Experimental Study on the Effects of Task Characteristics and Gamification Design on Citizen Science Participation Intention (Postprint)

Authors: Zhou Xin Xue, Tang Jian, Wang Tianmei

Date: 2023-08-27T00:00:00+00:00

Abstract

[Purpose/Significance] This study investigates the influence of task characteristics and gamification design on user participation intention in citizen science—a crowdsourcing model that recruits the general public to collaborate on scientific research—providing guidance for effectively optimizing task design and gamification application in citizen science projects. [Method/Process] Based on the Job Characteristics Model and Self-Determination Theory, a theoretical model of influencing factors on user participation intention in citizen science projects is constructed to explain how citizen science task characteristics affect public participation intention by satisfying basic psychological needs, and to discuss the moderating effect of game elements on the relationship between task characteristics and basic psychological needs. An empirical between-subjects experiment (gamification design group vs. control group) was conducted to obtain 506 valid data points, and the theoretical model was validated using structural equation modeling. [Results/Conclusions] Data analysis results indicate that individuals' three basic psychological needs all positively influence participation intention; the importance of citizen science tasks positively influences relatedness, feedback positively influences competence, and complexity negatively influences competence; while gamification design moderates the relationship between task characteristics and participants' psychological needs.

Full Text

Preamble

An Experimental Study on the Impact of Task Characteristics and Gamification Design on Participation Intention in Citizen Science

Zhou XinXue, Tang Jian, Wang TianMei
School of Information, Central University of Finance and Economics, Beijing

100081

Abstract

[**Purpose/Significance**] This study investigates how task characteristics and gamification design influence user participation intentions in citizen science—a crowdsourcing model that recruits ordinary citizens to collaborate on scientific research. The findings provide guidance for optimizing task design and gamification applications in citizen science projects. [**Method/Process**] Drawing upon job characteristics theory and self-determination theory, we construct a theoretical model explaining how citizen science task characteristics affect public participation intentions by satisfying basic psychological needs, and examine the moderating role of game elements on the relationship between task characteristics and psychological needs. We employed a between-subjects experiment (gamification design group vs. control group) to collect 506 valid responses and validated the theoretical model using structural equation modeling. [**Result/Conclusion**] Results demonstrate that all three basic psychological needs positively influence participation intention. Task significance positively affects relatedness, feedback positively affects competence, and task complexity negatively affects competence. Furthermore, gamification design moderates the relationship between task characteristics and participants' psychological needs.

Keywords: citizen science, task characteristics, self-determination theory, gamification, participation intention

1 Introduction

The emergence and development of crowdsourcing has facilitated mass collaboration among internet users. When the initiators of crowdsourcing projects are scientists or research institutions aiming to solve scientific problems, crowdsourcing evolves from a traditional business model into a novel scientific collaboration paradigm known as scientific crowdsourcing. Scientific crowdsourcing leverages the wisdom and power of online masses to address challenges in scientific discovery and technological innovation, enabling cooperation between scientists, research teams, and the general public to solve specialized or interdisciplinary scientific problems. Compared with traditional business crowdsourcing, scientific crowdsourcing projects are more complex in terms of granularity and attribute structure, requiring careful task design and decomposition to be comprehensible to the public. They also generate more complex and diverse data.

Not all scientific crowdsourcing projects can be defined as citizen science initiatives. Geiger and Schader classified scientific crowdsourcing into emergent and non-emergent types. Emergent scientific crowdsourcing involves individual contributions that form part of a collective whole, aiming to gather extensive distributed information and data. Non-emergent scientific crowdsourcing features independent individual contributions with optimization-based selection, such as competition-based scientific crowdsourcing. Wei et al. categorized scientific crowdsourcing into integrative and selective types, with citizen science belonging to the integrative model. Citizen science projects demonstrate stronger public acceptance and comprehension, yield greater quantities of user feedback and samples, and possess public welfare and social mission attributes.

Citizen science, also known as crowdsourced science or public participation in scientific research, represents a form of collaborative scientific crowdsourcing that recruits large numbers of non-professional scientists, science enthusiasts, and public volunteers through online platforms. Ordinary citizens assist scientists by collecting data, submitting observations, and contributing ideas. Citizen science enhances public awareness of scientific participation, provides information exchange platforms for public training and learning, and helps solve challenging research problems. Wiggins and Crowston classified citizen science projects into five categories based on content and nature: action-oriented projects, conservation projects, investigation projects, virtual scientific projects, and educational projects. Shirk et al. proposed a five-level classification based on participant engagement: contractual projects, contributory projects, collaborative projects, co-created projects, and collegial projects.

Existing research has defined citizen science from multiple perspectives. Some scholars view it as a methodology supporting research in various domains, including public service, nature conservation, and education. Others consider it a tool for connecting human and natural ecosystems, while some regard it as a branch of crowdsourcing—an open scientific research model. In summary, citizen science is a scientific crowdsourcing model emphasizing social, voluntary, and mission-oriented characteristics.

Currently, mature citizen science projects abroad include Galaxy Zoo and Foldit, while China remains in the exploratory stage regarding design and operational mechanisms. This study analyzes domestic and international research on citizen science task design, examining task characteristics and gamification design perspectives. Based on job characteristics theory and self-determination theory, we investigate how task characteristics influence participation intentions by satisfying psychological needs and explore whether gamification design moderates the relationship between task characteristics and basic psychological needs. This research aims to identify the effects of task characteristics and gamification design on public participation intentions, providing specific guidance for designing citizen science projects in China to attract broader participation and promote scientific innovation.

2 Literature Review

2.1 Citizen Science from a Scientific Crowdsourcing Perspective

Scientific crowdsourcing utilizes the wisdom and power of online masses to solve scientific discovery and technological innovation challenges, facilitating collaboration between scientists, research teams, and the general public to address specialized or interdisciplinary scientific problems. Participants may include ordinary citizens as well as researchers from different scientific institutions and teams. Primary tasks encompass data collection, reporting, research design, and assisted R&D, with knowledge and outcomes shared openly through online platforms.

Scientific crowdsourcing represents a problem-solving philosophy and paradigm, yet not all scientific crowdsourcing projects qualify as citizen science initiatives. Citizen science is a specific manifestation of scientific crowdsourcing that emphasizes public welfare and social mission attributes. While scientific crowdsourcing theory provides the foundational framework for citizen science projects, citizen science is rooted in the integrative model of scientific crowdsourcing, where public acceptance and comprehension are stronger, yielding more extensive user feedback and samples.

2.2 Task Design Characteristics

Task design constitutes the core of citizen science projects, with participants completing small tasks to help solve larger problems. Citizen science tasks vary in complexity and modularity, including classification tasks, problem-solving tasks, pattern recognition tasks, and data contribution tasks. Effective task design requires understanding task characteristics. Zheng et al. studied how task attributes—autonomy, variety, task identity, task significance, and feedback—affect participation behavior through intrinsic and extrinsic motivation, finding that increased autonomy, variety, and feedback enhance intrinsic motivation. Shi Lei's research revealed that users prefer crowdsourcing tasks with high rewards, low complexity, and short duration. Finnerthy et al. explored four monetary reward mechanisms, noting that dynamic reward systems improve task completion quality. Chiu examined enterprise crowdsourcing task design, considering appropriateness, feasibility, variety, complexity, task decomposition, and participant matching.

As a specific form of scientific crowdsourcing, citizen science participants are primarily motivated by contribution consciousness and altruism. Projects with significant social impact stimulate public enthusiasm and contribution consciousness. Therefore, task significance represents a critical design attribute. Task interdependence refers to whether tasks are independent or interconnected. Low interdependence enables high autonomy, allowing participants to determine their own completion schedules and approaches. Franzoni and Sauermann classified citizen science projects based on independence and professional skill requirements, finding that projects with greater independence and lower skill demands attract more participants. Additionally, citizen science tasks require different professional skills depending on the scientific domain, with varying complexity levels. High complexity reduces public participation. For instance, in Old Weather and Galaxy Zoo, common knowledge suffices to complete tasks, attracting numerous participants. Finally, feedback is particularly important in citizen science tasks. Given the long duration of such projects, receiving feedback and recognition during participation enhances perceived competence and encourages continued engagement.

2.3 Gamification Design

Gamification design enhances user experience and motivates employee engagement in enterprise software. In educational contexts, gamification represents a novel strategy that increases learner motivation and improves learning outcomes. Landers et al. applied goal-setting theory to investigate leaderboard effects, proposing that others' scores on leaderboards can serve as reference points for participants' goal setting, with higher goals leading to better performance. In citizen science projects, extrinsic factors such as community and software are key to attracting participation, while intrinsic factors—particularly interest in the topic—drive sustained engagement.

The successful integration of gamification and citizen science has prompted scholars to explore multiple dimensions of this relationship. Bowser et al. experimentally found that motivations such as earning badges and competing with others drive citizen science participation. Massung et al. examined three task design approaches: non-gamified tasks, point-based tasks, and tasks combining points with monetary rewards, concluding that gamification enhances performance, efficiency, and sustained participation intention. Motivation research reveals that participation motives include enjoyment, contribution consciousness, and virtual community sense, with gamification serving as a primary factor in maintaining participant motivation.

In summary, existing citizen science research primarily employs descriptive methods to categorize project and task types. However, few studies examine the impact of task characteristics from an empirical perspective, and limited research explores how task characteristics affect participation motivation. Given the specialized nature of citizen science projects, optimizing design to create enjoyment and stimulate motivation is essential. Effective integration of gamification and citizen science project design remains theoretically underexplored. This study comprehensively analyzes citizen science task characteristics, participant psychological needs, and gamification design to investigate factors influencing participation intention, aiming to provide guidance for project design and enrich gamification theory.

3 Model Construction and Research Hypotheses

3.1 Research Model

Task characteristics are inherent attributes of work or tasks. Job characteristics theory proposes that work characteristics influence employee psychological states, subsequently affecting motivation and work outcomes, emphasizing the psychological interaction between work characteristics and employees. Participant motivation and work design are closely interconnected. Self-determination theory posits that human behavior is determined by the degree to which basic psychological needs are satisfied, proposing that autonomy, competence, and relatedness significantly influence intrinsic motivation and behavior.

Based on job characteristics theory and the citizen science task characteristics identified above, this study focuses on four key characteristics—significance, interdependence, complexity, and feedback—combined with the three basic psychological needs from self-determination theory to construct a citizen science participation intention model, as shown in Figure 1 [Figure 1: see original paper].

3.2 Impact of Task Characteristics on Psychological Needs

(1) Significance refers to the meaning of citizen science tasks. Task significance satisfies individuals' relatedness needs, as participants perceive that their contributions positively impact others' work and lives. When participants recognize task meaningfulness, they develop a sense of mission, investing more time and effort, while fostering closer relationships with community members and stronger belonging. Therefore, we propose:

H1: Task significance positively influences relatedness.

(2) Interdependence refers to the degree of connection between tasks. Higher interdependence—where participants' task completion depends heavily on others—reduces autonomy during task completion. Stronger task interconnections lead to lower degrees of individual choice and greater constraints. Therefore, we propose:

H2: Task interdependence negatively influences autonomy.

(3) Complexity refers to task content multiplicity, requiring participants to continuously seek solutions. Zheng et al. found in crowdsourcing research that easily analyzable tasks positively influence intrinsic motivation, while difficult-to-solve problems reduce user enthusiasm. Martinez validated that simple, solvable crowdsourcing tasks positively relate to physical and cognitive engagement. Lower complexity enhances participants' confidence in their competence. Therefore, we propose:

H3: Task complexity negatively influences competence.

(4) Feedback refers to participants receiving timely information about their task execution. When individuals receive recognition for their performance, it generates pleasure and increases confidence for future performance. Receiving feedback on self-performance enhances self-efficacy and boosts pride and enthusiasm for task completion. Feedback about others' participation helps participants adjust their goal setting and enhances self-efficacy. Therefore, we propose:

H4: Feedback positively influences competence.

3.3 Impact of Psychological Needs on Participation Intention

(1) Relatedness is the psychological state where participants feel connected to researchers through citizen science participation and perceive their contributions as helpful to the project team or society. Participating in citizen science tasks represents helping others and sharing knowledge, with relatedness promoting participation behavior. Therefore, we propose:

H5: Relatedness positively influences participation intention.

(2) Autonomy refers to individuals' rights to make sufficient choices when participating in tasks, including freedom to decide completion timing and methods. Crowdsourcing task autonomy positively influences participation intention through intrinsic motivation. When participants' autonomy needs are satisfied, intrinsic motivation drives their participation behavior. Therefore, we propose:

H6: Autonomy positively influences participation intention.

(3) Competence refers to participants' confidence and perceived self-efficacy in citizen science participation. Successfully completing tasks generates self-efficacy that encourages individuals to persist or strive for improvement. Self-efficacy affirmation maintains participation intention in crowdsourcing users. In big data crowdsourcing activities, self-efficacy positively influences participation behavior. Therefore, we propose:

H7: Competence positively influences participation intention.

3.4 Moderating Role of Game Elements

(1) Traditional game elements such as points and leaderboards provide additional motivation, enabling participants to perceive task feedback and communicate and compete with peers. Leaderboards allow participants to compare their performance with others, understanding completion status. Close interaction with other participants enhances belonging. In identical citizen science tasks, gamified forms increase perceived relatedness. Therefore, we propose:

H8a: When game elements are added, the positive relationship between significance and relatedness is strengthened.

(2) Receiving confirmation from others about one's behavior enhances public self-efficacy, increases enjoyment, and leads to higher participation intention. Point acquisition is a dynamic process that generates achievement feelings. Ranking advancement brings honor to participants' efforts. Obtaining points makes participants perceive tasks as more easily completable, continuously enhancing confidence. Leaderboard advancement and point accumulation provide direct feedback on task completion, enabling self-capability affirmation. Andrés et al. found that feedback game elements increase perceived competence. Under identical task designs, gamification provides direct feedback, enhancing self-efficacy and moderating the relationship between feedback/complexity and competence. Therefore, we propose:

H8b: When game elements are added, the negative relationship between complexity and competence is weakened.

H8c: When game elements are added, the positive relationship between feedback and competence is strengthened.

4 Research Design

4.1 Experiment and Scale Design

As China currently lacks mature citizen science projects, this study modeled its experimental task after natural image annotation projects from the UK Zooniverse alliance, which collects seasonal landscape change images requiring participants to identify leaf colors and defoliation patterns to understand plant changes and climate impacts. We employed a between-subjects experimental design, developing an experimental platform where participants answered questions about natural images. As shown in Figure 2 [Figure 2: see original paper] and Figure 3 [Figure 3: see original paper], the experimental group included cumulative scoring and leaderboard game elements, while the control group used a non-gamified citizen science project. Participants were randomly assigned to experimental or control groups and completed questionnaires after task participation.

The questionnaire used a 7-point Likert scale, with items primarily adapted from domestic and international literature and modified according to research objectives. Task characteristic items were adapted from Morgeson and Humphrey's Work Design Questionnaire, gamification design items from Witt et al.'s game element scale, and basic psychological needs items from self-determination theory scales. To ensure measurement validity, after initial questionnaire design, we conducted focus group sessions with experts and graduate students to categorize questions, modifying indicators based on classification results to finalize a 25-item scale.

4.2 Pre-test

We conducted a pre-test survey to ensure reliability and validity, collecting 100 questionnaires for analysis. Cronbach's α assessed reliability, with SPSS analysis revealing overall scale reliability of 0.827 and all factor reliabilities exceeding the 0.7 threshold. The KMO value was 0.82, with Bartlett's test significance at 0.000, indicating data suitability for factor analysis. Using varimax rotation, although only eight components had eigenvalues greater than 1, the ninth component's cumulative variance contribution exceeded 70%, confirming its acceptability and alignment with established variables. Thus, the measurement tool proved valid. To clarify question wording, we revised measurement items for significance and feedback.

5 Data Collection and Analysis

5.1 Experimental Process

The main experiment recruited participants through campus and online platforms. Invited participants accessed the citizen science project platform via links, with the system randomly assigning them to experimental or control groups. Before formal tasks, participants completed three practice image questions to ensure consistent task experience. The formal task comprised 10 image sets requiring annotation. Upon completion, participants finished the questionnaire section. The experiment ultimately obtained 506 valid responses: 337 from university students and 169 from the Zhubajie platform. Gender distribution was consistent across recruitment channels, with most participants aged 20-40 and primarily holding bachelor's degrees (81.6% of sample). The sample comprised 45% male and 55% female participants. Random assignment ensured proportional consistency between groups and the overall sample.

To verify experimental control effectiveness, we conducted independent sample t-tests on game element perception across experimental and control groups. Three measurement items were tested, revealing significantly higher mean scores for game elements in the gamified group ($t = 5.791$, $p < 0.001$), confirming successful experimental control.

5.2 Reliability and Validity Testing

In confirmatory factor analysis, Cronbach's α coefficients greater than 0.7 and composite reliability (CR) greater than 0.8 indicate reliable measurement design and high questionnaire stability. Average variance extracted (AVE) greater than 0.5 demonstrates good convergent validity. Table 1 presents reliability and validity analysis. All factors met ideal standards except feedback and interdependence composite reliabilities, which approached 0.8 and were deemed acceptable.

For discriminant validity testing, we examined the correlation coefficient matrix. Table 1 shows each factor's AVE square root exceeded its correlations with other factors. However, significance and feedback, as well as autonomy and competence needs, showed high correlations. To test discriminant validity, we merged highly correlated variables and refit the model. The chi-square difference was substantial despite only one degree of freedom difference, confirming discriminant validity.

5.3 Structural Equation Model Testing

Using LISREL 8.70, we estimated model parameters via covariance structure modeling and maximum variance method to analyze factors influencing citizen science participation intention. Model fit indices in Table 2 satisfied all requirements, indicating strong data fit for hypothesis testing.

In covariance-based SEM, moderation effects can be validated using product-indicator approaches. For reflective models with measurement reliability/loadings above 0.7, two-stage SEM is appropriate. Our measurement tools exceeded 0.7 reliability, enabling this method to test game elements' moderating effects. Figure 4 [Figure 4: see original paper] presents path coefficients and hypothesis testing results.

(1) Main effects of task characteristics. Results show H5, H6, and H7 reached significance, confirming that relatedness, autonomy, and competence positively influence participation intention. When citizen science task design satisfies these three basic psychological needs, participation intention significantly increases. Regarding task characteristics, significance positively influenced relatedness (H1 supported). When tasks are perceived as important and socially meaningful, contribution consciousness and social belonging drive active participation. Interdependence's effect on autonomy was non-significant (H2 not supported). A plausible explanation is that participants lacked prior citizen science experience, preventing clear perception of task independence/dependence. Additionally, some users perceived leaderboards as creating dependency—seeing others' progress motivated them to complete more—potentially biasing interdependence responses. Complexity significantly and negatively influenced competence (H3 supported), while feedback significantly and positively influenced competence (H4 supported). Higher complexity reduces competence perceptions, whereas timely feedback about completion status and project progress enhances achievement feelings and self-efficacy, stimulating participation.

(2) Moderating effects of game elements. Since participants' varying attention to game elements differentially affects behavior, and greater attention yields more significant effects, we treated game elements as a latent variable measuring individual perception rather than a simple categorical variable. This approach assessed participants' attention to scores and leaderboards to more effectively validate moderating effects.

For game elements' moderating role, the product indicator of significance and game elements significantly and positively influenced relatedness ($\beta = 0.0018$, $p < 0.05$). Since significance positively affects relatedness, gamification strengthened this relationship (H8a supported). The complexity-game elements product indicator significantly and positively influenced competence ($\beta = 0.011$, $p < 0.05$). Given complexity's negative effect on competence, gamification weakened this negative relationship (H8b supported). However, the feedback-game elements product indicator showed the opposite relationship ($\beta = -0.0045$, $p < 0.001$), failing to support H8c. A possible explanation is that leaderboards sometimes reduce motivation, as participants seeing high scores may develop feelings of unattainability, diminishing competence when used as feedback.

6 Discussion and Conclusion

6.1 Summary and Recommendations

As citizen science becomes part of daily life, greater participation provides crucial project support. Citizen science tasks harness collective intelligence to deliver substantial value to research. Institutions with extensive collections and cultural heritage, such as libraries and archives, can utilize citizen science for resource improvement and ancient text classification, obtaining more economical solutions through collective participation and wisdom.

This study offers several key recommendations for citizen science task design. First, individuals have psychological needs in every activity. When basic psychological needs are satisfied, sustained participation is encouraged. We validated that relatedness, autonomy, and competence positively affect participation intention. Therefore, good citizen science design should maximize satisfaction of these three needs. Second, to satisfy relatedness needs through task characteristics, projects should clearly articulate their significance and importance, helping users understand substantive task content, enhancing belonging, and stimulating participation intention. Third, to satisfy competence needs, task design should reduce complexity, minimize cumbersome procedures, and lower challenge levels to enhance competence perceptions and participation enthusiasm. Additionally, feedback design is crucial—timely feedback significantly impacts participants by informing them about personal progress and project advancement. Fourth, gamification applications are increasingly prevalent. Our experiment confirms that game elements moderate relationships between task characteristics and psychological needs, positively influencing citizen science task design. Beyond providing enjoyment, game elements foster belonging through competition and enhance competence perceptions, effectively increasing participation motivation. Therefore, applying gamification to citizen science projects represents an effective method to attract broader participation.

6.2 Limitations and Future Directions

This study has several limitations. First, model construction could benefit from further exploration. Different citizen science project types have varying characteristics and participation requirements, warranting deeper investigation into how diverse project features affect participants. Second, China's lack of mature citizen science platforms prevented surveying actual participants. Our simulated project incorporated identified task characteristics, but investigating one-time participants cannot fully substitute for surveying experienced individuals, potentially creating perception biases. Future research could integrate specific digital humanities platforms to examine how citizen science models drive digital humanities knowledge service innovation. Finally, regarding gamification applications, this study only examined points and leaderboards, without comprehensively considering all game elements. Future research should investigate richer gamification designs and how varying game element types and intensities influence participant behavior.

References

[1] Zhang Jiuqing. Impact of scientific crowdsourcing on Chinese research activities [J]. China Science and Technology Forum, 2015(3): 1.

[2] Shirk J, Ballard H, Wilderman C, et al. Public participation in scientific research: a framework for deliberate design [J]. Ecology and Society, 2012, 17(2): 29-48.

[3] Zhao Yuxiang. Citizen science projects from a scientific crowdsourcing perspective: conceptual analysis, model exploration, and disciplinary opportunities [J]. Journal of Library Science in China, 2017, 43(5): 42-56.

[4] Pang Jiangang, Liu Zhiying. Research on scientific crowdsourcing-based technological innovation—From the perspective of network mass technological innovation input [J]. China Soft Science, 2016(5): 184-192.

[5] Huang Mincong. The rise of citizen science and the role of libraries [J]. Library and Information Service, 2014, 58(14): 59-62.

[6] Wang Ye. Research on library support services under the scientific crowdsourcing model [J]. Library Research, 2017, 47(4): 62-65.

[7] Zhang Shaoli, Zheng Xiaoqi. Innovation and implementation paths of scientific crowdsourcing network models [J]. China Science and Technology Forum, 2016(9): 5-10.

[8] Geiger D, Schader M. Personalized task recommendation in crowdsourcing information systems—current state of the art [J]. Decision Support Systems, 2014, 65(C): 3-16.

[9] Wei Dongqi, Jiang Tao, Tao Siyu, et al. Scientific crowdsourcing—a new model of scientific cooperation [J]. Science Research Management, 2015, 33(2): 16-19.

[10] Franzoni C, Sauermann H. Crowd science: the organization of scientific research in open collaborative projects [J]. Research Policy, 2014, 43(1): 1-20.

[11] Wiggins A, Crowston K. From conservation to crowdsourcing: a typology of citizen science [C]//Proceedings of the 2011 44th Hawaii International Conference on System Sciences. Hawaii: IEEE Computer Society, 2011: 1-10.

[12] Kobori H, Dickinson JL, Washitani I, et al. Citizen science: a new approach to advance ecology, education, and conservation [J]. Ecological Research, 2016, 31(1): 1-19.

[13] Sagarra O, Gutierrez-Roig M, Bonhoure I, et al. Citizen science practices for computational social sciences research: the conceptualization of pop-up experiments [J]. Frontiers in Physics, 2016, 3: 93.

[14] Preece J. Citizen science: new research challenges for human-computer interaction [J]. International Journal of Human-Computer Interaction, 2016, 32(8): 585-612.

[15] Crain R, Cooper C, Dickinson JL. Citizen science: a tool for integrating studies of human and natural systems [J]. Annual Review of Environment & Resources, 2014, 39(1): 641-665.

[16] Dickinson JL, Zuckerberg B, Bonter DN. Citizen science as an ecological research tool: challenges and benefits [J]. Annual Review of Ecology & Systematics, 2011, 41(1): 149-172.

[17] Pilny A, Keeegan B, Wells B, et al. Designing online experiments: citizen science approaches to research [C]//Proceedings of the 19th ACM conference on computer supported cooperative work. San Francisco: ACM, 2016: 498-502.

[18] Niu Yichong, Zhao Yuxiang, Zhu Qinghua. Exploring the operational mechanism of citizen science projects based on scientific crowdsourcing—A case study of Evolution MegaLab [J]. Library and Information Service, 2017, 61(1): 5-13.

[19] Fan Wenqiang, Wang Zhibo, Han Yingying. Analysis of open research models and changes to university research operations [J]. Modern Distance Education Research, 2016(3): 59-68.

[20] Gadiraju U, Demartini G, Kawase R, et al. Human beyond the machine: challenges and opportunities of microtask crowdsourcing [J]. IEEE Intelligent Systems, 2015, 30(4): 81-88.

[21] Estelles-Arolas E, Gonzalez-Ladron-de-Guevara F. Towards an integrated crowdsourcing definition [J]. Journal of Information Science, 2012, 38(2): 189-200.

[22] Zheng HC, Li DH, Hou WH. Task design, motivation, and participation in crowdsourcing contests [J]. International Journal of Electronic Commerce, 2011, 15(4): 57-88.

[23] Shi Lei. Research on factors influencing user participation behavior in Chinese crowdsourcing platforms [D]. Chongqing: Chongqing University, 2012: 1-34.

[24] Finnerthy A, Kucherbaev P, Tranquillini S, et al. Keep it simple: reward and task design in crowdsourcing [C]//Proceedings of the biannual conference of the Italian chapter of SIGCHI. Trento: ACM, 2013: 1-4.

[25] Chiu CM, Liang TP, Turban E. What can crowdsourcing do for decision support? [J]. Decision Support Systems, 2014, 65(1): 40-49.

[26] Bowser A, Hansen D, He Y, et al. Using gamification to inspire new citizen science volunteers [C]//Proceedings of the first international conference on gameful design, research and applications. Toronto: ACM, 2013: 18-25.

[27] Aristeidou M, Scanlon E, Sharples M. Profiles of engagement in online communities of citizen science participation [J]. Computers in Human Behavior, 2017, 74: 246-256.

[28] Erdos F, Kallos G. Benefit evaluation model for gamified add-ons in business software [J]. Acta Polytechnica Hungarica, 2014, 11(5): 109-124.

[29] Figueroa FJF. Using gamification to enhance second language learning [J]. Digital Education Review, 2015, 27: 32-54.

[30] Landers RN, Bauer KN, Callan RC. Gamification of task performance with leaderboards: a goal setting experiment [J]. Computers in Human Behavior, 2015, 71(1): 508-515.

[31] Massung E, Coyle D, Cater KF, et al. Using crowdsourcing to support pro-environmental community activism [C]//Proceedings of the SIGCHI conference on human factors in computing systems. Paris: ACM, 2013: 371-380.

[32] Iacovides I, Jennett C, Cornish TC, et al. Do games attract or sustain engagement in citizen science? A study of volunteer motivations [C]//CHI'13 extended abstracts on human factors in computing systems. Paris: ACM, 2013: 1101-1106.

[33] Curtis V. Motivation to participate in an online citizen science game: a study of Foldit [J]. Science Communication, 2015, 23(6): 967-974.

[34] Meng Liang. Task design and individual intrinsic motivation based on self-determination theory: an empirical study from a cognitive neuroscience perspective [D]. Hangzhou: Zhejiang University, 2016: 21-34.

[35] Deci EL, Ryan RM. The "what" and "why" of goal pursuits: human needs and the self-determination of behavior [J]. Psychological Inquiry, 2000, 11(4): 227-268.

[36] Martinez MG. Solver engagement in knowledge sharing in crowdsourcing communities: exploring the link to creativity [J]. Research Policy, 2015, 44(8): 1419-1430.

[37] Hamari J. Transforming homo economicus into homo ludens: a field experiment on gamification in a utilitarian peer-to-peer trading service [J]. Electronic Commerce Research & Applications, 2013, 12(4): 236-245.

[38] Zhong Qiuyan, Wang Yanjie, Qiu Jiangnan. Empirical study on user sustained participation behavior in crowdsourcing communities [J]. Information and Documentation Services, 2014(3): 74-79.

[39] Wu Jinhong, Chen Qiang, Ju Xiufang. User willingness to participate in big data crowdsourcing activities and influencing factors [J]. Journal of Dalian University of Technology (Social Sciences Edition), 2011, 32(1): 1-6.

[40] Lindenberg S. Intrinsic motivation in a new light [J]. Kyklos, 2001, 54(2/3): 317-342.

[41] Andres FA, Aparicio S, et al. Analysis and application of gamification [C]//Proceedings of the 13th international conference on human-computer interaction. Elche: ACM, 2012: 1-2.

[42] Morgeson FP, Humphrey SE. The work design questionnaire (WDQ): developing and validating a comprehensive measure for assessing job design and the nature of work [J]. Journal of Applied Psychology, 2006, 91(6): 1321-1339.

[43] Witt M, Scheiner C, Robra-Bissantz S. Gamification of online idea competitions: insights from an exploratory case [C]//Proceedings of Informatik 2011 - Informatik schafft Communities, Lecture Notes in Informatics. Berlin: Informatik schafft Communities, 2011: 192-206.

[44] Deci EL, Connell JP, Ryan RM. Self-determination in a work organization [J]. Journal of Applied Psychology, 1989, 74(4): 580-590.

[45] Fornell C, Larcker DF. Evaluating structural equation models with unobservable variables and measurement error [J]. Journal of Marketing Research, 1981, 18(1): 39-50.

Author Contributions

Zhou XinXue: Proposed research ideas, designed paper framework, collected data, wrote and revised paper.
Tang Jian: Proposed research direction, provided revision guidance.
Wang TianMei: Determined paper topic, provided revision guidance, writing instruction.

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