

Assessing the Value Orientations of Contributors to Virtual Citizen Science Projects

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ABSTRACT

Like other crowdsourcing communities, e.g., Wikipedia, citizen science projects struggle to attract and retain long-term contributors. Long-term contributors are critical to the success of many projects; research about motivational drivers has attracted the attention of many scholars. Prior literature has argued that values are motivational constructs linked to behavioral outcomes, and value orientations differ among demographic groups and cultures. In this paper, we assess the value orientations of volunteers who contribute to Zooniverse - an online platform that connects the public and researchers who collaborate on scientific research. We conducted an online survey (N=5,436) to measure the value orientations of Zooniverse contributors using Schwartz's Portrait Values Questionnaire (PVQ). We found the most salient value orientations of the population were achievement, self-direction, and security. Value prioritization differs slightly among some demographic groups. We present strategies for motivating contributions based on value orientations in the discussion.

CCS CONCEPTS

• **General and reference** → **Surveys and overviews; Evaluation**; • **Social and professional topics** → **User characteristics**.

KEYWORDS

citizen science, human values, participant survey, value priorities

ACM Reference Format:

Eunmi (Ellie) Jeong, Corey Jackson, Liz Dowthwaite, Tallal Ahmad, and Laura Trouille. 2023. Assessing the Value Orientations of Contributors to Virtual Citizen Science Projects. In *The 11th International Conference on Communities and Technologies (C&T) (C&T '23)*, May 29-June 2, 2023, Lahti, Finland. ACM, New York, NY, USA, 12 pages. <https://doi.org/10.1145/3593743.3593782>

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C&T '23, May 29-June 2, 2023, Lahti, Finland

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ACM ISBN 979-8-4007-0758-2/23/05...\$15.00
<https://doi.org/10.1145/3593743.3593782>

1 INTRODUCTION

Citizen science describes projects that engage the public in scientific research. Since the 19th century, various citizen science projects have successfully produced research results by partnering the public ("citizen scientists") with professional researchers [33, 48]. People contribute to citizen science by performing tasks such as gathering, evaluating, or scientifically computing data in various fields [9, 21, 48]. Galaxy Zoo, for example, is one of the most prominent examples of online citizen science. It asks its volunteers to classify images of galaxies supplied by the Sloan Digital Sky Survey (SDSS). More than 200,000 people have contributed to this project, and the results have been used in more than 50 research papers [48]. While citizen science has played a role in democratizing science, prior research on participant demographics revealed that the population of citizen science contributors is homogeneous regarding age, gender, country of residence, and level of education. Although there are some differences between projects, it has been found that citizen scientists tend to be middle-aged or older, well-educated males who reside in Global North nations [33, 35]. While citizen science projects have become more diverse, many projects' demographic composition still fails to reflect that of the larger population.

Understanding what motivates people to contribute to citizen science can help give useful insights into design implications, which, when prioritized, can diversify the user population. One approach to understanding motivation is understanding an individual's value orientations [38, 40, 42]. Values are beliefs that guide actions, arousing feelings that motivate people's goals. Schwartz's theory of basic human values [12, 42] articulates ten distinct values: power, achievement, hedonism, stimulation, self-direction, universalism, benevolence, tradition, conformity, and security. In practice, these values have been influential in understanding people's attitudes about science [24], media use [3], technology adoption [17], and a host of other outcomes.

A few studies investigated the values of citizen scientists in relation to their motivations to contribute to citizen science projects. They reported that self-direction and benevolence were the most salient values of citizen scientists [22, 30]. However, it is hard to generalize their findings since each study is based on a single or a few citizen science projects. Therefore, this research seeks to understand the primary values of large-scale online citizen scientists who contribute to various types of citizen science initiatives organized by Zooniverse. Zooniverse is the world's largest citizen science

platform that enables people-powered research by empowering the public to engage in research projects at a level beyond what researchers could achieve alone. The platform has seen the creation of more than 2.5 million registered accounts and launched more than 450 projects over the course of its existence [44]. Based on the findings about the value orientations of online citizen scientists, we present suggestions for designing citizen science projects so that they can gain sustained contributions from diverse volunteers. We explore specific research questions: **What are the primary values of contributors to Zooniverse?** and **How do value orientations differ in different demographic groups?**

As public participation in scientific research (PPSR) increases in popularity, knowing who participates in citizen science efforts and what motivates their contribution may help inform recruitment strategies for non-traditional populations [31]. Participation in citizen science has been shown to have benefits for individuals as well as society. For individual contributors, participation in citizen science has been linked to increased scientific literacy, engagement with science, and better attitudes toward science [1, 19]. Beyond individual benefits, citizen science platforms can play a role in facilitating digital commoning. Digital commoning enables the collective creation and management of resources and assets that are owned by a community using digital technologies. It decentralizes forms of organization, promotes democratic decision-making processes, and encourages the cultivation of values that extend beyond economic interests [4, 32, 37]. Bettega et al. [4] stresses the importance of understanding the needs and interests of community members when designing digital platforms to promote digital commoning. Furthermore, citizen science is increasingly used to inform policy-making. For example, the Snapshot Wisconsin project asks a subset of volunteers to establish camera traps throughout Wisconsin, USA. The images are uploaded to a digital platform and analyzed by citizen scientists. The results inform decisions about the number of hunting tags to help control wildlife populations. Additional examples of digital citizen science projects with policy implications include Penguin Watch EY and OceanEYES¹. Beyond policy, solving global challenges require diverse geographic participation. For example, environmental monitoring projects require data from people in diverse regions (urban and rural); knowing how best to motivate and sustain contributors from diverse geographic regions may help increase the representativeness of the data collected.

2 BACKGROUND LITERATURE

Citizen science project owners may support the primary values of minority groups when they design their projects so that an under-represented audience can be motivated to contribute. The following sections review the literature on participant demographics, values, and motivations.

2.1 Who Participates in Citizen Science

Prior research on contributors to citizen science projects found that the demographics of the volunteer population differ from project to project. However, most studies suggest that the population is relatively homogeneous. In terms of age, middle-aged or older volunteers account for a large portion of citizen science participants in

virtual and in-person projects [10, 33, 35]. Reed et al. [35] surveyed participants of Zooniverse and found that the average participant age was 40.7 years ($\sigma = 15.69$). Similar results were discovered in Galaxy Zoo, where the mean participants' age was 43.2 [33]. In GreatPollinator, an in-person biology project, 64% of participants were in their fifties [10].

Curtis [9] reviewed the demographics of volunteers in six virtual citizen science studies and found that male contributors were dominant in many studies (56%-82%). Several studies also found that a small percentage of participants were from minority racial or ethnic groups [5, 9, 26, 46]. A survey of five different VOLCROWE (Volunteering and Crowdsourcing Economics) projects revealed that 13% of respondents indicated they were members of minority groups [9, 26]. In another study of 300 biodiversity citizen science projects, only 11.4% of respondents were from minority groups. Along with ethnicity, contributions from participants who reside in the Global South tended to be underrepresented in virtual and in-person citizen science projects [2, 23, 48]. A survey of the Zooniverse project Higgs Hunters found that one-quarter of respondents were from the United States, and 16% were residents of the United Kingdom [2]. A review of prior research by Vasiliades et al. [48] discovered that 38% of citizen scientists were from America and 36% were from European countries. In contrast, only 11% were from Global South regions such as Africa (6%) and Asia (5%). Citizen scientists of virtual and in-person projects also tend to be well-educated and have science degrees [2, 10, 15, 35]. Reed et al. [35] found that among 119 Zooniverse participants who provided their educational background, the majority attained a college degree (72.9%), whilst citizen scientists' employment status is diverse. 90% of respondents had professions related to science, such as Computer and Mathematical (19.8%) and Education, Training, and Liberty (10.2%). Similar results were found at the project level; 74% of Higgs Hunters participants had a bachelor's degree, 39% had a master's degree, and 14% had a doctoral degree ($N = 322$). The most common professions were teachers, engineers, consultants, developers, and researchers [2].

Few studies have examined the income level of citizen scientists, so little is known about it, but we can learn from other types of projects. Domroese and Johnson [10] reported almost half of the GreatPollinator project had moderate (annual household income \$30-75K) to high (above \$75K) income levels. Participants of Audubon's Christmas Bird Count (CBC), another in-person project, reported higher income levels, with 33% saying they earn more than \$100K annually [20].

In general, the population of citizen science participants remains homogeneous and often does not represent the larger population. Such an unequal constitution of the volunteers has limitations in representing a wide range of populations.

2.2 The Motivations of Citizen Scientists

The topic of motivation in citizen science has attracted the attention of many scholars who report that a complex and diverse set of motivations drive and sustain contribution [9, 35, 36]. Most studies investigating the motivational factors that drive contribution in citizen science find that, while no one motivation drives participation, intrinsic motivations tend to be most salient [34, 35]. Raddick et al. [34] conducted one of the earliest investigations of motivation in

¹<https://www.zooniverse.org/projects/mrniaboc/penguin-watch-ey/about/research>

online citizen science projects, surveying 826 contributors to the Galaxy Zoo and interviewing 22. The authors discovered twelve broad categories of motivation: learning, desire to discover, social interaction, use of the project as a resource for teaching, the beauty of the images, fun, amazement by the vast scale of the universe, desire to help, interest in the project, interest in astronomy, and general science. In another survey ($N = 2,162$), Dowthwaite et al. [11] showed that citizen scientists were not motivated by a single reason but by multiple reasons; helping (contributing to science, a particular subject, or a good cause), interest (interested in the topics explored, and/or curious about the projects), and enjoyment (enjoy taking part, enjoy the tasks, or find the projects fun) were the most salient motivators among contributors. Curtis [8] conducted a survey, interviews, and observations of 37 Foldit (an online puzzle video game where people volunteer to conduct protein folding) participants. He discovered a similar set of motives driving participation, including contribution to science, background interest in science, intellectual challenge, curiosity, liking puzzles, liking computer games, learning something new, friendly competition, visual appeal/aesthetics, etc. Another finding from the literature on motivation in citizen science is that motivations are dynamic. Several studies find that as volunteers' relationship to the project changes, so do the factors that drive their motivation [7, 36]. For instance, research by Jackson et al. [18] suggests that social interactions such as learning through engagement with other members drive participation for sustained members but are less salient during the early stages of involvement. Rotman et al. [36] identified feelings of egoism, e.g., curiosity about the subject matter or prior engagement in science projects, dominate motives during early stages; however, these motives were not significant contributors to long-term ones engagement suggesting participants may be motivated by other factors. While many motivation studies exist, few have examined how motivation and demographic factors may be implicated in motivation.

2.3 Schwartz's Values Theory

Values reflect motivations, and the relationship between values and motivation has been shown to shape individuals' attitudes and guide their behaviors [12, 42]. Studies on human values have contributed to a rich body of knowledge, giving primacy to the value priorities of human actors in computer systems. Schwartz's theory of basic human values, measured through the Schwartz Value Survey and the Portrait Values Questionnaire, have been used to measure the value priorities of diverse users across various contexts and cultures. According to the theory, ten values are defined as distinct motivation types: power, achievement, hedonism, stimulation, self-direction, universalism, benevolence, tradition, conformity, and security. Each value is described with its central goal as specified in Table 1. The ten values are categorized into four higher-level value dimensions: openness-to-change (self-direction, stimulation), self-transcendence (benevolence, universalism), conservation (security, conformity, tradition), and self-enhancement (hedonism, achievement, power) [42].

Schwartz argues that values are associated with demographic features such as age, gender, education, and employment [41]. For instance, younger people are more likely to have a higher level of

hedonism, stimulation, and self-direction values since they have more opportunities for new challenges. In contrast, conformity, tradition, and security are important values for older people. Values might also be influenced by gender. According to Schwartz [41], men have high priorities in hedonism, stimulation, and self-direction values, while women consider benevolence, universalism, conformity, and security values important. Education is also related to values; in particular, people with a high education level are likely to give high importance to achievement value. Schwartz describes how values may lead to differently motivated behaviors: self-transcendence values (i.e., benevolence and universalism) motivate activities for social benefits. Therefore, people who prioritize these values are more likely to participate in collaborative activities for social good. In contrast, openness-to-change values (i.e., self-direction, stimulation) focus on independence and change; thus, these values motivate engagement in innovative tasks.

The analysis of the value preferences of pro-scientific and anti-scientific groups demonstrated that self-direction, benevolence, and universalism led to pro-scientific beliefs. At the same time, conformity and power were related to anti-scientific beliefs [24]. Besley [3] uncovered that a type of media people used could be explained with values. For instance, television exposure was linked to conservative values such as security and tradition, but internet exposure was related to liberal values like self-direction.

Regarding adopting a technology-supported attendance control system in a primary school, benevolence was the most relevant for children using the technology. On the contrary, security was the most significant value observed from parents using the service [17]. The differences in values between children and parents represent that children and parents have distinct attitudes toward technology adoption.

3 THE RELATIONSHIP BETWEEN MOTIVATION AND VALUES

Many other researchers have tried to identify the association between Schwartz's values, and particular motivations [38, 42]. Their findings imply that values function as the source of motivation, becoming standards or criteria for choosing behaviors [6, 14, 25, 28]. In workplace studies, scholars have examined the association between values and workers' commitment (i.e., developing meaningful long-term relationships within a community). Glazer et al. [14] surveyed hospital nurses in 4 countries: Hungary, Italy, the UK, and the US, and found that although the correlations differed from country to country, generally, values associated with openness to change (i.e., self-direction, stimulation) negatively correlated with commitment and conservative values (i.e., conformity, tradition, and security) positively correlated with commitment (except in the UK). Another study reported that conformity, benevolence, universalism, and power values were positively related to the commitment of bank employees in Israel, whilst self-direction and stimulation values were negatively correlated with commitment [6]. People with high benevolence and universalism values considered relationships important and were motivated to exhibit more commitment. However, the primary motivations of people who highly valued self-direction and stimulation were their successes and advancement, so they showed weaker commitment [6, 25]. In addition, conservative

Table 1: The ten values in Schwartz and defining goals taken from [39].

Value	Defining goal
Power	Social status and prestige, control or dominance over people and resources
Achievement	Personal success through demonstrating competence according to social standards
Hedonism	Pleasure or sensuous gratification for oneself
Stimulation	Excitement, novelty, and challenge in life
Self-direction	Independent thought and action—choosing, creating, exploring
Universalism	Understanding, appreciation, tolerance, and protection for the welfare of all people and for nature
Benevolence	Preserving and enhancing the welfare of those with whom one is in frequent personal contact (the ‘in-group’)
Tradition	Respect, commitment, and acceptance of the customs and ideas that one’s culture or religion provides
Conformity	Restraint of actions, inclinations, and impulses likely to upset or harm others and violate social expectations or norms
Security	Safety, harmony, and stability of society, of relationships, and of self.

values such as conformity were closely related to a desire to maintain relationships and organizations, which led to more substantial commitment [14]. In another study, self-direction was related to self-development motivations. Self-direction emphasizes learning, creating, and exploring [29].

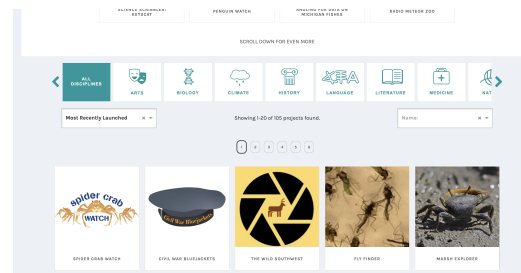
Oreg and Nov [28] investigated motivations and four values of volunteers (i.e., achievement, self-direction, benevolence, and universalism) that could explain motivations in the context of Open Source, which engages volunteers in the software development process. The results showed achievement value is associated with reputation-building motivations. Since people with high achievement values focus on demonstrating their competence, they are likely to contribute to open source to establish a reputation for good work. The open-source context also enhances volunteers’ self-development motivations by offering chances to improve their skills. Benevolence value involves an emphasis on concern for the welfare of others, and universalism stresses concern for others. Both values significantly concentrate on doing good for others; they have a positive relationship with altruistic motivations.

We argue that awareness of the values of citizen science participants might help shed new light on why some groups are more or less motivated to participate in citizen science efforts. To our knowledge, only two studies have examined the value orientations of citizen scientists. Palacin et al. [30] interviewed 15 volunteers who participated in a virtual environmental data collection citizen science project, and they found self-direction was critical to initial participation. Levontin et al. [22] investigated the motivations of contributors to one virtual and two in-person citizen science projects, finding that self-direction and benevolence were the most salient values.

4 THE ZOONIVERSE PLATFORM

Zooniverse [44] is an online platform for people-powered science that connects researchers with the public. Zooniverse has helped build and launch more than 450 projects. Since its inception, more than two and a half million registered accounts have been created on the platform, and participants have contributed more than one billion classifications. Most projects are built using the Project Builder interface, a web tool that allows researchers to create projects by

uploading data and defining the task. Depending on the data, researchers can build workflows that include one or many task types, including drawing, question answering, and surveying (i.e., a selection from many options). The Project Builder has standard features visible in most projects, e.g., Talk pages. For participants, the features and interactions across projects are seamless. Participants can create a Zooniverse account (although one is not required) and decide which project to contribute by selecting from a list of projects which are categorized into eleven disciplines (Figure 1). Once participants select a project, they can explore project materials (e.g., read science materials) and contribute by executing tasks. Participants can contribute to discussions via the Talk interface, where they can interact with other participants or research team members.

**Figure 1: A screenshot of the Zooniverse.org projects landing page.**

5 METHOD

5.1 Survey Instrument

Zooniverse sends weekly email digests to a listserv announcing new projects and other newsworthy information. Survey participants were recruited through the weekly email listserv containing 30,000 participants. The population represents a small portion of the over 2.5 million registered accounts. The survey was developed in Qualtrics. A recruitment message and a link to the survey were included in the email and distributed to the listserv on October 7th, 2021. To incentivize participation and completion of the survey,

respondents were entered into a \$100 raffle. Respondents were informed of their rights and responsibilities as research participants before submitting a consent form. The consent form asked respondents to acknowledge that they read the consent form and indicate if they were under 18. The respondents who submitted a consent form could continue with the survey and were allowed to leave it at any time without completing it.

The survey was closed on October 21st, 2021. The survey comprised fifty-four questions grouped into five sections: Demographics, Participation and Engagement, Motivations, Community, and Values. In the Demographics section, respondents were asked about their gender identity, age, ethnicity, educational background, and income level. The Participation and Engagement section focused on participation behaviors such as the frequency of contribution, from where they contribute (e.g., work), technology devices they use to contribute, their interactions with project features (e.g., project tutorials, discussion boards), other volunteers, science teams, and Zooniverse staff. In the Motivation section, we asked what motivates people to start, continue, and stop contributing to Zooniverse projects. Questions asked in the Community section were to capture people's attitudes about Zooniverse and their experiences in the Zooniverse community. For instance, respondents were asked how they perceived the Zooniverse community regarding diversity, agency, identity, and belonging.

In the Values section, the Portrait and Values Questionnaire (PVQ) [42] was used to identify the value priorities of the Zooniverse volunteers. The PVQ is a short version of the Schwartz Value Survey [38, 39]. It includes 21 short verbal 'portraits' that implicitly illustrate a person's goals, aspirations, or wishes relevant to a specific value. Respondents were asked to rate similarities between the 21 portraits and themselves using a 6-point Likert scale (1 for not at all like me and 6 for very much like me) [49]. The scale shows respondents' value priorities by demonstrating the relative importance of the different values [41, 42]. PVQ is a universal index to capture value orientations across countries and cultures [38]. Empirical studies in various countries demonstrated that people responded to ten values as distinct regardless of their nationalities or cultures [40, 42]. Thus, PVQ was an appropriate instrument to measure the values of international volunteers. This study reports on responses in the Demographics and Values sections to uncover the value orientations of the entire survey respondent population and various demographic groups. We expect that the distinctive value priorities of different demographic groups will provide deeper insight into the diverse motivations behind their contributions to Zooniverse projects.

5.2 Data Analysis

We received 7,453 responses to our survey. To ensure high-quality data, we excluded survey responses that were less than seventy percent complete. We removed survey speeders (i.e., responses where the completion time was two standard deviations more or less than the average completion time). To ensure the instrument's reliability, we removed responses containing non-answers for any PVQ items. We also analyzed the survey times to remove survey speeders (i.e., responses where the survey completion time was two

standard deviations from the mean on either side of the distribution). Using these criteria, 5,436 responses remained.

As is standard with questionnaires, we conducted reliability tests using Cronbach's alpha to determine the internal consistency of our responses. The reliability for ten values ranged between 0.06 and 0.39, indicating very low reliability based on a general acceptance of 0.7 as good reliability. Previous studies which employed PVQ have raised an issue with low reliability. For example, one study reported that Cronbach's alpha for ten values ranged from 0.20 to 0.41 [49]. According to Schwartz [40, 41] who developed and tested PVQ, it is impossible to have high reliability for all ten values since PVQ tries to cover the range of content of the full motivational continuum of values with a limited number of value types and items. Each index consists of 2-4 items that measure different aspects of the value; since the items do not measure a single aspect sufficiently, these indexes produce low reliability. Despite their low reliability, it is suggested that the hypothesized associations of these value scores support their validity as evidenced by the predictive power of values found from the empirical research across numerous nations [43].

To understand the value prioritization of survey respondents, we produced mean ranked scores of each value by different demographic groups—gender, age, ethnicity, education level, and income level. Age is divided into three groups: young (18-38 years old), middle (39-64), and old (65-99). We referred to data provided by the U.S. Census Bureau to define the ranges of the three age groups². According to the data, the median age of Americans is 38.8 years old. Thus, the middle-aged group starts at 39 years old. The profile of older Americans published by the U.S. Census Bureau [27] identifies the older population as being 65 years and older, so the old age group is defined as starting at 65 years old. Questions about education included answer choices from the International Standard Classification of Education (ISCED) 2011 [13]. We later groped these into five categories - advanced degree, college, vocational training, high school, and less than high school. For income levels, we referred to the income classification thresholds from a survey of Pew Research Center³.

We used one-way ANOVA to determine whether actual value scores differed within respective demographic groupings. Before ANOVA, we tested whether the dataset violated any ANOVA assumptions: (1) the responses for each factor level have a normal population distribution by reviewing QQ plots of the value scores (2) the variance among the groups was approximately equal by using Levene's test and residuals versus fits plots, and (3) the observations are independent of each other. The QQ plots demonstrated the normality of the data. We did not find evidence of a significant difference between variances across groups from Levene's test and residuals versus fits plots. The responses of the participants were independent of each other. Therefore, we concluded that there was no indication that our data violated the ANOVA assumptions.

Finally, to account for multiple tests, we used the Bonferroni correction to account for running multiple comparisons, which increases the chances of false-positive results. Since the tests were

²[https://data.census.gov/table?q=B26102:+MEDIAN+AGE+BY+GROUP+QUARTERS+TYPE+\(3+TYPES\)&t=Age+and+Sex&g=0100000US&tid=ACSDT1Y2021.B26102/](https://data.census.gov/table?q=B26102:+MEDIAN+AGE+BY+GROUP+QUARTERS+TYPE+(3+TYPES)&t=Age+and+Sex&g=0100000US&tid=ACSDT1Y2021.B26102/)

³<https://www.pewresearch.org/social-trends/2022/04/20/covid-19-pandemic-pinch-finance-of-americas-lower-and-middle-income-families/>

conducted for each factor (demographic), our new alpha becomes 0.005. While ANOVA informs if the means of independent groups are different, it does not show where those differences lie. Thus, the Tukey HSD test was used as a post-doc pairwise comparison method to see which pairs of group means are statistically different and how much they are different.

6 RESULTS

6.1 Participant Demographics

The participant demographics are summarized in Table 2. We categorized gender into three groups: female, male, and other. There was a larger female population (59%) than the male population (38%). We divided age into young (18-38 years old), middle (39-64), and old (65-99) groups. Middle-aged respondents accounted for the largest proportion (46%). We assigned respondents who selected multiple ethnicity groups to a multiracial group. Except for the multiracial group, respondents identified themselves as White, Asian, Black, and Hispanic. Accordingly, we had five ethnicity groups for analysis. White participants were dominant (86%) and the rest ethnicity groups accounted for small proportions of the entire respondents. We categorized eleven education levels into five groups: less than high school education, high school education, vocational education, college education, and advanced degree. People with a college education and education degrees accounted for 80% of the entire respondents. We grouped respondents into high ($\geq \$5,000$), middle ($\$3,000 - \$4,999$), and low ($< \$3,000$) income levels based on the monthly income they reported. The thresholds were calculated based on the annual income in dollars by household size. We asked for the monthly gross income of individual respondents through our survey. Thus, we converted the annual income thresholds for a household of one into monthly income thresholds. The proportion of the low-income group was the largest (48%).

6.2 Value Priorities of Zooniverse Participants

The value prioritization for the entire population of survey respondents is depicted in Figure 2. Overall, Zooniverse participants' ranked prioritization reveals that values of achievement ($\mu = 3.80$, $\sigma = 1.47$), security ($\mu = 3.72$, $\sigma = 1.41$), self-direction ($\mu = 3.70$, $\sigma = 1.67$), hedonism ($\mu = 3.55$, $\sigma = 1.39$), and benevolence ($\mu = 3.34$, $\sigma = 1.42$) were among the highest prioritized values. Conversely, participants placed less emphasis on power ($\mu = 1.98$, $\sigma = 1.07$), tradition ($\mu = 2.49$, $\sigma = 1.16$), universalism ($\mu = 2.82$, $\sigma = 1.48$), conformity ($\mu = 3.03$, $\sigma = 1.45$), and stimulation ($\mu = 3.05$, $\sigma = 1.50$).

6.3 Value Priorities of Demographic Groups

We computed mean value scores of different groups included in five demographic variables: gender, age, income level, ethnicity, and education level. Table 3 shows the relative value rankings within each demographic group. The rankings revealed several interesting findings. First, all groups deprioritized universalism, tradition, and power. Second, when examining gender, income, and age demographic categories, the value priorities were not substantially different and tended to reflect the value prioritization of the overall population. There is, however, slight variance in the exact order of prioritization. Third, ranking value prioritization by ethnicity and

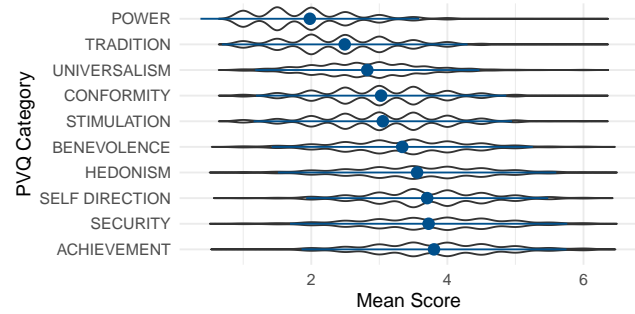


Figure 2: The mean score for each of the ten human values.

education level revealed the starkest differences among the respondents. While benevolence was prioritized in the mid-range of values (Figure 2), it was the second-ranked value of Black respondents. When examining the value prioritization by education level, respondents prioritized self-direction if their level of education was high school and less than high school; most other groups reported that achievement was the most salient. Interestingly, for respondents who indicated their highest level of education was less than high school, hedonism was a lower priority (seventh-ranked) than most other groups in the same category (third or fourth-ranked). Finally, there were negligible differences in the value ranks for gender, age, and income variables.

The results above demonstrate potential differences in the populations of Zooniverse participants. We conducted additional tests to identify differences within each demographic category to deepen our understanding of the relationships between demographics and values. The entirety of our results is included in the Appendix.

Gender. The ANOVA revealed significant mean differences in seven values for gender. Female respondents tended to have higher value scores for hedonism ($+0.2$, $F(2, 5350) = 25.35$, $p < 0.001$) and self-direction ($+0.2$, $F(2, 5350) = 33.42$, $p < 0.001$) than male respondents. Conversely, male respondents had significantly higher value scores in stimulation ($+0.15$, $F(2, 5350) = 16.60$, $p < 0.001$), power ($+0.28$, $F(2, 5350) = 79.86$, $p < 0.001$), and universalism ($+0.23$, $F(2, 5350) = 51.04$, $p < 0.001$) than female respondents. Furthermore, male respondents showed significantly higher value scores for power ($+0.25$, $F(2, 5350) = 79.86$, $p < 0.001$) and universalism ($+0.26$, $F(2, 5350) = 51.04$, $p < 0.001$) than respondents who identified themselves other types of genders (e.g., non-binary). Other types of genders had higher value scores for benevolence than males ($+0.32$, $F(2, 5350) = 13.48$, $p < 0.001$) and females ($+0.37$, $F(2, 5350) = 13.48$, $p < 0.001$) respondents.

Age. Significant mean differences in all values were found from the ANOVA. The pairwise comparison indicated a consistent pattern across all values: older age groups reported higher value scores. For instance, respondents in the old group reported higher value scores for hedonism ($F(2, 5431) = 73.76$, $p < 0.001$) than respondents in the middle-aged ($+0.15$) and young groups ($+0.44$). Additionally, respondents in the middle-aged group had significantly higher hedonism value scores than those in the younger group ($+0.30$).

Ethnicity. ANOVA indicated significant mean differences for all values except power. White respondents indicated higher mean

Table 2: Participant demographics.

	Gender			Age			Race/Ethnicity						Education					Income		
	Female	Male	Other	Middle	Old	Young	White	Asian	Multi racial	Hispanic	Black	Adv. Degree	College	Voc. Training	High School	< High School		Low	High	Middle
Frequency	3141	2020	192	2487	1566	1381	4594	333	234	125	33	2010	1718	511	395	15		1819	1039	940
Percent	59	38	4	46	29	25	86	6	4	2	1	43	37	11	8	0		48	27	25

Table 3: The value prioritization ranks by the demographic group.

	Gender			Age			Race/Ethnicity						Education					Income		
	Female	Male	Other	Middle	Old	Young	Asian	Black	Hispanic	Multi racial	White	Adv. Degree	College	High School	< High School	Voc. Training		High	Low	Middle
ACHIEVEMENT	1	1	1	1	1	1	1	1	1	1	1	2	1	2	2	1		1	1	1
BENEVOLENCE	5	5	4	5	5	5	4	2	5	5	5	5	5	5	6	5		5	5	5
CONFORMITY	6	7	7	7	7	6	6	6	7	6	7	6	7	7	5	7		7	7	7
HEDONISM	4	4	2	4	4	4	5	5	4	4	4	4	4	3	7	4		4	4	4
POWER	10	10	10	10	10	10	10	10	10	10	10	10	10	10	9	10		10	10	10
SECURITY	3	2	3	3	2	2	2	3	3	2	2	1	3	4	3	3		2	3	2
SELF.DIRECTION	2	3	5	2	3	3	3	3	2	3	3	3	2	1	1	2		3	2	3
STIMULATION	7	6	6	6	6	7	7	7	6	7	6	7	6	6	4	6		6	6	6
TRADITION	9	9	9	9	9	9	9	9	9	9	9	9	9	9	10	9		9	9	9
UNIVERSALISM	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8		8	8	8

scores than other ethnic groups for the nine values. Asian respondents reported the lowest value scores among all ethnicity groups in hedonism (2.87, $F(4, 5314) = 60.80$, $p < 0.001$), self-direction (2.97, $F(4, 5314) = 73.77$, $p < 0.001$), achievement (3.26, $F(4, 5314) = 34.20$, $p < 0.001$), and benevolence (2.87, $F(4, 5314) = 25.46$, $p < 0.001$). Black respondents tended to have the lowest value scores in the values of stimulation (2.42, $F(4, 5314) = 51.69$, $p < 0.001$), security (3.12, $F(4, 5314) = 41.02$, $p < 0.001$), universalism (2.33, $F(4, 5314) = 35.70$, $p < 0.001$), conformity (2.44, $F(4, 5314) = 22.84$, $p < 0.001$), and tradition (1.98, $F(4, 5314) = 20.42$, $p < 0.001$).

Education level. ANOVA indicated statistically significant mean differences between different education level groups in self-direction and stimulation values. Respondents with advanced degrees tended to have lower value scores than those who had high school education and vocational education for self-direction ($F(4, 4644) = 8.68$, $p < 0.001$) and stimulation ($F(4, 4644) = 18.44$, $p < 0.001$).

Income level. Respondents with high income showed higher values scores for power (+0.13, $F(2, 3795) = 9.94$, $p < 0.001$) and universalism (+0.14, $F(2, 3795) = 13.81$, $p < 0.001$) than respondents in the low-income group.

7 VALUES ORIENTATIONS IN ONLINE CITIZEN SCIENCE

While it is argued that demographic characteristics convey value orientations [22], our results suggest that some demographics display

different value orientations to the overall population of Zooniverse volunteers. The lowest-rated value prioritization was shared among all demographic groups and aligned with overall value prioritization - values of power, tradition, universalism, and conformity were consistently listed as the least prioritized values.

The highest value priorities among all groups were achievement, security, self-direction, hedonism, and benevolence, although their order of priority and overall salience varied slightly between some demographic groups. It could be interpreted that major motivations commonly found among Zooniverse participants are demonstrating their competence (achievement), keeping the safety, harmony, and stability of society (security), and pursuing independent thought and action (self-direction). Among these values, our results align with Palacin et al. [30], who found that self-direction and benevolence were also identified as primary values of contributors who participated in the project.

For gender, prior literature suggests that the value priorities of hedonism, stimulation, and self-direction values were most salient for men. At the same time, women consider benevolence, universalism, conformity, and security values important [41]. Our results showed that the order of value priorities was similar between males and females; however, in terms of salience, females tended to have higher scores in hedonism (enjoyment) and self-direction (exploring), which could be linked to intrinsic motivations. In comparison,

the male group tended to have higher scores for power (social recognition) and universalism (concern for others) values that could be considered to be extrinsic motivations [47]. It should be noted that the gender distribution in our results is a departure from many studies showing that more men than women contribute to citizen science projects; we suspect this is because, in our data (and on the Zooniverse platform), there are many more ecology projects. Prior research has demonstrated gender differences depending on the type of project; more women participate in ecology projects [45].

Schwartz [41] also suggested conformity, tradition, and security are significant to older people, while young people value hedonism, stimulation, and self-direction more. However, our results demonstrated that achievement, security, and self-direction were primary values commonly shared by all respondents regardless of their age. In fact, despite older respondents having higher overall scores for all values than middle-aged and young respondents, middle-aged respondents placed a higher value on self-direction relative to other values (second-ranked) than older respondents (third-ranked). It could be understood that young contributors tend to place a greater priority on the safety and stability of the community and themselves than older contributors do.

Previous research on the correlation between education level and values aligned well with our findings. A previous study suggested that people with a high education level tended to prioritize achievement value. Likewise, our results illustrated that achievement was first ranked for respondents with at least bachelor's degrees. At the same time, it was in the lower position for those with a high school education or less. Besides achievement, we found that the priority of self-direction and stimulation varies depending on the education level. Respondents with advanced degrees had lower scores for self-direction and stimulation than those with bachelor's degrees and high school education. We suspect that engaging with Zooniverse projects allows individuals with bachelor's degrees and high school education to experience self-direction.

Little is known about ethnicity and income level related to value orientations. Regarding ethnicity, our results show that benevolence stood out in Black respondents as the second-ranked value, while it was ranked fourth or fifth in other ethnicity groups. No significant correlation between income level and values was identified in this study.

7.1 Influencing Design through Value Prioritisation

Understanding motivations can predict contributors' participation behavior, such as duration of participation and willingness to participate [22]. Values are indicators of motivations, so value priorities can be employed to induce desired behavior of contributors. Project initiators and software designers must understand that satisfying all volunteers' demands is impossible since trade-off characteristics exist among specific values [16]. For example, values associated with innovation and new challenges (e.g., stimulation and self-direction) are opposed to conservative values (e.g., security, conformity, and tradition) according to the circular structure of values [42]. Therefore, promoting stimulation may weaken security value. Accordingly, it is necessary to define potential contributors and establish design strategies that align with the value priorities

of the target population. Also, values are not likely to be static, but the magnitude of primary values may change over time [16]. While our overall results show achievement, self-direction, and security are mainstreamed, some demographic groups show other value priorities. Thus, design strategies need to be flexible to accommodate such groups. We envision several strategies to help project initiators and software developers realize values in the context of this research.

Strategy 1. Support hedonism and self-direction for the female population. Previous studies indicated that male contributors were dominant in citizen science projects; in our study, we found a larger population of respondents who indicated they were female. The women in our study tended to have higher scores for hedonism and self-direction (compared to male respondents); other citizen science project leaders need to consider methods to support these values. We suggest projects improve avenues for meaningful choice (i.e., which tasks) and include praise and encouragement to make people feel good as a way of helping contributors have more opportunities for independent actions and achieve enjoyment from their work.

Strategy 2. Supporting benevolence for underrepresented populations. According to our analysis, benevolence was a highly prioritized value among Black respondents. If the field hopes to promote involvement from participants who identify as Black, designing a collaborative project will be effective. Benevolence is the value of "Preserving and enhancing the welfare of those with whom one is in frequent personal contact (the 'in-group')." Thus, citizen science platforms might consider ways to articulate community benefits of involvement in citizen science. For example, projects may make explicit community partners, specific communities impacted, and how the project will improve community outcomes.

Strategy 3. Support self-direction and stimulation values for people with various educational backgrounds. It was found that the majority of volunteers had college degrees. In other words, citizen science projects are not representing people with different educational backgrounds. To mitigate such a limitation, project initiators are recommended to support self-direction and stimulation values, which are important to people who don't have college or higher degrees. These values are associated with innovation and new challenges. Therefore, embedding creative tasks and features in citizen science projects may attract contributions from more diverse populations. For example, offering different levels of tasks so that volunteers can have diverse options of contribution and opportunities for challenges may be helpful. Adding more user-friendly interface features such as personal workbooks, which help volunteers customize their work log and develop their insights on the projects they took part in, may also support self-direction and stimulation values.

8 LIMITATIONS

As with any research, there are limitations. First, we did not conduct a multivariate analysis to tease out how the intersections of respondents' identities may factor into their value prioritization. For example, it may be that volunteers who identify as young and female have different values orientations than older females. Second, since the population of Zooniverse participants is global, developing universally accepted classification thresholds for some analyses

was challenging (e.g., income classifications). We solved this issue by using classifications from established research institutes. For example, since the population of respondents was primarily US based, for income levels, we referred to the income classification thresholds from a survey by the Pew Research Center.

9 CONCLUSIONS AND FUTURE WORK

This study is an exploratory work that reveals the value orientations of contributors who participate in citizen science projects offered by Zooniverse. We found that the entire volunteer population commonly prioritizes achievement, self-direction, and security, but value prioritization differs slightly among certain demographic groups. Based on the findings, we suggested several design strategies for motivating contributions from the groups we studied. Future research needs to identify specific reasons for different value orientations based on participants' backgrounds and the projects they are involved in. We expect that future research using quantitative and qualitative approaches will be helpful in developing practical strategies for applying the design suggestions that we present. Furthermore, scholars need to shed light on the implications of values on the actual behaviors of contributors. Studying the correlation between values and behaviors may lead to more insights for designing citizen science projects and platforms that appeal to a wide range of contributors more effectively.

ACKNOWLEDGMENTS

We thank the millions of Zooniverse volunteers; without them the dedicated effort of Zooniverse volunteers who worked on the projects and contributed to this research, there would be no article.

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A ANOVA RESULTS

Table 4: ANOVA results

Demographic variables	Value	ANOVA			
		df group	df residual	F	Pr(>F) (0.005)
	Hedonism	2	5350	25.35	1.09E-12 ***
	Self direction	2	5350	33.42	3.77e-15 ***
	Stimulation	2	5350	16.60	6.47e-08 ***
	Security	2	5350	0.59	0.556
	Conformity	2	5350	6.39	0.002 *
	Tradition	2	5350	3.16	0.042
	Achievement	2	5350	3.84	0.022
	Power	2	5350	79.86	<2e-16 ***
	Universalism	2	5350	51.04	<2e-16 ***
	Benevolence	2	5350	13.48	1.46E-06 ***
Age	Hedonism	2	5431	73.76	<2e-16 ***
	Self direction	2	5431	157.78	<2e-16 ***
	Stimulation	2	5431	297.92	<2e-16 ***
	Security	2	5431	91.65	<2e-16 ***
	Conformity	2	5431	125.48	<2e-16 ***
	Tradition	2	5431	82.74	<2e-16 ***
	Achievement	2	5431	114.17	<2e-16 ***
	Power	2	5431	53.05	<2e-16 ***
	Universalism	2	5431	254.72	<2e-16 ***
	Benevolence	2	5431	55.62	<2e-16 ***
Ethnicity	Hedonism	4	5314	60.80	<2e-16 ***
	Self direction	4	5314	73.77	<2e-16 ***
	Stimulation	4	5314	51.69	<2e-16 ***
	Security	4	5314	41.02	<2e-16 ***
	Conformity	4	5314	22.84	<2e-16 ***
	Tradition	4	5314	20.42	1.03e-16 ***
	Achievement	4	5314	34.20	<2e-16 ***
	Power	4	5314	2.12	0.076
	Universalism	4	5314	35.70	<2e-16 ***
	Benevolence	4	5314	25.46	<2e-16 ***
Education level	Hedonism	4	4644	3.56	0.007*
	Self direction	4	4644	8.68	5.62e-07 ***
	Stimulation	4	4644	18.44	4.8e-15 ***
	Security	4	4644	7.87	2.57e-06 ***
	Conformity	4	4644	0.58	0.678
	Tradition	4	4644	5.34	2.74E-04 ***
	Achievement	4	4644	1.15	0.333
	Power	4	4644	0.20	0.941
	Universalism	4	4644	4.41	0.001 ***
	Benevolence	4	4644	2.25	0.061
Income level	Hedonism	2	3795	1.86	0.156
	Self direction	2	3795	4.09	0.017
	Stimulation	2	3795	0.76	0.467
	Security	2	3795	2.67	0.069
	Conformity	2	3795	4.51	0.011
	Tradition	2	3795	3.62	0.027
	Achievement	2	3795	3.86	0.021
	Power	2	3795	9.94	2.65E-05 ***
	Universalism	2	3795	13.81	8.42E-07 ***
	Benevolence	2	3795	0.37	0.689

B PVQ SURVEY QUESTIONS

Below are some statements that describe a person. Read them carefully and respond to how each statement resonates with you as a person. Rate your responses on a scale of 1-6, where '1' means 'very much like me,' and '6' implies 'not at all like me.'

	1 - very much like me	2 - like me	3 - somewhat like me	4 - a little like me	5 - not like me	6 - not like me at all
They think it is important that every person in the world be treated equally. They believe everyone should have equal opportunities in life.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
It is important to them to make their own decisions about what they do. They like to be free and not depend on others.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
It is important to them to live in secure surroundings. They avoid anything that might endanger their safety.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
It is important to them to be rich. They want to have a lot of money and expensive things.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
They believe that people should do what they're told. They think people should follow rules at all times, even when no one is watching.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
It is important to them to be in charge and tell others what to do. They want people to do what they say.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

	1 - very much like me	2 - like me	3 - somewhat like me	4 - a little like me	5 - not like me	6 - not like me at all
It is important to them to listen to people who are different from them. Even when they disagree with them, they still want to understand them.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
It is important to them to be humble and modest. They try not to draw attention to themselves.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Being very successful is important to them. They hope people will recognize their achievements.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Thinking up new ideas and being creative are important to them. They like to do things in their own original way.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
It's very important to them to help the people around them. They want to care for their well-being.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
They like surprises and are always looking for new things to do. They think it is important to do lots of different things in life.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Tradition is important to them. They try to follow the customs handed down by their religion or their family	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
It is important to them that the government ensure their safety against all threats. They want the state to be strong so it can defend its citizens.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
It is important to them always to behave properly. They want to avoid doing anything people would say is wrong.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
They seek every chance they can to have fun. It is important to them to do things that give them pleasure.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
It's very important to them to show their abilities. They want people to admire what they do.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
They look for adventures and like to take risks. They want to have an exciting life.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

	1 - very much like me	2 - like me	3 - somewhat like me	4 - a little like me	5 - not like me	6 - not like me at all
Having a good time is important to them. They like to "spoil" themselves.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
They strongly believe that people should care for nature. Looking after the environment is important to them.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
It is important to them to be loyal to their friends. They want to devote themselves to people close to them.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

Figure 3: Portrait Values Questionnaire (PVQ) survey questions.