Postprint of an Experimental Study on the Motivational Effects of Feedback Information Type and Valence on Citizen Science Volunteers' Participation Performance

Authors: Tang Jian, Zhou Xin-xue, Meihua Yu

Date: 2023-04-01T16:02:50+00:00

Abstract

[Purpose/Significance] Providing feedback is an important design for enhancing user motivation and participation. This study investigates the motivational effects of feedback information on the participation performance of citizen science volunteers, providing guidance and recommendations for improving feedback information design in citizen science projects and enhancing volunteer participation performance. [Method/Process] Based on the feedback intervention theory framework, combined with social cognitive theory and flow theory, this study constructs a theoretical model of influencing factors of feedback type and feedback valence on the participation experience and participation performance of citizen science project volunteers, and explores the interaction effect between feedback type and feedback valence. An empirical 2 (feedback type: descriptive vs. evaluative) $\times$ 2 (feedback valence: positive vs. negative) between-subjects experiment is employed to validate the model. [Results/Conclusion] The analysis results indicate that in citizen science projects, feedback type and feedback valence have differential effects on volunteer participation experience; specifically, volunteers have higher self-efficacy in evaluative feedback than in descriptive feedback, and higher self-efficacy and flow experience in positive feedback than in negative feedback. Feedback type and feedback valence have an interactive effect on self-efficacy; in negative feedback, volunteers have higher self-efficacy in evaluative feedback than in descriptive feedback. Volunteer participation experience has a positive effect on participation performance.

Full Text

Preamble

Feedback Information Type and Valence: An Experimental Study on Motivational Effects on Volunteer Performance in Citizen Science Projects

Tang Jian[1], Zhou Xinxue[1], Yu Meihua[2]

[1]School of Information, Central University of Finance and Economics, Beijing 100081
[2]School of Government and Public Affairs, Communication University of China, Beijing 100024

Abstract: [Purpose/Significance] Providing feedback is a crucial design element for enhancing user motivation and participation. This study investigates the motivational effects of feedback information on volunteer performance in citizen science projects, offering guidance for improving feedback design and volunteer engagement. [Method/Process] Grounded in feedback intervention theory and integrated with social cognitive theory and flow theory, we propose a theoretical model examining how feedback type and valence influence volunteer experience and performance, including their interaction effects. A 2 (feedback type: descriptive vs. evaluative) × 2 (feedback valence: positive vs. negative) between-subjects experiment was conducted for model validation. [Result/Conclusion] Results indicate that feedback type and valence differentially impact volunteer experience: evaluative feedback yielded higher self-efficacy than descriptive feedback, while positive feedback produced higher self-efficacy and flow experience than negative feedback. A significant interaction effect emerged for self-efficacy, with evaluative feedback outperforming descriptive feedback under negative valence conditions. Volunteer experience positively influenced participation performance.

Keywords: citizen science; feedback information; participation experience; participation performance; feedback intervention

Citizen science, a new paradigm that mobilizes ordinary public collaboration and collective intelligence for scientific research, has attracted considerable attention from information science, library and information studies, and related fields. Citizen science projects enable volunteers to transcend temporal and geographic constraints, participating in scientific collaboration through data collection, analysis, computational resource sharing, and solution development. Originating in biology and astronomy, citizen science has expanded into digital humanities, exemplified by projects like the Shanghai Library's Sheng Xuanhuai Archives transcription initiative. Such projects enrich citizen science formats while providing new opportunities for advancing digital humanities research.

High-quality volunteer participation is essential for project success and for enhancing public scientific literacy and scientist-citizen collaboration. However, citizen science tasks often demand substantial time and professional knowledge, resulting in limited active participation, inconsistent contribution quality, and challenges in sustaining engagement. While volunteers are primarily motivated by personal interest, altruism, curiosity, and learning, platform designers must also consider effective project-level incentives. From a human-computer interaction perspective, feedback provision creates positive user experiences and attitudes toward technology use. Prior research demonstrates that feedback emphasizing task characteristics effectively motivates citizen science volunteers and improves performance. For instance, the eBird project provides volunteers with contribution statistics, participation duration, and showcases top photographs to encourage sustained involvement.

Despite theoretical discussions on citizen science's significance and volunteer motivation, few studies have empirically examined how specific feedback information dimensions affect volunteer behavior. This research addresses this gap by investigating feedback type and valence effects on volunteer experience and performance, offering practical guidance for citizen science project design.

2. Literature Review

2.1 Citizen Science and Volunteer Performance

Citizen science recruits non-professional scientists, enthusiasts, and public volunteers through online platforms, harnessing collective intelligence for cost-effective research collaboration. Compared to traditional research, citizen science exhibits openness, interactivity, and autonomy. Existing research has explored application domains, volunteer characteristics, and operational mechanisms. Project design studies have investigated platform technology, task characteristics, and user motivations to inform best practices.

Volunteer performance is critical for citizen science success, typically measured through participation intensity (time spent daily), persistence (duration of active engagement), and contribution quantity and quality. Prior studies have examined influences such as task characteristics, personal interest, information quality management, and data collection workflows. Motivations include perceived meaning, enjoyment, personal interests, learning, and societal contribution. However, research from human-computer interaction perspectives on enhancing performance through effective incentive design remains limited.

2.2 Feedback Information Design

Feedback influences individual need satisfaction and intrinsic motivation by providing information about task performance or past behavior, consciously delivered to induce motivation and affect performance. Feedback serves three functions: motivational, reinforcement, and informational. The motivational function is particularly relevant for generating positive user experiences.

Feedback information possesses multidimensional characteristics. Scholars have differentiated feedback by credibility, focus, or value orientation. Feedback valence—positive or negative—indicates performance relative to standards. Positive feedback affirms performance exceeding expectations, while negative feedback criticizes substandard performance. Research suggests valence effects depend on task characteristics.

In citizen science, feedback encourages contribution behavior. The Foldit project uses scores and leaderboards to show volunteers their relative performance. Project progress information and individual performance metrics enhance self-efficacy and perceived enjoyment. J. Laut et al. found that providing different types of peer performance information (none, lagging, similar, or leading) influenced volunteers to adjust their contributions accordingly. K. Scheliga et al. confirmed positive motivational effects of feedback mechanisms, though effective implementation remains limited. Further research is needed on how feedback dimensions affect volunteer experience and performance in citizen science contexts.

3. Model Development and Research Hypotheses

3.1 Research Model

Feedback intervention theory posits that performance information triggers internal motivation, ultimately affecting performance levels. Based on feedback characteristics (standards, goals), different types influence individual focus, experience, and behavior. Social cognitive theory and flow theory, widely used to explain experience-behavior relationships, frame our investigation. Self-efficacy—individuals' belief in their capability to complete tasks—significantly influences virtual community contributions. Flow experience, characterized by challenge and enjoyment, explains deep engagement behaviors.

We propose a "feedback → participation experience → participation performance" framework. Feedback type (descriptive vs. evaluative) and valence (positive vs. negative) influence two participation experiences: self-efficacy and flow. These subsequently affect participation performance, measured by contribution quantity and quality. Descriptive feedback reports task completion data against objective standards, while evaluative feedback provides summarized subjective assessments of performance quality.

3.2 Effects of Feedback Type and Valence on Volunteer Experience

Descriptive feedback provides objective data on completion rates compared to standards. Evaluative feedback offers direct evaluation of ability-related information (e.g., "You did well"), most effectively meeting competence needs and enhancing self-efficacy. Evaluative feedback's emotional language more easily generates positive emotions and flow experiences, effectively satisfying intrinsic needs and fostering pleasant, immersive states.

Feedback valence indicates positive or negative deviations from standards. Negative feedback emphasizes capability deficits, potentially creating stress and performance concerns. Positive feedback satisfies competence and autonomy needs, strengthening capability confidence and intrinsic motivation. Positive feedback enhances perceived enjoyment and persistence, while negative feedback increases tension. Since enjoyment is a key flow dimension, positive feedback is more likely to induce flow experiences.

Hypotheses: - H1a: Evaluative feedback yields higher self-efficacy than descriptive feedback - H1b: Evaluative feedback yields higher flow experience than descriptive feedback - H2a: Positive feedback yields higher self-efficacy than negative feedback - H2b: Positive feedback yields higher flow experience than negative feedback

3.3 Effects of Volunteer Experience on Performance

Self-efficacy represents volunteers' achievement capability beliefs. Higher self-efficacy encourages greater effort and improved performance. R. Tinati et al. found that domain knowledge and skill acquisition are key performance determinants. When individuals experience capability improvement, they demonstrate better performance. Flow experience—characterized by focused attention and interest—facilitates task completion. When volunteers concentrate and lose track of time, task quantity increases. Flow experiences significantly influence knowledge-related behaviors.

Hypotheses: - H3a: Self-efficacy positively influences participation quantity - H3b: Self-efficacy positively influences participation quality - H4a: Flow experience positively influences participation quantity - H4b: Flow experience positively influences participation quality

3.4 Moderating Effect of Feedback Valence

While positive feedback offers motivational advantages, negative feedback highlights performance-standard gaps, creating tension. The literature shows inconsistent effects of negative feedback, suggesting context matters. We examine whether feedback type effects differ by valence.

Under positive feedback, both types provide performance information, but evaluative feedback's emotional language and praise generate higher positive affect and capability perception. Under negative feedback, descriptive feedback emphasizes specific gaps, creating stronger negative psychological impact. Evaluative feedback's summarized assessment (e.g., "poor performance") lacks specific gap perception, reducing impact on self-efficacy. However, evaluative feedback's emotional language may still enhance flow experience relative to descriptive feedback's objective negativity.

Hypotheses: - H5a: The advantage of evaluative over descriptive feedback for self-efficacy is more pronounced under negative valence - H5b: The advantage of evaluative over descriptive feedback for flow experience is more pronounced under negative valence

4. Research Design

4.1 Experimental Design

We developed a citizen science platform based on Zooniverse's natural image annotation project, presenting volunteers with wild plant images for feature identification (flowers, leaves, bark/trunk, fruit, stems). This data analysis task is representative of citizen science projects. A 2$×$2 between-subjects experiment manipulated feedback type (descriptive vs. evaluative) and valence (positive vs. negative), creating four experimental groups.

Feedback content was controlled as shown in Table 1 . Descriptive-positive feedback stated: "Answering 3 correctly meets the standard; you answered x correctly in this group, meeting the standard" (x randomly 3-5). Descriptive-negative feedback stated: "Answering 2 incorrectly fails the standard; you answered x incorrectly in this group, failing the standard" (x randomly 2-5). Evaluative feedback provided summary assessments (positive: "Your performance is excellent"; negative: "Your performance is poor").

4.2 Experimental Procedure

We recruited participants through an online survey platform. After viewing a project introduction, participants were randomly assigned to one of four groups. Each participant viewed 20 plant photos with five feature questions per photo. After the first 5 images, participants received baseline feedback on accuracy to familiarize them with the task. After the next 5 images, they received their group's specific feedback (content predetermined, independent of actual performance). After 15 images, participants could choose to continue with 5 more images or exit. Finally, they completed questionnaires measuring experience, demographics, and manipulation checks.

4.3 Measurement

A 7-point Likert scale adapted from established measures assessed self-efficacy (3 items, e.g., "I am confident in completing citizen science tasks") and flow experience (4 items, e.g., "I am focused when completing tasks"). Participation performance was measured through platform-recorded contribution quantity and quality. Interest in botany was assessed with a single item. Manipulation checks verified feedback content and valence perception.

5. Data Analysis

5.1 Sample Descriptive Statistics

Of 184 recruited participants, 22 were excluded (16 for uniform responses, 6 for failed manipulation checks), leaving 162 valid cases. The sample was 61.1% male, 84% under 39 years old, and 70.4% held college degrees or higher. Kruskal-Wallis tests revealed no significant differences across groups in gender (p=0.407), age (p=0.785), or education (p=0.585), but significant differences in botany interest (p=0.000).

5.2 Reliability and Validity

Confirmatory factor analysis using LISREL 8.80 examined the measurement model. Cronbach's $\alpha > 0.7$ and composite reliability > 0.8 indicated satisfactory reliability. Average variance extracted (AVE) > 0.5 demonstrated good convergent validity. Table 3 shows discriminant validity: the square root of each factor's AVE exceeded its correlation with the other factor.

5.3 Effects of Feedback Type and Valence on Experience

A 2$×$2 MANOVA tested feedback effects on experience (self-efficacy, flow), controlling for botany interest. Table 4 presents means and standard deviations. Significant main effects emerged for feedback type, F(1,160)=6.33, p<0.01, Wilks' λ=0.925, and valence, F(1,160)=27.10, p<0.001, Wilks' λ=0.742. The interaction on overall experience was marginally non-significant, F(1,158)=2.50, p=0.086, Wilks' λ=0.970, but significant for self-efficacy alone, F(1,158)=4.83, p<0.05.

Feedback type: Evaluative feedback produced higher self-efficacy (M=5.80) than descriptive feedback (M=5.04), p=0.000, supporting H1a. No significant difference emerged for flow experience (M_{descriptive}=5.50, M_{evaluative}=5.71, p=0.465), rejecting H1b.

Feedback valence: Positive feedback yielded higher self-efficacy (M=6.24) and flow (M=6.33) than negative feedback (M_{self}-efficacy=4.60, M_{flow}=4.88), both p=0.000, supporting H2a and H2b.

Interaction effect: As shown in Figure 3 [Figure 3: see original paper], under negative feedback, evaluative feedback produced higher self-efficacy than descriptive feedback (Mean Difference=1.24, p=0.000). Under positive feedback, no significant difference appeared (Mean Difference=0.27, p=0.414), supporting H5a. No interaction emerged for flow experience (negative: p=0.201; positive: p=0.954), rejecting H5b.

5.4 Effects of Participation Experience on Performance

Hierarchical linear regression in Stata 14.0 examined experience-performance relationships, controlling for demographics and botany interest. Table 5 shows correlations below 0.7, indicating no multicollinearity. Table 6 presents regression results with robust standard errors to address autocorrelation.

For participation quantity, Model 2 (adding self-efficacy and flow) was significant, F=19.97, $p<0.01$, adjusted $R^2=0.31$. Self-efficacy positively predicted quantity ($\beta=5.27$, $p<0.001$), supporting H3a. Flow's effect was non-significant, rejecting H4a.

For participation quality, Model 2 was significant, F=11.40, $p<0.001$, adjusted $R^2=0.35$. Flow experience positively predicted quality ($\beta=0.04$, $p<0.001$), supporting H4b. Self-efficacy's effect was non-significant, rejecting H3b.

6. Discussion and Conclusion

6.1 Conclusions

Citizen science plays vital roles in solving scientific problems and informing policy. Volunteer engagement drives scientific innovation and enhances public scientific literacy. This study examined feedback mechanisms to improve volunteer experience and performance.

Results demonstrate that evaluative feedback enhances self-efficacy more than descriptive feedback, though both types similarly affect flow experience by providing performance information that maintains task focus. Positive feedback, being affirming and encouraging, produces higher self-efficacy and flow than negative feedback. A significant interaction reveals that under negative feedback, evaluative feedback better preserves self-efficacy compared to descriptive feedback's objective gap-highlighting approach.

Self-efficacy positively influences participation quantity, while flow experience enhances participation quality. The non-significant effects may reflect that quality depends more on knowledge levels than self-efficacy alone, and that immersive focus increases time per task, potentially reducing quantity.

6.2 Research Value and Limitations

This study advances citizen science research theoretically by integrating feedback intervention, social cognitive, and flow theories from a human-computer interaction perspective. It empirically validates feedback effects on performance through experimental methods and explores dimensional interactions. Practically, findings guide project managers in designing effective feedback: evaluative feedback maintains volunteer efficacy, positive feedback sustains engagement, and gameful elements (badges, points) can enhance experiences.

Limitations include: (1) limited feedback types (descriptive/evaluative only) and artificially controlled valence—future research should test natural performance-based feedback; (2) individual characteristics and task features (granularity, difficulty) were not examined as moderators; (3) the plant biology context may limit generalizability to digital humanities citizen science projects.

Future studies should explore these dimensions to deepen understanding of volunteer engagement mechanisms across diverse scientific domains.

Note: Figure translations are in progress. See original paper for figures.

Source: ChinaXiv — Machine translation. Verify with original.