov, Arazy, and Anderson 2014; Wright et al. 2015; Clary and Snyder 1999; Jacobson, Carlton, and Monroe 2012).

MOTIVATIONS

The many parallels between volunteering and CS participation can advance understanding of CSV motivations (Geoghegan et al. 2016; West and Pateman 2016). This section explores Katz's (1960) seminal functional approach to understanding volunteerism, the subsequent creation of the Volunteer Functions Inventory (VFI), and the progression of motives research alongside relevant environmental volunteerism literature. Finally, I present two models specific to understanding CSVs, as they are the foundation on which this study's conceptual framework positions itself.

The functional approach to understanding volunteering was created initially by Katz (1960) and was later applied by Clary and Snyder (1999). The Approach contains three fundamental assumptions. First, it is a motivational perspective that directs inquiry into the personal and social processes that initiate, direct, and sustain action (Katz 1960). Second, volunteers perform the same actions because of various psychological functions (e.g., different people engage in the same volunteer activity but do so to fulfill different motives). Third, it suggests that important psychological events, such as embarking on a course of volunteer activities and then maintaining those activities over extended periods of time, depend on matching the motivational concerns of individuals with situations—i.e., volunteer opportunities—that can satisfy those concerns (Clary and Snyder 1999).

Research employing the functional approach discovered that volunteers may be motivated by several factors

simultaneously, and that motives may intersect and interact in multifaceted, complex manners (Cnaan and Goldberg-Glen 1991; Clary and Snyder 1999; Yeung 2004; McDougle, Greenspan, and Handy 2011). That is to say, people may volunteer for the same activity for different reasons, and if they feel the activity does not satisfy their motivation (Shirk et al. 2012), they will cease participation (Bruyere and Rappe 2007). Using the functional approach, Clary et al. (1998) developed the Volunteer Functions Inventory (VFI) with six functions:

- (1) Values—acts to express an important value, such as helping the environment.
- (2) Understanding—desires to learn more about a subject or gain skills.
- (3) Enhancement—aims to improve psychologically through volunteering.
- (4) Career—wants to network or gain experience.
- (5) Social—participates to create and strengthen social relationships.
- (6) Protective—uses volunteer activities to reduce negative self-image.

This approach was applied (as well as modified) in several environmental volunteerism studies (Ryan et al. 2001; Martinez and McMullin 2004; Yeung 2004). As such, the VFI is “the most widely used approach for studying and understanding motivations for volunteerism” (Bruyere and Rappe 2007, p. 506). However, Ryan, Kaplan, and Grese (2001) and Bruyere and Rappe (2007) uncovered two additional motivators that were not addressed by the inventory: These are “user” (recreationists who use the spaces and feel the need to help maintain them through volunteerism) and “get outside.” Moreover, Bruyere and Rappe (2007) found the Protective and Enhancement Functions to be only “marginally represented” in their study. As such, a downfall of the VFI is that the functions are not exhaustive and subject to modification.

Because of the apparently evolving nature of the VFI and the fact that motives are often context-specific (Bennett et al. 2018), scholarship on volunteer motives tends to employ a broader approach with the motivational framework of intrinsic and extrinsic motivations, as developed by Finkelstien (2009) (for examples, see Cecere, Mancinelli, and Mazzanti 2014; Moskell, Broussard, and Ferenz 2010; Martinez and McMullin 2004; Measham and Barnett 2008). Intrinsic motivations manifest as action from an underlying ethic, value, or belief that forms one’s identity (Chan et al. 2016; Fernandes and Guiomar 2016; Leopold 1949; Robinson et al. 2012; Maslow 1943). Extrinsic motivators ensure a reward for action; these may be career-oriented, economic, social, or even legal (Bennett et al. 2018).

Intrinsic motivations are often the principal motivator driving CSVs, and these types of motivations are more durable and enduring than extrinsic motivators (Bennett et al. 2018, p. 603; Campbell and Smith 2005). Accordingly, previous studies conclude the intrinsic motivator “helping the environment” is often most frequently selected, and career advancement, which is an extrinsic motivator, to be the least selected (Grese et al. 2001; Bruyere and Rappe 2007; Alender 2016; Cetas and Yasué 2017). In CS, the principal motive varies. CSVs involved in Wright et al.’s (2015) bird atlas project named “contributing to science” as the top motivator, while Crall et al.’s (2013) project investigating invasive species and Domroese and Johnson’s (2017) bee-monitoring assessment found that learning was the strongest motivator for participation. By comparison, Alender (2016) conducted a study of water quality monitors; the top motivator was helping the environment, with scientific contribution ranking fourth. Additional studies report common reasons for participation to be an interest in (1) the project’s topic, (2) science in general, and (3) learning something new (Hobbs and White 2012; de Vries, Land-Zandstra, and Smeets 2019; Jennet et al. 2016; Alender 2016).

Research specifically on CSVs engaged with the two principal motives of intrinsic and extrinsic and found that (1) both motivational factors are important at several stages (West and Pateman 2016; Land-Zandstra et al. 2016; Mueller and Tippins 2011; Rotman et al. 2012), (2) multiple motives can drive participation simultaneously (Larson et al. 2020; Asah and Blahna 2012; Katz 1960), and (3) motivation(s) to participate may change over time (Ryan et al. 2001; Jacobs 2018). Two process models exist to explain CSV motivations and stages of participation.

In the first model, Rotman et al. (2012) applied the four motives for community involvement, developed by Batson, Ahmad, and Tsang (2002), wherein a person is motivated to act owing to one or more of the following: egoism (to increase one’s welfare), altruism (to increase the welfare of one or more individuals), collectivism (to increase the welfare of a group), and principlism (to uphold a moral principle or values).

Rotman et al. (2012) used the four motives to understand CSV involvement throughout a project’s timeframe with feedback from scientists. They determined that egoism—in the form of personal interest and a “thirst for knowledge”—was the most important motivational factor at the initial stages of participation. Without recognition from the scientists or program staff, CSVs were likely to end their participation (Carballo-Cárdenas and Tobi 2016). Alternatively, if recognition and additional training through program support were provided to the CSV, participation would likely continue owing to the extrinsic (reward-based)

nature of the motivation. After sustained involvement, the motivations for participation shift from egoism to collectivism and altruism as a result of the inclusion in community involvement and advocacy, e.g., how the CS data are used and disseminated (Ward-Fear et al. 2020). However, if this level of involvement in the community is not reached, participation is likely to cease (Rotman et al. 2012, p. 224). Hence, CS project participation is an iterative process and should be assessed via inclusion of the (in) actions of the organization.

Accordingly, responding to the various motivational factors at different points of participation can help keep volunteers engaged (Land-Zandstra et al. 2016), and recognition/rewards may be important to certain CSVs for sustained participation (Alender 2016). It is important to note that some CS projects have a specific start and end date, with perhaps one or more time periods wherein data are collected. Alternatively, other projects, like the water quality monitoring program in the present study, are ongoing and aim to grow data-collection efforts by attracting new and sustaining current volunteers.

In the second explanatory model, West and Pateman (2016) detail the process with key factors of participation over time in three distinct stages: decision to participate, initial participation in the project, and sustained participation. West and Pateman (2016) expanded and modified Penner's (2002) basic model on volunteering with two key variables—dispositional and organizational—to fit CS participation. Dispositional variables that influence participation are the attributes of an individual, such as motivation, personal circumstances, and sociodemographic characteristics. Organizational variables are the attributes of the organization leading the project, i.e., the program's organization and communication (Geoghegan et al. 2016) and/or the program's reputation, values, and practices (Penner 2002). Accordingly, the organizational variable plays a role in the decisions to participate, to initiate involvement/participation, and to sustain participation.

Applications of such process-modeling and changing motivations over time are few (Geoghegan et al. 2016). Ryan et al. (2001) found that new volunteers tend to be motivated by wanting to help the environment (principlism) and to learn new things (egoism), but that social factors (collectivism/altruism and community involvement) were more important for long-term retention. This is similar to Rotman et al.'s (2012) understanding of the initial motivator to be egoism (wanting to learn to improve the self) and then a shift to collectivism or altruism (wanting to continue to participate for the welfare of the group or others). Likewise, Fisher et al. (2011) and Measham and Barnett (2008) found that social contact and personal ties were key for participation. Volunteers are also more likely

to continue to participate if their motivations are fulfilled and they are satisfied with their role (Welty Peachey et al. 2014; Wu, Li and Khoo 2016; de Vries et al. 2019; Haywood 2016). To that end, CSV motivations tend to play a role in maintaining a strong volunteer base, and motives are linked to organizational attributes. Therefore, there is a need to examine the two in concert (West and Pateman 2016).

CONCEPTUAL FRAMEWORK AND HYPOTHESES

The conceptual framework guiding this study combines key properties from the two process models to form the Dispositional-Organization Interactions Framework (DOIF) (*Figure 1*). The DOIF conceptual model assesses (1) dispositional variable relations, (2) dispositional-organizational interactions, and (3) indicators of commitment with organizational and dispositional variables. Similar to West and Pateman (2016), two overarching variables are present: dispositional and organizational. Dispositional variables include sociodemographic characteristics and motivations, which are then assessed for relationships because sociodemographic characteristics may influence types of motivations, as discussed by Rotman et al. (2012), among others.

At the base of this framework, organizational variables include program efficacy, results, and recognition (*Figure 1*). The DOIF posits organizational variables work iteratively with dispositional variables, namely motivations. Motivations for CSV participation can be met by organizational variables, including a program's efficacy, values, and communication practices. On the one hand, if a CSV is motivated by a desire to help the environment, they will feel their motivational concern is satisfied if the CS program can provide evidence that the data collected are used to address an environmental concern. On the other hand, a CSV motivated by advancing their career may feel satisfaction from receiving organizational recognition in the form of a certificate for training or participation.

The center of the framework reflects the final phase of the three major phases of interaction: sustained participation (West and Pateman 2016) (*Figure 1*). As this study is not a longitudinal study and cannot account for factors (both dispositional and organizational) that affect the decision to participate and initial participation, sustained participation is measured via proxy through Indicators of Commitment. In sum, if CSVs are not satisfied with their desired individual gains, program efficacy, and/or the (lack of) tangible results, and these limitations from the organization affect their motives, they may cease participation. Conversely, CSVs who are motivated by a desire to learn new skills may be

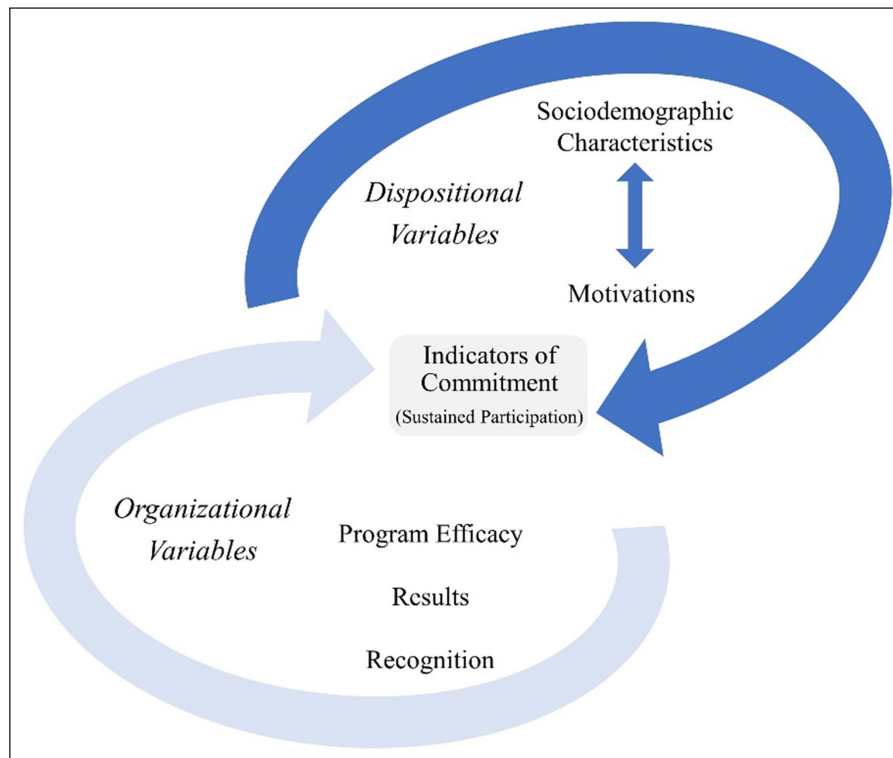


Figure 1 The Dispositional-Organizational Interactions Framework (DOIF), which demonstrates how dispositional variables, such as sociodemographic characteristics and motivations, are related to and may influence organizational variables, e.g., program efficacy, results, and recognition. These interactions may affect indicators of commitment, or sustained participation in CS programs.

enticed to continue and sustain participation if the program offers additional training and opportunities to grow. To that end, this study applies the DOIF to identify interactions and general patterns by testing the following hypotheses:

- Hypothesis 1 (H1): differences exist among sociodemographic characteristics and motivations to participate (dispositional variables).
- Hypothesis 2 (H2): differences in motivations will reflect in the organizational variables valued.
- Hypothesis 3 (H3): indicators of commitment will differ based on motivations (dispositional variables).
- Hypothesis 4 (H4): indicators of commitment will differ based on valued organizational variables.

DATA AND METHODS

In spring 2019, I developed a survey with a large CS nonprofit organization in a community geography partnership (see Lopez 2020a). Community geography is a form of participatory action research (PAR) (Davis et al. 2020; Robinson 2010; Pain 2004) wherein the community partner guides the research questions and objectives.

The organization is referred to as the “community partner” to maintain privacy. The community partner

functions across the state of Texas and has trained more than 10,000 CSVs in water quality monitoring and riparian restoration. The CS program has more than 1,400 testing sites and works with 55 subgroups or partner organizations (Figure 2) that also train CSVs whose data are included in a large dataset maintained by the Texas Commission on Environmental Quality (TCEQ).

The survey focused on understanding the status, preferences, and motivations of citizen scientists. The 30-question, web-based survey was created using the software Qualtrics and was approved by the Institutional Review Board in May 2019 (Project #6440). The survey was created based on previous surveys of CS water quality monitors (e.g., Alender 2016) and was slightly modified to fit community partner-specific needs. The survey contained many previously measured motivational statements like “I want to help or enhance the environment” and “I want to contribute to scientific knowledge,” as well as novel statements developed by the community partner, such as “I want to learn more about water resources.” The survey was structured with closed questions and Likert scales of primarily 5 points (i.e., 5 = strongly agree or extremely likely, 1 = strongly disagree or extremely unlikely). In the spirit of community geography whereby community partners designed survey responses as they deemed appropriate, some questions

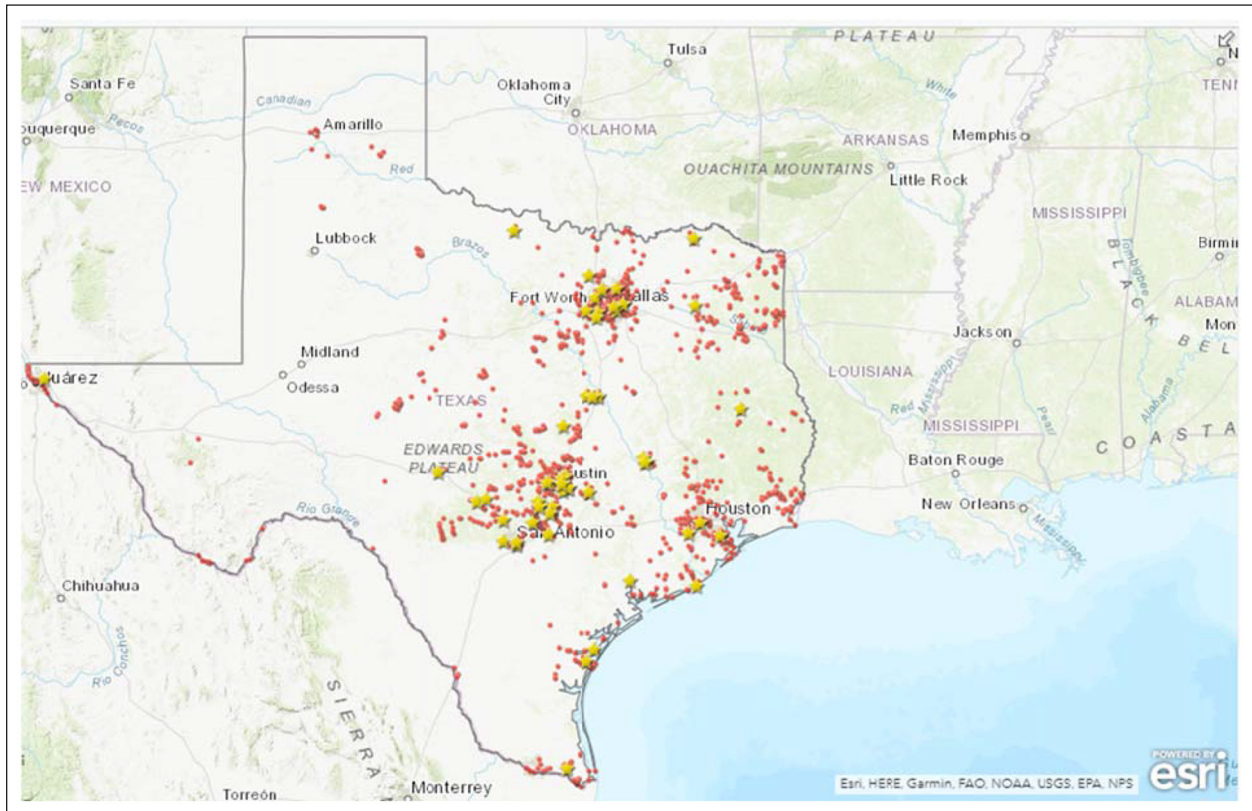


Figure 2 The state of Texas (USA), showing locations of the citizen science volunteer water quality monitoring testing sites (red circles) ($n = 1,459$) and subgroup locations (yellow stars) ($n = 55$).

had 3- or 7-point scales; these are adjusted for analyses as indicated in table notes.

As an incentive to boost participation, respondents were entered to win one of two \$25 Amazon gift cards. The target audience was the ~3,000 volunteers on the community partner's volunteer email distribution lists. An initial email invitation was sent in early summer 2019 with three reminders sent at two-week intervals.

METHODS

All data were cleaned, measurement variables were standardized to a 5-point scale (5 = highest score; 1 = lowest score), and sociodemographic characteristic grouping variables were combined as appropriate (**Table 1**). These data were analyzed in two primary ways in JMP Pro 14, first through exploratory factor analyses (EFA) and then through a series of nonparametric tests. As the motives described in the preceding section are evolving, varied, and context/case-specific, this study needed to account for specific underlying constructs that may have influenced the CSV water quality monitor's motivations. Also, as the organizational variables are broadly defined in the literature and through previous frameworks (i.e., communication, reputation, values,

and practices), I also needed to determine what, if any, underlying factors emerged to form valued organizational attributes. As an EFA attempts to reveal complex patterns by exploring the data (Yong and Pearce 2013; Child 2006), this was the most appropriate method for creating conceptual grouping categories from the motivational (**Table 2**) and organizational (**Table 5**) variables.

The variables were tested for suitability for factorability using the Kaiser-Meyer-Olkin (KMO) Measure of Sampling Adequacy and Bartlett's Test of Sphericity: Dispositional/motivational variables returned a KMO of 0.798 and a Bartlett's Test of $p < 0.0001$, chi-square of 1,467.265 and organizational variables' KMO of 0.681 and Bartlett's of $p < 0.0001$, chi-square of 391.361, which is acceptable (Kaiser 1974).

Following best practices from the literature, a maximum likelihood EFA was conducted on the motive statements from the survey, and five factors were retained based on loadings, cumulation variance, eigenvalues, scree plots, and theoretical reasoning (Conway and Huffut 2003; Fabrigar et al. 1999; Hair et al. 2013). Factors were rotated using both Orthogonal (Varimax) and Oblique (Quartimin, as the recommended Oblique rotation in JMP Pro 14) to assess for multicollinearity issues and provide the most comprehensive approach. Both rotations produced similar

SOCIODEMOGRAPHIC CHARACTERISTICS	CATEGORIES	SURVEY RESPONDENTS (%)²
Gender ¹	Male	39%
	Female	60%
Race/ethnicity ¹	White	85%
	Nonwhite	15%
Age ³	18–24	13%
	25–34	11%
	35–44	16%
	45–54	12%
	55–64	26%
	65–74	20%
	75–84	4%
Education ¹	Some college	15%
	4-year degree	47%
	Doctorate/ professional degree	37%
Household income ¹	Less than \$10,000	8%
	\$10,000–\$29,999	11%
	\$30,000–\$49,999	12%
	\$50,000–\$79,999	28%
	\$80,000 +	42%
Political views ¹	Liberal	58%
	Moderate	16%
	Conservative	26%
Employed in environmental/water-related field	Yes	27%
	No	73%
Employment ¹	Government or public	24%
	Private	16%
	Nongovernment organization or nonprofit	10%
	Self-employed	8%
	Student	13%
	Retired	29%

Table 1 Sociodemographic characteristics of survey respondents.

¹ Categories combined for clarity and statistical analysis owing to low count or lack of information. Gender had “prefer not to say” (n = 3) option that was removed. Race was reduced to white and nonwhite because of low counts in each category, e.g., nonwhite total is 37. Education, high school (n = 2) was removed from analysis. Prefer not to say (n = 46) was removed from household income. Political views had responses of “Do not know” (n = 12) and “prefer not to say” (n = 29) that were removed. Further, answer responses included “slightly liberal/conservative” and “extremely conservative/liberal,” which were reduced to two categories, conservative and liberal. For employment, disabled (n = 1) and other (n = 4) were removed. ² Percentages are rounded and may not add up to 100. ³ Age categories were expanded based on the community partner’s needs to capture college students (18–24) and young professionals (25–34).

loading patterns without any cross-loadings. However, with the Oblique rotation, the statements “I want to spend time with family and friends” and “I want to socialize” did not load above 0.4 on any factor. These two statements had factor loadings of < 0.5 in the original Orthogonal (Varimax) rotation. These two statements were removed, and the EFA was relaunched using Varimax rotation because this was the best fit for the data and provided a sound theoretical interpretation of the factors. In terms of internal reliability, Cronbach’s alpha was 0.85 for the entire set of variables and 0.82 when the two statements of “friends and family” and “socialize” were removed.

The same process was completed for the organizational variables. Similar loading patterns were found as well as no issues of multicollinearity or cross-loading. Three factors were retained, with two statements “I like one-time training events in order to participate” and “I like to complete sequential training activities to increase my level of expertise,” which did not load highly on any factors and were not used in subsequent analyses. Cronbach’s alpha with the entire set was 0.56 and 0.55 with the two removed statements. The final factor loadings, proportional and cumulative variation, eigenvalues, and measures of fit are results of the maximum likelihood EFA with Varimax rotation.

The results of the EFA were then used to create groupings of motivational and organizational factor statements. Category means, or composite scores of the categories, are generally used as the measurement variable for the nonparametric assessments as detailed in result tables.

Second, a series of Mann-Whitney and Kruskal-Wallis nonparametric tests were conducted with categorical and measurement variables as specified in table notes. When nonparametric tests resulted in statistically significant outcomes, pairwise comparisons were made using Dunn’s Method, which corrects for multiple comparisons and provides information regarding which categorical/grouping variable scores are significantly different from one another, i.e., between-group differences.

RESULTS

SAMPLE CHARACTERISTICS

There were 327 complete responses to the survey, with a response rate of 13%. Sociodemographic characteristics indicated that respondents were predominately female (60%), white (85%), affluent (42%), liberal (58%), not employed in the environment/water field (73%), retired (29%), and well educated by having obtained a 4-year degree or higher (84%) (**Table 1**). Similar to previous studies on field-based CS programs (rather than online/virtual), the demographics are mostly white and well educated

	FACTOR 1	FACTOR 2	FACTOR 3	FACTOR 4	FACTOR 5
	SOCIAL EXCHANGE	PERSONAL ENHANCEMENT	VALUES EXPRESSION	CAREER ORIENTED	KNOWLEDGE ATTAINMENT
Share my experience with others	0.784				
Learn from experienced others	0.741				
Interact with like-minded people	0.712				
Meet new people	0.452				
Be physically active		0.795			
Get outside		0.685			
Have fun		0.635			
Help the community			0.814		
Help or enhance the environment			0.687		
Contribute to scientific knowledge			0.547		
Advance career				0.810	
Enhance my reputation				0.757	
Learn new skills					0.819
Learn more about water resources					0.644
Eigenvalues/SS loadings	4.312	2.139	1.589	1.117	1.024
Proportion variation (%)	14.75	13.24	11.42	10.40	9.27
Cumulative variation (%)	14.75	27.99	39.41	49.81	59.07
Measures of fit	AIC	BIC	Root mean square error approximation	Tucker-Lewis Index	
	26.566	-83.815	0.085	0.877	

Table 2 Motivation/dispositional variable factor loadings, eigenvalues, variation, and measures of fit.

AIC = Akaike information criterion; BIC = Bayesian information criterion.

(Herodotou et al. 2020). A major difference in this sample population is gender: Other studies have predominately male respondents (Ganzevoort et al. 2017; Isaacs 2017).

HYPOTHESIS 1: SOCIODEMOGRAPHIC CHARACTERISTICS AND MOTIVATIONS

Results of the EFA recommended five factors that were well defined and retained for further analysis (*Table 2*). The five factors explained almost 60% of the variation, which is considered acceptable (Hair et al. 2013). On the basis of the EFA results, motivational variables were grouped into five categories representing underlying factors or desires driving CSV participation: social exchange, personal enhancement, values expression, career oriented, and knowledge attainment. Theoretically, these five are similar to the VFI (social, values, enhancement, career, and learn), which is notable as they are commonly thought to cover the basic functions of motives to volunteer and are reflected in this study. The social exchange motivational factor contained statements of wanting to share experiences and knowledge,

learn from others with more experience, interact with like-minded people, and meet new people. Overall, this group is motivated by interpersonal interactions, termed here as social exchange.

The factors that loaded highly on personal enhancement were related to wanting to do something physically active, get outside and connect with nature, and have fun. This motivational group is interpreted as participating for personal entertainment, exercise, and enjoyment. The values expression group contains citizen scientists expressing their desire to help the community and environment and to contribute to scientific knowledge. Further, values expression also holds the highest-scored statement: “I want to help or enhance the environment” ($m = 4.84$) (*Table 3*). Next, career oriented consists of the statements: “I want to advance my career...”—which is the lowest-scored statement ($m = 3.02$)—and “I want to enhance my reputation...” and are interpreted as volunteering for career purposes or for professional growth. Lastly, knowledge attainment holds statements of wanting

to learn new skills or gain hands-on knowledge and learn about water resources (Table 3).

The first aim of the DOIF is to assess sociodemographic characteristics and types of motivations. H1 aims to determine what, if any, differences exist among sociodemographic characteristics in the scoring of the five categories for motivation. Evidence supports H1. Table 4 describes results from nonparametric statistics wherein the category mean of the motivation factor category (Table 3) was used as the measurement variable against

the sociodemographic characteristics (grouping variable), as shown in Table 1. Political views (a sociodemographic characteristic) and values expression (a motive) showed no significant differences and are not included in Table 4.

Between-group differences were found with social exchange as well as employment and environmental job. For employment, private and nongovernment organization (NGO)/nonprofit employees scored social exchange items highest (m = 4.00 and 4.10, respectively). Significant between-group differences (p < 0.05) existed among

CATEGORY	“I VOLUNTEER WITH THIS ORGANIZATION BECAUSE...”	MEDIAN	MEAN (SD)	CATEGORY MEAN (SD)
Social exchange	I like sharing my experiences, knowledge, or expertise with others.	4	3.94 (1.19)	3.73 (0.93)
	I like learning from others with more experience.	5	4.19 (1.11)	
	I want to interact with like-minded people.	4	3.70 (1.20)	
	I want to meet new people.	3	3.11 (1.22)	
Personal enhancement	I want to do something physically active.	4	4.12 (1.03)	4.29 (0.75)
	I want to get outside and connect with nature.	5	4.61 (0.69)	
	I want to have fun.	4	4.09 (1.02)	
Values expression	I want to help the community.	5	4.76 (0.56)	4.79 (0.42)
	I want to help or enhance the environment.	5	4.84 (0.48)	
	I want to contribute to scientific knowledge.	5	4.79 (0.52)	
Career oriented	I want to advance my career through gained experience or networking.	3	3.32 (1.43)	3.17 (1.28)
	I want to enhance my reputation in my community.	3	3.02 (1.34)	
Knowledge attainment	I want to learn new skills or gain hands-on knowledge.	5	4.60 (0.65)	4.60 (0.62)
	I want to learn more about water resources.	5	4.60 (0.71)	

Table 3 Descriptive statistics of motivational statements and factors.

SOCIODEMOGRAPHIC CHARACTERISTICS	MOTIVATIONAL FACTORS			
	SOCIAL EXCHANGE	PERSONAL ENHANCEMENT	CAREER ORIENTED	KNOWLEDGE ATTAINMENT
Gender ¹				(5.2919) 0.0214*
Race ¹			(7.6213) 0.0058*	
Employment ²	(21.4577) 0.0007***		(86.5078) <0.0001***	
Environmental job ¹	(4.9017) 0.0269*		(37.2994) <0.0001***	
Age ²		(16.2948) 0.0123*	(82.0756) <0.0001***	
Education ²		(10.9472) 0.0042**	(15.7986) 0.0004***	(10.5791) 0.0050**
Household income ²			(22.7535) 0.0001***	

Table 4 Nonparametric results of sociodemographic characteristics and motivational factors analyses (H1).

¹ Results of Mann-Whitney or ² Kruskal-Wallis tests, dependent on the number of group variables in each test. Motivational factors (category means, see Table 3) are the measurement variable. Test statistics are denoted in parentheses and p-values are below; *, **, and *** denote statistical significance of p < .05, .01, and .001, respectively. Significant results reported only; political views and values expression were not significantly associated with any group or measurement variable and are not included in this table.

student ($m = 3.94$) and retired ($m = 3.33$) groups. Also, the retired group score was significantly different ($p < 0.05$) than government and public ($m = 3.86$), private, and NGO/nonprofit. Additionally, those employed in an environmental job scored social exchange differently than those not employed in the field (“yes,” $m = 3.98$; “no,” $m = 3.64$) (*Table 4*).

Personal enhancement had significant differences in scores for age and education. Significant differences ($p < 0.001$) in between-group scores for age were those 18–24 years of age ($m = 4.68$; highest score) and 65–74 ($m = 4.10$). CSVs with “some education” scored personal enhancement highest ($m = 4.61$) and significantly differently ($p < 0.01$) than those with “doctorate/professional degree” ($m = 4.19$).

Career oriented had significant between-group differences in each sociodemographic characteristic except for gender (*Table 4*). Regarding race, nonwhite CSVs scored this motive higher ($m = 3.76$) than white CSVs ($m = 3.11$). Employment pairwise comparisons revealed multiple between-group differences. Students, while providing the highest score ($m = 4.36$), significantly differed from retired, self-employed, private, and government/public respondents ($p < 0.05$). No difference exists between students and NGO/nonprofit respondents ($m = 4.04$). Further, retired CSVs provided the lowest score ($m = 2.15$), which was also significantly different ($p < 0.01$) from the score of private, government/public, and NGO/nonprofit CSVs (all groups except self-employed [$m = 2.95$]). Related to employment, environmental job values were significantly different between those who reportedly held these jobs (“yes” $m = 4.03$) and who did not (“no” $m = 2.90$). Pairwise comparisons show many significant between-group differences ($p < 0.01$) among the age-group levels. CSVs aged 18–24 scored career oriented highest ($m = 4.32$) and significantly different from the scoring of those 45 and above. Age level 25–34 ($m = 4.12$) was significantly different from age levels 55 and above. Finally, the age level 35–44 ($m = 3.70$) was significantly different from age levels 55 and above. No differences were found in age levels 18–24, 25–34, and 35–44.

The remaining between-group differences for career oriented are in education and household income. Those with “some college” ($m = 3.80$) scored items highest and significantly differently ($p < 0.001$) than those with a “doctorate/professional degree” ($m = 2.84$). CSVs with lower incomes (\$10,000–\$29,000) scored items higher ($m = 4.19$) and significantly differently ($p < 0.01$) than those reporting higher income brackets of \$50,000 to \$79,999 ($m = 3.08$) and \$80,000 or more ($m = 2.96$).

The motive knowledge attainment had significant between-group differences with gender (women scored

higher [$m = 4.67$] than men [$m = 4.48$]) and education (*Table 4*). Those with “some college” scored highest with a mean of 4.67, which was significantly different ($p < 0.01$) from “doctorate/professional degree” ($m = 4.44$).

To summarize, motivational factors showed many between-group differences as hypothesized. Social exchange was scored differently by employment type and environmental job. Personal enhancement was scored differently by age and education levels. Career oriented had between-group differences with each sociodemographic characteristic except gender. Finally, knowledge attainment was scored differently by groups in gender and education. Values expression did not have any between-group differences, which is noteworthy and will be explored in the discussion section.

HYPOTHESIS 2: ORGANIZATIONAL VARIABLES AND MOTIVATIONS

The remaining overarching variable in the DOIF relates to attributes of the organization. EFA revealed three distinct latent variables, which are interpreted as individual gains, tangible results, and program efficacy (*Table 5*). The three factors explained 37% of the variation, with factor 1 (individual gains) offering the highest proportional variation (~17%). Although this amount of explained variation is less than ideal (Hair et al. 2013), an exploratory study such as this may be subject to more uncertainty. Nonetheless, the factors appear to be a good fit for the data collected based on the measures of fit in *Table 4*, namely the root mean square error of approximation (RMSEA), which, at < 0.01 , indicates a good fit (Hu and Bentler 1999).

Individual gains, factor 1, loaded highly statements of gaining recognition or advancement for the self: “I like to earn recognition,” “Opportunities for my role to grow ... are important to me,” and “It is important to me to receive some form of recognition for my work.”

Factor 2, the tangible results an organization produces, are important for CSVs who want their data to be used in scientific publications and “like” when environmental problems are solved because of their data, and when data/results are shared with them.

Factor 3 is interpreted as program efficacy, as the organizational variables grouped are related to general satisfaction with program management and outcomes: “The data collected for this project are used appropriately,” “I think the data collected are not being used to their full potential,” and “I feel that staff would support me if I wanted to deepen my level of participation.” Note that “I think the data collected are not...” was coded in reverse to indicate level of agreement in a positive manner.

Among these three factors, which are descriptively presented in *Table 6* above “form of recognition,” the

		FACTOR 1	FACTOR 2	FACTOR 3
		INDIVIDUAL GAINS	TANGIBLE RESULTS	PROGRAM EFFICACY
Earn recognition for training		0.821150		
Opportunities for my role to grow		0.650053		
Receive recognition for my work		0.626201		
Environmental problems addressed by data			0.632153	
Data used for scientific publications			0.559192	
Data/results shared with me			0.545561	
Data are used appropriately				0.619704
Staff would support me				0.564744
Data are not used to full potential (reversed)				0.416639
Eigenvalues/SS loadings		2.4240	1.6549	1.4039
Proportion variation (%)		16.69	11.07	9.436
Cumulative variation (%)		16.69	27.75	37.19
Measures of fit	AIC	BIC	Root mean square error of approximation	Tucker-Lewis Index
	-25.596	-89.964	0.000	1.055

Table 5 Organizational variable factor loadings, eigenvalues, variation, and measures of fit.

AIC = Akaike information criterion; BIC = Bayesian information criterion.

highest scored statement was “I like when environmental problems are addressed because of our data” ($m = 4.89$). The lowest scored statement was “I think the data are not being used to their full potential” ($m = 2.90$). Further, the “forms of recognition” (lower portion of [Table 6](#)), were also scored moderately low. CSVs found the seven forms of recognition to be only slightly to moderately important. These forms of recognition are not used in analyses, but presented as descriptive information to CS practitioners to compare with future assessments of recognition types.

[Table 7](#) provides the results of testing H2—that motivation factors would reflect in the organizational variables valued. Organizational factors (individual gains, tangible results, and program efficacy) were collapsed into categorical variables with three levels of agreement, as detailed in table notes, to gauge between-group differences in a nonparametric assessment. The purpose was to examine trends in agreement in how high-scoring motivational factors also reflect organizational factors CSVs valued or agreed were likable or important. Significant ($p < 0.001$) between-group differences existed in individual gains and all motivation factors, and between program efficacy and career oriented, and between program efficacy and values expression. No differences

existed among motivational factors and agreement with tangible results.

The organizational factor individual gains differed in scoring among each motivational factor ([Table 7](#)). First, individual gains and social exchange showed a trend of agreement whereby those who agreed ($m = 4.04$) with valuing individual gains also scored items of social exchange highest and significantly differently ($p < 0.01$) than those who were neutral ($m = 3.64$) and those who disagreed ($m = 3.22$); disagree and neutral were also significantly different ($p < 0.05$). Next, those who scored personal enhancement highly ($m = 4.46$) also agree with individual gains significantly differently ($p < 0.0001$) than those who disagree ($m = 4.0$). Career oriented held significant between-group differences ($p < 0.0001$) between CSVs who agree ($m = 3.72$) and those who were neutral ($m = 2.87$), as well as between those who agree and those who disagree ($m = 2.36$).

Values expression and individual gains: although overall scores were high ($m > 4.5$), significant between-group differences ($p < 0.01$) were found between the groups that agreed ($m = 4.89$) and disagreed ($m = 4.64$) and between groups that were neutral ($m = 4.79$) and disagreed. Lastly, knowledge attainment had between-group differences

CATEGORY	ITEM DESCRIPTION	MEDIAN	MEAN (SD)	CATEGORY MEAN (SD)
Individual gains	I like to earn recognition or a reward for completing training activities, such as a rank for my expertise level or special event. ¹	3	3.34 (1.38)	3.39 (1.10)
	Opportunities for my role to grow or advance are important to me. ¹	4	3.93 (1.26)	
	It is important to me to receive some form of recognition or appreciation for my work. ²	3	2.95 (1.29)	
Tangible results	I like when environmental problems are addressed because of our data.	5	4.89 (0.41)	4.67 (0.52)
	It is important to me that our data are used for scientific publications.	5	4.26 (0.91)	
	I like when data and/or results are shared with me.	5	4.73 (0.55)	
Program efficacy	I feel that the staff would support me if I wanted to deepen my level of participation.	5	4.28 (1.09)	3.86 (0.83)
	The data collected for this project are used appropriately.	5	4.39 (0.91)	
	I think the data collected are not being used to their full potential. ³	3	2.90 (1.31)	
Forms of recognition	<i>“How important are the following forms of recognition to you?”⁴</i>			
	Hand-written card	2	2.16 (1.23)	2.29 (0.96)
	Personalized email	2	2.43 (1.17)	
	Volunteer appreciation event	2	2.34 (1.27)	
	Certificate or token of appreciation	2	2.38 (1.25)	
	Gifts such as stickers, t-shirts, and hats from organization	3	2.64 (1.29)	
	Name recognition in newsletter(s)	2	2.19 (1.23)	
	Name recognition on social media	1	1.92 (1.18)	

Table 6 Descriptive statistics of organizational factors and forms of recognition.

¹ 7-point scale coded to 5 point; e.g., strongly disagree and disagree were combined, and strongly agree and agree were combined.

² 3-point scale coded to 5 point; 1 = disagree; 3 = neutral; 5 = agree.

³ Coding reversed.

⁴ 5-point scale: 1 = not important at all; 2 = slightly important; 3 = moderately important; 4 = very important; 5 = extremely important. SD = standard deviation.

MOTIVATIONS/DISPOSITIONAL FACTOR CATEGORIES	ORGANIZATIONAL FACTOR CATEGORIES ¹	
	INDIVIDUAL GAINS	PROGRAM EFFICACY
Social exchange	(42.5811) <0.0001***	
Personal enhancement	(18.3532) 0.0001***	
Career oriented	(50.9344) <0.0001***	(8.4229) 0.0148*
Values expression	(27.6619) <0.0001***	(9.0598) 0.0108*
Knowledge attainment	(36.9414) <0.0001***	

Table 7 Nonparametric results of organizational variable groups and motivational factors analyses (H2).

¹ These categories were collapsed into three grouping variables: disagree, neutral, and agree based on conversion of Likert-scores presented in Table 6. For example, 1 and 2 were coded to disagree, 3 is neutral, and 4 and 5 are coded as agree. Results of Kruskal-Wallis tests, test statistics are denoted in parentheses and p-values are below; *, **, and *** denote statistical significance of p < .05, .01, and .001, respectively. There were no differences among any motivational factors and tangible results.

($p < 0.001$) with those who agree ($m = 4.79$) and those who were neutral ($m = 4.41$), and between those who agree and disagree ($m = 4.36$).

Finally, agreement with program efficacy showed differences with career oriented and values expression (**Table 7**). Between-group differences revealed CSVs who agree ($m = 3.32$) with program efficacy did so significantly differently ($p < 0.05$) than with those who were neutral ($m = 2.75$). CSVs who scored items of values expression highest ($m = 4.90$) were in the disagree group of program efficacy. Significant between-group differences ($p < 0.05$) exist between those who agree ($m = 4.82$) and those who are neutral ($m = 4.73$).

H2 is supported by the results, as differences in scoring of motivational factors were reflected in the valuing of organizational variables with a general trend of agreement. Some dispositional (motivational) factors held more substantial evidence for agreement with organizational variables. To explicate, in individual gains and social exchange, all three agreement-level groups are significantly different, and others trend in agreement with weaker evidence (e.g., program efficacy and career oriented). Differences existed only between those who agree and those who were neutral and program efficacy and values expression, in which the disagree group

scored value expression higher but no different than the agree group.

HYPOTHESIS 3: INDICATORS OF COMMITMENT AND DISPOSITIONAL (MOTIVATIONAL) VARIABLES

H3 was that indicators of commitment differ on the basis of motivations/dispositional variables. The study survey captured several indicators of commitment (**Table 8**), which the DOIF posits serve as a proxy for sustained participation. CSVs were asked how likely they were to maintain, decrease, and increase their rate of volunteerism. In this study, the community partner encourages CSVs to maintain a rate of volunteerism, which is typically one water-monitoring test per month. Participation may increase through attending advanced training sessions, testing more frequently, or volunteering in other capacities. As such, we explicitly asked if participants were likely to decrease their commitment, which indicates the CSV is becoming disengaged from the CS program.

In addition to assessing the rate of volunteerism, we asked how likely CSVs were to recommend volunteering to others (**Table 8**). The length of time as a volunteer and frequency of water testing were also captured. CSVs were overall likely to maintain their rate of volunteerism ($m = 4.21$) and

INDICATORS OF COMMITMENT				
"IN THE FUTURE, HOW LIKELY ARE YOU TO..."		MEDIAN	MEAN	SD
Maintain	Continue volunteering at the same rate?	5	4.21	1.13
Increase	Increase the amount of time you spend volunteering?	4	3.62	1.09
Decrease	Decrease the amount of time you spend volunteering? ¹	4	3.80	1.01
Recommend	Recommend volunteering to others?	5	4.47	0.80
Time a Volunteer	How long a citizen science volunteer? ²	Less than 1 year (23%)		
		1 to 3 years (39%)		
		3 to 5 years (14%)		
		5 years or more (24%)		
Frequency	How often do you monitor? ²	Once a week (7%)		
		Once a month (73%)		
		At least once a quarter (11%)		
		At least once a year (9%)		

Table 8 Descriptive statistics for indicators of commitment.

¹ Coding reversed.

² Combined into fewer groups for clarity and statistical analysis due to low count. Twice a year ($n = 4$) was combined with at least once a year ($n = 19$) and every other month ($n = 8$) was combined with at least once a quarter ($n = 10$). Most watershed groups encourage citizen scientists to monitor once a month.

SD = standard deviation.

recommend volunteering to others ($m = 4.47$). Furthermore, they were likely to maintain the amount of time they volunteered ($m = 4.21$). The predominant category time volunteered is 1 to 3 years (39%), and the majority of CSVs monitored water quality once a month (73%). These indicators were assessed for relationships among dispositional and organizational variables (Table 9).

Significant differences were found among increase and social exchange and knowledge attainment; decrease and social exchange and values expression; and time a volunteer and career oriented (Table 9). Maintain and frequency were no different among any motivational factor, and personal enhancement and program efficacy were no different among any indicator of commitment. Between-group differences ($p < 0.01$) for increase and social exchange were between “likely” to increase rate of volunteerism (with a mean score of 3.85 for social exchange) and “neutral” ($m = 3.47$). Pairwise comparisons for increase and knowledge attainment yield weak evidence for between-group differences ($p < 0.10$) with scores of knowledge attainment for those who are likely ($m = 4.67$) and neutral ($m = 4.48$).

Decrease was scored differently when compared with social exchange groups at a 90% confidence interval, with between-group differences with likely not to decrease ($m = 3.38$) and neutral ($m = 3.54$) ($p < 0.10$). Decrease and values expression had a significant global test and significant between-group differences ($p < 0.05$) with unlikely to not decrease (read: likely to decrease rate of volunteerism) ($m = 4.63$) and likely to not decrease ($m = 4.82$). Lastly, CSVs

who volunteered for 1 to 3 years scored career oriented higher and significantly differently ($p < 0.01$) than those who had volunteered for 5 years or more ($m = 2.84$).

Indicators of commitment—excluding maintain, recommend, and frequency—had significant differences with social exchange (increase and decrease), values expression (decrease), knowledge attainment (increase), and career oriented (time a volunteer). H3 is largely accepted, with some caveats because maintain and frequency did not have any significant differences among the organizational variables and because of the weak evidence for a relationship between decrease and social exchange.

H4: INDICATORS OF COMMITMENT AND ORGANIZATIONAL VARIABLES

The final hypothesis (H4) was that indicators of commitment differ based on valued organizational variables (Table 9). Indicators and organizational factors with significant differences are increase and individual gains and tangible results, and recommend and tangible results. Program efficacy was not different among any indicators.

Increase and individual gains had a significant global test, but pairwise comparisons showed no actual between-group differences. Not dissimilar, increase and tangible results had a significant global test, and pairwise comparisons revealed a weak difference ($p < 0.10$) between groups likely ($m = -4.74$) and unlikely ($m = 4.56$) to increase

CATEGORIES	INDICATORS OF COMMITMENT ¹			
	INCREASE	DECREASE	RECOMMEND	TIME A VOLUNTEER
Social exchange	(9.9891) 0.0068*			
Values expression		(7.9660) 0.0186*		
Career oriented				(8.1330) 0.0433*
Knowledge attainment	(7.8536) 0.0197*			
ORGANIZATIONAL				
Individual gains	(6.8552) 0.0325*			
Tangible results	(6.7089) 0.0349*		(7.7411) 0.0208*	

Table 9 Nonparametric results for Indicators of Commitment and organizational and dispositional variables (H3 and H4).

¹ Kruskal-Wallis tests where indicators of commitment are categorical/grouping variable; increase, decrease, and recommend were reduced to three grouping variables (likely, neutral, and unlikely). The motivational and organizational factors are measurement variables using the category means as described in Tables 3 and 6. Test statistics are denoted in parentheses and p-values are below; * Denotes statistical significance of $p < .05$. Indicators of commitment that were not significant are not included in the table (maintain and frequency). Likewise, personal enhancement and program efficacy were not statistically different and are not displayed in the table.

the rate of volunteerism. Lastly, recommend and tangible results showed significant between-group differences ($p < 0.05$) between likely ($m = 4.71$) and neutral ($m = 4.33$).

Because some differences do exist, H4 is supported. However, where differences occur in group scores, there is no strong evidence of between-group differences. The most reliable relationship exists between recommend and tangible results.

DISCUSSION

Major findings for the first research question indicate that, similar to previous studies, “wanting to help the environment” was descriptively the most prevalent motivator, with “contribute to science” scoring highly as well (Grese et al. 2001; Bruyere and Rappe 2007; Alender 2016; Lopez 2020b). By employing the DOIF and carrying out an EFA on 14 motivational statements, 5 factors of motivations were uncovered. The factors are comparable to the VFI, with five of the six functions represented:

- social (social exchange)—participates to strengthen and create social relations;
- understanding (knowledge attainment) —desires to learn more about a subject or gain a skill;
- enhancement (personal enhancement) —aims to improve psychologically through volunteering;
- values (values expression) —acts to express important values; and
- career (career oriented) —wants to network or gain experience.

As this was not a confirmatory factor analysis, the theoretical correspondence among the statements of the VFI and this dataset may indicate a motivationally diverse volunteer pool.

Beyond inadvertently validating the VFI, the DOIF seeks to expand knowledge, specifically CS theory, by attempting to understand how, if at all, motivational factors interact with organizational factors, and how these may indicate differences in commitment to sustained participation. In that vein, enacting a novel framework may involve uncertainty. As the EFA for the organizational variables showed three distinct factors, though with low explanation of variation, a baseline understanding of the factors that are valued to participants emerge: individual gains, tangible results, and program efficacy. Regarding dispositional/motivational variables and organizational variable factor formation, two universal factors were uncovered from both: values expression and tangible results. They are the highest-scored factors in motivational factors (values

expression; $m = 4.79$) and organizational factors (tangible results; $m = 4.67$). They also had no differences among sociodemographic characteristic grouping scores and motivational factors measurement scores in subsequent analyses. That is to say, all CSVs are motivated by overarching, intrinsic values (Lopez 2020b) and a desire for transformative change in the form of environmental problems solved, advancements in science, and visible results of the data. This finding reiterates the importance of CS programs’ ability to provide CSVs with information about the data they collect, which in turn provides volunteer satisfaction and subsequent retainment (Shirk et al. 2012; de Vries et al. 2019; Haywood 2016). A further examination of values expression and tangible results is offered below.

Though no sociodemographic characteristic groups scored values expression differently, the motive trends in agreement with the desire for individual gains from participation at the organization. Further assessment of program efficacy and values expression (*Table 7*) shows the group that disagreed with valuing program efficacy had the highest mean score of values expression ($m = 4.90$) and there was no statistical difference with the group that agreed. Stated alternatively, CSVs who scored values expression high do not necessarily value program efficacy. Further, values expression was found to indicate sustained participation with their unlikeliness to decrease their rate of volunteerism (*Table 9*). Indeed, CSVs who participate to express values are intrinsically driven, which is known to be a more durable form of motivation (Bennett et al. 2018).

CSVs who value tangible results are likely to increase their rates of participation and recommend volunteering to others. de Vries et al. (2019) observed that the most successful recruitment strategies were built on existing and personal relationships when building a CS program. Moreover, CSV initial program participation rates were significantly higher when CSVs learned they could view their contributed data, track their own observations, and compare the data trends with others in the program (Bonney et al. 2009; Druschke and Seltzer 2012). Further, CSVs were shown to feel encouraged to sustain participation when presented with evidence of preliminary project results (Iacovides et al. 2013) and when data and project outcomes were used by scientists and/or policymakers (Bell et al. 2008). A takeaway for CS practitioners is that tangible results—or demonstrated changes—are a key to sustained participation as well as a method for volunteer recruitment. Davis et al. (2020) provide an insightful framework on how to communicate progress with data collection, results, and publications to CSVs.

Beyond the “values expression” motive and the vital organizational factor “tangible results,” the remaining four motivational factors begin to show nuanced groupings of CSVs who volunteer to fulfill different motivational

concerns through their varied and multiple desires. The factors are not mutually exclusive, and some overlap exists among trends in sociodemographic characteristics, which is expected as multiple motives can be at play and can shift throughout a person's CSV tenure (Rotman et al. 2012; Clary and Snyder 1999; Katz 1960). The motivational factors and how they play into the DOIF are discussed below. Implications of findings to CS literature and practice are also presented.

SOCIAL EXCHANGE

The social exchange motive was scored highly by college students, NGO/nonprofit employees, and those already employed in the environmental field. The NGO/nonprofit and environmental field employees may be the same respondents because these were two separate survey items. They valued individual gains from the organization, and are likely to increase participation, which indicates sustained participation.

Indeed, young adults in the US are becoming an important group of volunteers in environmental science initiatives (McDougle et al. 2011). Young adults volunteer for environmental causes at a higher rate than older adults (Bureau of Labor Statistics 2015), and US student enrollment in environment-related degree programs is increasing (Galbraith 2009), likely because of students' awareness of climate change, of their place within the ecological landscape, and of other issues (McDougle et al. 2011). In light of this awareness and intrinsically held values for learned environmental protection, normative and social influences from peers are also presumed to play a role in a young adult's choice to become involved in environmental science and environmental volunteerism (Kollsmuss and Agyeman 2002).

Studies show students and young adults do indeed volunteer for different motives that change over time (Rehberg 2005; Winniford, Carpenter, and Grider 1995). "Altruistic motivations were the most important factor for students to begin volunteering, self-interest motivations such as social interactions were what eventually caused them to stay committed to the organization" (McDougle et al. 2011, p. 329). Further, regardless of the CSV's age, CS organizations that focus on social engagements, in addition to environmental objectives, are often more successful in their environmental objectives than organizations that forgo social interaction as an organizational goal (Garrah et al. 2019; Neves 2009; Sommer 2003; Foster 2018, Ahmed 2004). As posited by Shirk et al. (2012), CSVs who feel satisfied with their volunteer experience may also increase the quantity of time dedicated to volunteering; i.e., organizational variables affect sustained participation. Toward that end, value expression, social exchange,

and individual gains are likely to contribute to sustained participation in the long term.

PERSONAL ENHANCEMENT

The personal enhancement motive seems to resonate with young adult (likely college student) CSVs. They value individual gains and offer no clear indication of commitment or sustained participation. Their CS participation is a means to "get outside and connect with nature," "do something physically active," and "have fun." As the functional approach suggests, volunteers may be motivated by several factors simultaneously, and those motives may intersect and interact in multifaceted, complex manners (Clary and Snyder 1999; Yeung 2004; McDougle, Greenspan, and Handy 2011). Personal enhancement may be a secondary motive for young adults. This finding may change based on CS program type. In this specific program, water quality monitors are designated a surface water-testing site. No indoor work or data entry are required. Thus, conducting their (most likely monthly) water monitoring activity is a way to spend some time near a body of water, a place to which they may not otherwise have access.

CAREER ORIENTED

CSVs with a career advancement motive were nonwhite, college students, lower-income earners, employed in the environmental field, and younger (< 45). They valued individual gains and program efficacy. Although no clear indicators of commitment were present, the length of time they were volunteers altered the scoring of the career-oriented motive. CSVs with the program 1–3 years were more motivated by career advancement than those who had volunteered for 5 years or more. Although, as here, career advancement is not usually a primary driver of participation (Alender 2016; Cetas and Yasué 2017), a subgroup in this sample likely volunteers for their career.

Indeed, because of their desire to "gain experience," "network," and "enhance [their] reputation," these CSVs use volunteering to build their resume, gain experience, and establish networks (Herodotou et al. 2020; Larson et al. 2020). As suggested above in the sections "Personal enhancement" and "Social exchange," this subpopulation of young adult volunteers is motivated by desire to increase their well-being (Rehberg 2005) through work experience and to develop social connections and relationships (Omoto, Snyder, and Martino 2000; Handy et al. 2010; Gage and Thapa 2011).

The results highlight issues of diversity and inclusion in environmental organizations and CS programs such as the community partner in this study. Recall, 85% of CSVs in this study were "white alone," which is not reflective of the demographics of the state of Texas where these participants

reside and work (*Figure 2*); Texas is only 41% “white alone” (U.S. Census Bureau 2019). In addition to the disparities in volunteer participation (Newman et al. 2012), nonwhite people typically hold fewer positions in environmental jobs than their white counterparts (Taylor 2018). Therefore, nonwhite CSVs may sense the need to gain (1) more experience, (2) enhance their reputation, and (3) add more network connections than their white counterparts to “get a foot in the door” to an environmental field.

KNOWLEDGE ATTAINMENT

Knowledge attainment was scored highly by women and college students. They also valued individual gains, and indicated they are likely to increase participation. Interestingly, this was the only motive factor scored differently by gender. Women’s involvement with CS programs and confidence and enjoyment in data collection processes are shown to be on the rise (Lewandowski et al. 2017; Kimura 2019). Although it is beyond the present study’s scope to further examine the role of gender, this finding may be useful to future studies.

APPLICATION TO CITIZEN SCIENCE PROGRAMS

Overall, CSVs are more likely to continue to participate when their motivations are fulfilled, and they are satisfied with their role (Welty Peachey et al. 2014; Wu, Li and Khoo 2016; de Vries et al. 2019; Haywood 2016). To that end, CS organizations may wish to understand their CSVs more comprehensively, through approaches such as the community geography one used in this study. Alternatively, study findings can be quickly employed by administering a short questionnaire using the five major motives as simple constructs for assessment; these five motives may be reliable as they reflect the VFI and previous CS studies’ findings. For example, a CS organization could employ a five-item questionnaire asking incoming CSVs to rank their motivational desires, and/or the five-item inquiry could be posed to current volunteers in a newsletter or other form of communication. From these responses, CS programs can assess whether their volunteers are motivated by one or more of the five major motivators, and if these motives have changed over the course of an individual’s volunteerism. Having such insights provides direction for program resource use (e.g., should a program focus on teaching, frontloading volunteers, communicating findings, promoting social exchange among CSVs, and/or providing support for young environmental professionals). In sum, cultivating a general understanding of CSV motives would undoubtedly provide guidance to ensure a successful CS campaign; a community geography or PAR approach could facilitate the research if the CS program does not have the capacity.

A NOTE ON RECOGNITION

Previous studies of recognition show mixed results (Roggenbuck et al. 2001; Rotman et al. 2012), specifically when it comes to the age of the CSV (Alender 2016). Individual gains in the form of recognition played a role as an important organizational variable in this study, but the low-scored forms of recognition show a disconnect. Mean scores of individual gains were more varied than other statements among motivation factors (*Table 6*). Further, the types of recognition (e.g., personalized email, volunteer appreciation event) were generally labeled as “slightly” to “moderately important,” with high variation. This study shows variation is also based on motivation type and supports previous findings that those who are motivated by social factors would also like recognition (Bruyere and Rappe 2007; Butt et al. 2017). As such, it is not solely those who are motivated for career advancement who desire recognition. As the DOIF aimed to understand basic interactions, unpacking recognition by other sociodemographic characteristics is beyond the scope of this study; the findings presented may be useful in future studies.

LIMITATIONS

Several issues limited the study. First, the survey respondents are from one CS program that is managed at a central location, but subgroups are responsible for working with CSVs across the state (*Figure 2*). This is problematic because the program is not managed unilaterally and therefore each subgroup has its own strengths and weakness. However, this limitation may be beneficial because it demonstrates that although CSVs are being managed by subgroups, there are still clear patterns and relationships present. In turn, this makes the results more applicable to the general phenomenon of CS, as demonstrated by five motives that correspond to the VFI. Another limitation of the survey was that location was not asked; it is unknown if the respondents were clustered (mostly from a few subgroups) or distributed throughout the state.

In terms of the survey instrument, the survey was created in a community geography partnership to best serve the needs of the organization. As such, a variety of statements were included to address specific program needs, and were, at times, ranked on differing scales, and the motives categories were not constructed based on literature constructs (egoism, altruism, collectivism, and principlism, or the VFI). New, comparable categories with the VFI emerged organically from the EFA. Accordingly, the organizational variables were created along this same limitation.

CONCLUSION

This study surveyed CS water quality monitors in Texas and examined how individual sociodemographic characteristics interact with motivations and organizational attributes and indicators of commitment through the novel DOIF. The DOIF considers how dispositional variables and organizational variables interact, rather than viewing the individual and organization as independent. Results indicate the DOIF is an appropriate conceptual model that provides a nuanced understanding of CSVs and applicable insights, which improves CSV satisfaction and possible retention.

In applying the DOIF, results ($n = 327$) reveal that CSVs exhibited different and overlapping motivations and may value certain aspects of the CS organization more than others, e.g., program efficacy over recognition. However, all CS participants demonstrate predominant characteristics: they volunteer to express their (environmental) values and desire measurable change, or results, from their involvement. This study also found that CSVs who seek quantifiable change were likely to sustain participation and recommend volunteering to others. CS organizations may consider this specific finding for volunteer retention and recruitment. Despite the variation of CSV attributes, a key takeaway for CS practitioners is the importance CSVs place on value expression and tangible results.

As a foundation for future research, the DOIF should undergo repeated use for improvement and verification of relationships—specifically, attempts to reconstruct the five conceptual motivational factors and the refinement of organizational factors—and should include a survey of CSVs at different phases of participation (decision, initial, and sustained). Future applications can also determine the validity of values expression and tangible results as ubiquitous motivational and organizational factors. Finally, two ongoing issues within CS, recognition and representation, surfaced in this study and need further investigation: Mixed results need to be unpacked, and questions about how (a lack of) race/ethnicity representation in CS leadership affects CSV participation need to be answered.

SUPPLEMENTARY FILES

The supplementary files for this article can be found as follows:

- **Supplementary File 1.** Understanding Volunteer Motivations Survey Flow. DOI: <https://doi.org/10.5334/cstp.341.s1>
- **Supplementary File 2.** Exploratory Factory Analysis Code and Outputs. DOI: <https://doi.org/10.5334/cstp.341.s2>

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COMPETING INTERESTS

The author has no competing interests to declare.

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