

The Research on Design Framework for Citizen Science

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Abstract

Citizen science is a process in which ordinary citizens contribute to scientific research. How to create citizen science design framework to achieve better awareness, initiative and action is our research focus. This paper will explore citizen science design in the context of smart city, on the basis of activity theory and by means of digital social innovation. “Smart City” concept provides new elements including social communication, collaborative design and innovative community to citizen science. With the rapid development of science and information & communication technologies (ICTs) and with the arrival of Web 2.0, social innovation is endowed with digital factors so as to be evolved to digital social innovation (DSI) which gives various design perspectives on citizen science and also plays an important part in establishing citizen science evaluation model. In this paper, a citizen science design framework consisting of citizen science content model, design model and evaluation model is proposed by discussing related theories, models and citizen science cases. It acts as not only design lead to inspire two citizen science case practices, but also an evaluation term in the view of citizen science. The framework and models developed in this research will hopefully be leveraged and refined to support citizen science design in the future.

Keywords: citizen science; smart city; activity theory; digital social innovation

Introduction

Smart City Background

Smart city is envisioned as a kind of wired and ICT-driven cities that provide better urban life [1], innovative services [2], new business opportunities [3], efficient governance and sustainable environment development [4]. More and more cities are beginning to consider civic participation, and regard the smart citizen as a new direction of smart city. A smart sustainable city is an innovative city that uses information and communication technologies (ICTs) and other means to improve quality of life, efficiency of urban operation and services, and competitiveness, while ensuring that it meets the needs of present and future generations with respect to economic, social and environmental aspects” [5]. It is called technology-intensive city in which sensors spread and technology plays an indispensable part and it is one of the directions of smart city. While the other direction of smart city focuses on smart citizens. The common characteristic is embarking from the reality of the community needs, using the new techniques of digital tools, through participatory design so that the public participate in the maintenance of the new community building activities [6]. So smart city is characterized by comprehensive perception, ubiquitous connectivity, pervasive intelligence, and people-centered sustainable innovation which are featured by

user innovation, mass innovation, open innovation, and collaborative innovation [7]. Smart citizens, comprehensive perception, ubiquitous connectivity, pervasive intelligence, people-centered sustainable innovation are in some degree related to developmental features of citizen science. Consequently, smart city is regarded as the context where citizen science is formed, developed, advocated and popularized.

Tech Background

In the era of information, modern information and communication technology (ICT) plays a significant part in citizen science emergence and development. According to O'Reilly [8], "Web 2.0 is the business revolution in the computer industry caused by the move to the Internet as platform, and an attempt to understand the rules for success on that new platform. Chief among those rules is this: build applications that harness network effects to get more people to use them". In the background of Web2.0, new technologies such as the Internet, big data, cloud computing, wearable devices, intelligent home, artificial intelligence and SNS (Social Networking Services) have been applied to citizen science design.

Citizen Science Background

Citizen science is derived from open science which is the first scientific movement fueled by social network revolution. Over the last 5-10 years, citizen science has become increasingly popular. New digital tools make crowdsourcing more popular and a range of digital devices and sensors enable volunteers to collect, submit, and verify data. Following [9], the definition of citizen science is the form of collaboration involving active engagement of members of the public in scientific projects which address real world problems. There are different types of citizen science involving different levels of skill and commitment. Citizen scientists may participate in all aspects of the scientific method, from problem formation, to data collection, to analysis, and dissemination of the research results [10]. Leveraging well designed, accessible social media, crowdsourcing, cloud computing, remote sensing, visualization and gamification technologies hold great promise for citizen science.

Related Research

Related Theories

Among theories, the most important theory referred in this paper is activity theory. Activity theory (AT) is more of a descriptive meta-theory or framework than a predictive theory. It considers an entire work/activity system (including teams, organizations, etc.) beyond just one actor or user. It accounts for environment, history of the person, culture, role of the artifact, motivations, and complexity of real life activity. One of the strengths of AT is that it bridges the gap between the individual subject and the social reality—it studies both through the mediating activity. The unit of analysis in AT is the concept of object-oriented, collective and culturally mediated human activity, or *activity system*. This system includes the object (or objective), subject, mediating artifacts (signs and tools), rules, community and division of labor [11]. A particular activity is a goal-directed or purposeful interaction of a subject with an object through the use of tools, which indicates that citizen science can be thought as a purposeful interaction of a citizen subject with an science object through the

use of technology tools. AT recognizes the internalization and externalization of cognitive processes involved in the use of tools, as well as the transformation or development that results from the interaction [12]. So does citizen science.

Social Innovation and Digital Social Innovation

Social innovation has gained acceptance and popularity in both economic and social areas now. The current Stanford definition of social innovation describes that, “a social innovation can be a product, production process, or technology (much like innovation in general), but it can also be a principle, an idea, a piece of legislation, a social movement, an intervention, or some combination of them” [13]. Robin Murray, Julie Caulier-Grice and Geoff Mulgan from the Young Foundation defined six stages of social innovation and they are prompts, inspirations and diagnoses, proposals and ideas, prototyping and pilots, sustaining, scaling and diffusion, and systemic change [14].

Originated from social innovation, digital social innovation is one kind of social innovation whose objective is to help raise different solutions to the same problems in digital ways. Six areas are presented in NESTA’s report and they are open democracy, open access, collaborative economy, awareness network, new ways of making and funding acceleration and incubation [15].

Design and Development of Citizen Science

Citizen science has a research history and a great many application areas. Along with the historical process, amateurs are involved in scientific research process with different participation degrees. In 1874, a project was launched to measure the transit of the planet Venus and its personnel gathered and collected data from multiple positions on the globe simultaneously [16] and this project was the first successful citizen science example. The typical application is organism monitoring ranging from living organism monitoring to environmental monitoring. For living organism monitoring, the most popular part is related to ornithology whose notable projects are online citizen science projects Neighborhood Nestwatch [17] and Breeding Bird Survey [18] in 1966. Besides, the diversity of bees is monitored in the Great Sunflower Project [19]. The quantity of invasive crab species in the coast of USA is calculated in Invasive Tracers program [20] by citizens and coral reef biodiversity is monitored through space and time by citizen science program [21]. Some projects, such as the Citizen Weather Observer Program [22], focus on environmental monitoring rather than observing living organisms and the timing of cherry blossom has been recorded in Kyoto for 1200 years in citizen science programs.

The citizen science application needs support of citizen science models which witness three stages of development. The first is called science shop model or scientific consulting research model which argues that the problem formulated by amateurs are consulted, verified and modified by a certain science institution [23]. The second model “participatory action research model” suggests that amateurs join in every phase of scientific process together with professionals [24]. The third model is iterative and it created a loop in which amateur citizen and professional citizen verify science research progress and attains better citizen science, which is known as adaptive citizen science research model [25]. Following model theory, the typology of citizen science also takes shape and differentiates citizen science projects based on the criterion of public participation and three classes are contributory, collaborative and co-created [26].

Citizen Science Design Framework

Citizen Science Content Model on Activity Theory

Proposed by Vygotsky, Leont'ev and Luria, activity theory examines collective mediated behavior directly towards an outcome by taking activities as analyzing units [27], and regards expertise as a collective phenomenon and provides an understandable context where activities with tech features take place during the process of design and evaluation [28]. Subject, object, tools, community, rules, and division of labor and the key content elements which form four subsystems including production, exchange, consumption and distribution. [29]

Smart city is a context in which interaction occurs between people and people, people and environment, people and connected technology, as well as connected technology and environment. Main three elements, people, technology and environment discussed here form a collective and collaborative mutual triangle relationship just corresponding to activity theory basic model by seeing subject as people, object as environment and tool as technology. The triangle relationship and three elements as triangle's three vertices together make citizen science content model take shape, which is shown in Figure 1. The center, in other words, core of this content model is citizen science design, a kind of activity derived from human activities in activity theory and most importantly, "outcome" in activity theory is interpreted as "new citizen science experience" here that specifically includes better awareness, initiatives, actions, solutions and so on. Therefore, the whole content model can be explained in this way that design aspects including people, technology and environment are synthetically taken into consideration to discover new citizen science experience with the purpose of creating better objects, subjects and tools for citizen science.

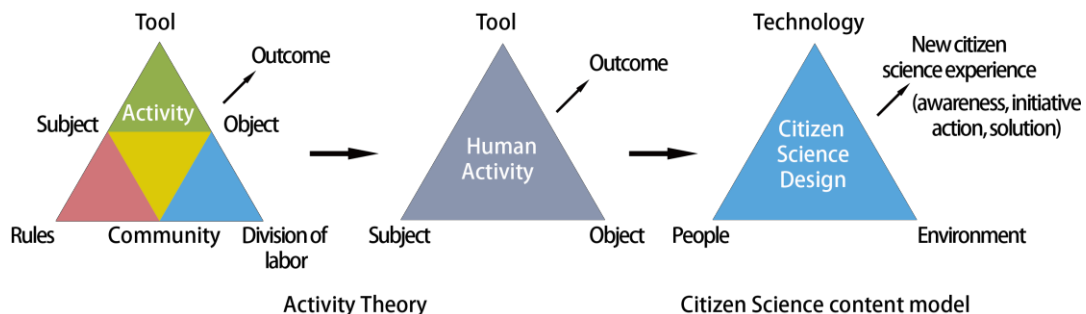


Figure 1: Citizen Science Content Model Informed by Activity Theory

Inspired by our previous research on activity theory principles for urban experience inclusive of Object-oriented, Mediation & artifact, Hierarchical structure, internalization & externalization and Development [30], activity theory principles for citizen science is put forward and embodied.

Object-oriented: Citizen Science is citizen-oriented science whose design needs to consider social, technological and cultural factors apart from physical features.

Mediation & artifact: Mobile device and social media become new mediation between citizen and smart city.

Hierarchical structure of activity: Activity is motive-oriented and composed of actions; user's needs lead to the motive. Action is the goal-oriented and motive defines the goal of

actions. Action consists of a series of operation [30]. Science design activities can also be decomposed into different design actions which can be decomposed into various design operations and for each action or operation there shall be a variety of interaction design points.

Internalization and externalization: Internal mental representations will affect the external interaction, and meanwhile, the external interaction process or pattern can also change people's mental representation [30]. Good citizen science design is not only capable of matching people's internal minds but also capable of letting people get access to smarter external scientific research ways and broader science scope.

Development: Time elapse and environment swift should be concerns for they can change people's behavior and activity and have influence on citizen science design. Besides activity theory principles, the activity checklist is intended to clarify the most important contextual factors of interaction. There are two versions of the checklist, the evaluation version and the design version [31]. The design checklists of research model informed by activity theory model are made up by four aspects: Means and ends, Environment, Learning and cognition and Development. Similarly, the four aspects can be also applied to citizen science design and interaction, which are demonstrated as follows.

Means and ends: To identify the main participants of citizen science, and which technology facilitates and constrains the attainment of participants' goals, what the conflicts between different goals in creating new citizen science experience are.

Environment: To integrate physical scientific field, Internet of things and social technology with requirements, tools, resources, and social rules of the environment from the virtual and physical aspects.

Learning and cognition: To conclude and analyze people's cognitive responses to citizen science interface, citizen science service systems and mutual transformations with target technology.

Development: To take the developmental transformation of the citizen science as an issue, and explore the more effective citizen science product or platform in a dynamic structure from macro and micro viewpoint.

Citizen Science Design Model on DSI

Digital social innovation advocates a type of social and collaborative innovation in which innovators, users and communities collaborate using digital technologies to co-create knowledge and solutions for a wide range of social needs and at a scale that was unimaginable before the rise of the Internet [32]. In the context of digital social innovation which has social, collaborative and connective features, citizen science content model can be further interpreted through adding social properties to "people" element to turn "people" to "social network" and in the meanwhile through endowing holistic concept "technology" with collaborative properties to turn "technology" to "connected things". Additionally, the concept "community" popular in smart city and DSI gives us suggestions on how to embody "environment". Considering that citizen science actions and operations are executed in a dynamic geographical spread that has local community, regional community and global community. These communities all play a part as "knowledge or science

containers”. To be specific, we call it scientific field where science is stored, discovered, spread and popularized.

Conclusively, the three triangle vertexes in citizen science content model are respectively changed to social network, connected things and scientific field while the core is still citizen science design and objective is to achieve new citizen science experience as well. All these elements form the citizen science design model is shown in Figure 2.

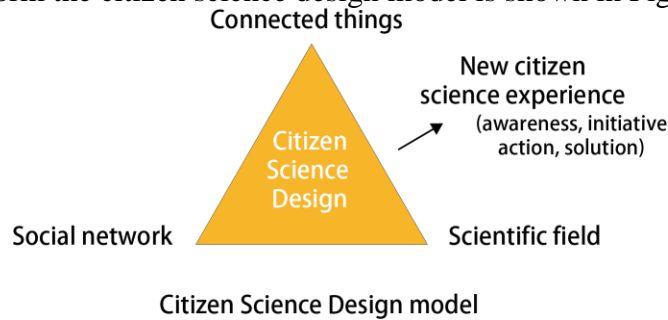


Figure 2: Citizen Science Design Model on DSI

The reason why we call it citizen science design model is that during the process of design embodiment of citizen science content model informed by activity theory, there emerge many design chances and challenges when analyzing better design and realization of three model elements in the context of digital social innovation.

Specifically, for social network, the features Online/Offline and Collective/Individual can be applied in view of the fact that there are online and offline social network in which science can be collected collectively or individually. For connected things, the features Platform/Product, Result / Process and Light/Heavy can be applied by considering that connected things can be understood as Internet of Things whose pattern can be platform or product and their deliverables can be result-oriented, a full product or process-oriented, a middleware or collected data. As for Light/Heavy, connected things system can be complex or simplified and operated in a light way which requires less resources or a heavy way which requires more intelligent social computing. For scientific field, the features Original/Reformed can be applied with an opinion that science has original forms such as natural science and reformed forms such as community collective science. The feature Open/Customized can also be an approach in consideration of open science, open data, professional knowledge and customized science. What discussed above is shown in Figure 3.

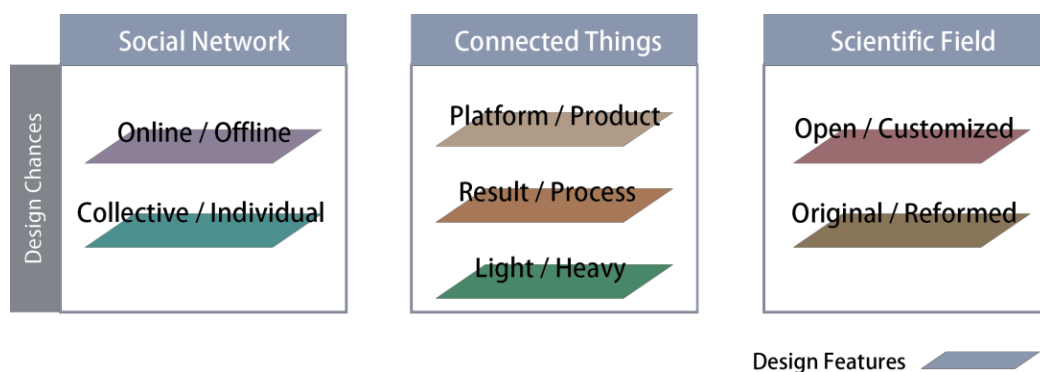


Figure 3: Design Features and Design Chances of Model Elements

Citizen Science Evaluation Model

Design activity needs evaluation. Therefore, we propose a citizen science evaluation model based on the elements in citizen science design model and seven pairs of design features. Firstly, pair features Online/Offline and Collective/Individual can be used to evaluate engagement and interactivity among participants in citizen science. Secondly, for design features of connected things, Platform/Product, Result/Process can be used in interactivity evaluation in view of Internet of Things while Light/Heavy plays a part in feasibility evaluation in regard to technology. Finally, as for Open/Customized and Original/Reformed features of scientific field, due to which science accessibility evaluation and science feasibility evaluation is concluded. What analyzed above is shown in Figure 4.

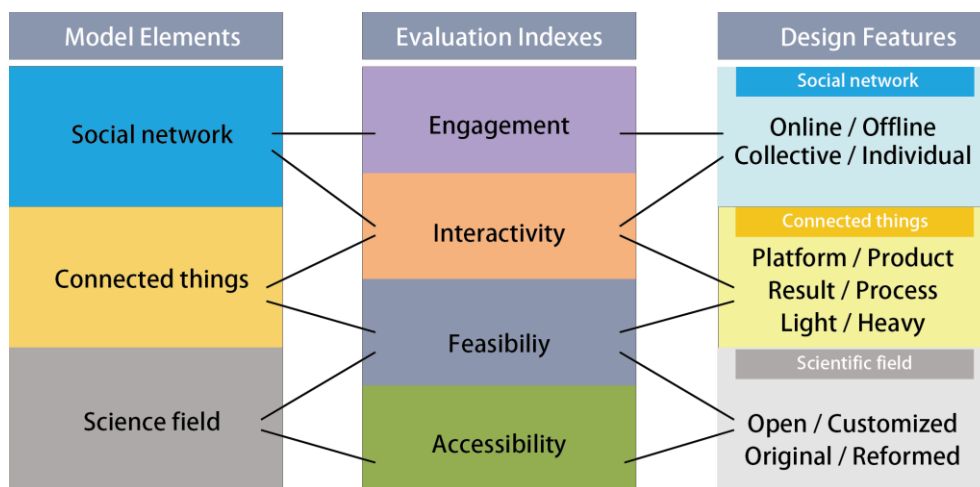


Figure 4: Citizen Science Evaluation Model

Case Studies

Case1: “ZoosseeFun” program and citizen science for zoological knowledge
 “ZoosseeFun” is a program with the aim to make people/citizen have more convenient and direct access to animal introduction and knowledge on a visit in a zoo, in the wild and in normal life. The overview of “ZoosseeFun” program is shown in Figure 5.



Figure 5: Overview of “ZoosseeFun” Program

Citizen science content model of “ZooseeFun” program.

In “ZooseeFun” program, we specify three elements of citizen science content model, “Environment” as “Zoo” ,”Zoo” here is a broad concept including physical zoo in city and natural zoo in wild and normal life, “People” as “Animal observers” and “Tech” as “Connection and Recognition”. Four aspects of design checklist of activity theory are used to identify how “ZooseeFun” achieves new citizen science experience.

Means and ends: The first using context is physical zoo and users are positioned as zoo visitors. Due to defects of current science popularization which is confined to boring text descriptions and a few images, more direct, interesting and abundant means for zoological science are come up with thanks to recognition technology and interaction design. The recognition technology enables visitors to attain basic introduction of a certain kind of animal by just taking a photo anytime and anywhere. The interaction design makes science spread in the form of sound, small videos. Visitors obtain zoological science by interacting with application with a positive method rather than a passive way that visitors just read the introduction board and know something limited to do with some animal.

The users range is then broadened and extended to animal observers who are amateurs or professionals. They are all allowed to upload information of some kind of animal with a short passage or paragraph of own introduction from an experience view or a professional view.

Environment: Zoological science environment has physical aspect and abstract aspect. For physical aspect, zoo is the place where citizen science is popularized through introduction boards, posters on infrastructures and QR code. For abstract aspect, zoo includes natural zoo, the wild and even normal life. Zoo here is considered as the occasions on which animals can be met or observed.

Integrating communication technology with environment is the key to fulfill new citizen science experience in zoological areas. Take physical zoo as an example, each infrastructure can be a scanning target capable of telling people some part of zoological science after they are scanned by smart phones and additionally each infrastructure is able to be connected with each other to create a scientific knowledge circle which facilitates understanding of multi-part and complicated zoological science.

Learning and cognition: There are many endangered species around the world but people still lack awareness of what they are, where they live and how endangered they are. This program takes advantage of interesting interaction of citizen science interface to get people to better known current station of endangered animals. Consequently, more attention will be paid to protection of endangered animals.

Development: Since animal knowledge is able to be handled so is plant knowledge. The extra functions such as plant science popularization, historical places of interest knowledge exploration can be developed to create a comprehensive citizen science program.

Citizen science design model of “ZooseeFun” program

For three elements of citizen science design model, social network, connected things and scientific field whose meanings in “ZooseeFun” program has been described in content model, the emphasis here is on the design opportunities, seven pairs of design features.

Table 1: Design Opportunities of “ZooseeFun” Program in Design Model

Element	Pair features	Design opportunities
Social network	Online/ Offline	For online feature, participants upload zoological science observation results and views, have discussions in online community to help each other to know zoological science, which inspires us to design a online platform on which people share animal knowledge and do some social activities. For offline feature, online community helps to form zoological science offline community where people take part in a citizen science program by conducting field observing together.
	Collective/ Individual	Collective feature inspires us not to ignore amateurs’ knowledge which is indispensable for collective intelligence. Individual feature inspires us to consult experts on zoological science regularly in citizen science design to better fulfill new citizen science experience.
Connected things	Platform/ Product	Platform feature tells us to create a open and collaborative platform for zoological science. Product feature inspires us not to confine our focus on platform, smart hardware product for zoological science can be a great design choice in the context of Internet of Things.
	Result/ Process	Result and process features inspire us attach importance to not only people’s knowing animal knowledge, but also big data in zoo for better zoo management.
	Light/ Heavy	Light feature means a simple and interesting way to get zoological science is needed such as scanning or taking a picture. Heavy features means Internet of Things can be made best use of, to be specific, connected zoo infrastructures to create a smart zoo for better citizen science though more resources will be cost.
Scientific field	Open/ Customized	Open feature inspires us to create a open environment for people free to share and obtain zoological science, for instance, observing panda activity. Customized feature inspires us to arrange customized zoological science learning and playing activities for customized needs.
	Original/ Reformed	Original and reform features remind us to design a iterative zoological science systems where zoological science is updated from the original state.

Citizen science evaluation model of “ZooseeFun” program

According to evaluation indexes discussed above, we come up with some detailed evaluation aspects for each evaluation index. For “engagement” evaluation index, the two evaluation aspects are knowledge and experience sharing and offline observation participation. For “interactivity” evaluation index, the two evaluation aspects are human communication with humans or objects and scientific knowledge link among connected things. For “feasibility” evaluation index, the two evaluation aspects are open framework/hardware and big data processing. For “accessibility” evaluation index, the two evaluation aspects are knowledge acquisition ways and knowledge openness. We used the 5-point scale to evaluate the design (1=totally disagree, 5=totally agree). For each aspects, we had two items to evaluate. 16 items were included in the scale (as shown in Table2). When doing the evaluation, we showed the order of these 16 items in random.

Table 2: The scale to evaluate “ZooseeFun”

Items	Aspects
Adding information to a real scene allows me to better understand the animal and learn the relevant knowledge.	Offline observation participation
When visiting the animals, it's a kind of boring if I can only see the animals through the fence.	
If I can see someone else's sharing relevant information, I think it will be more interesting.	Knowledge sharing
When I visit the animals, I want to be able to learn the ideas and opinions of others and see what others are paying attention to.	
If I can comment and communicate with others through this software, I think it will be more interesting.	Communication/commenting
I want to "take these animals home" to communicate and share with families or friends who cannot come along with me.	
If the software can help me link and set up the knowledge between animals, I think I will understand the animals and the relationship between them better.	Knowledge link among things
When I visit the animals, I want to know or see how animals live in different seasons.	
It is more convenient for me to get a description by scanning or taking pictures of animals.	Openness for knowledge
It's a kind of trouble when I need to squeeze the crowd and get close to the introduction card to get the relevant knowledge of animals.	
It's very natural and easy for me to get information by clicking the button or voice.	Knowledge acquisition ways
I hope that someone can give me an introduction when I am watching animals.	
Through a large amount of data of the various aspects of the animal, my understanding of animals can be deeper.	Big data processing
I would like to learn the data of how much food animals eat every day, the amount of exercise they take and their weight etc., which makes me feel very interested.	
If this software allows users to modify and improve their content and functions, I will be more inclined to use it.	Open framework
I would like to have a software that can be edited and defined with functions about the various animal information.	

Based on these detailed evaluation aspects, we did an evaluation survey among 30 users of “ZooseeFun” program where users give rating for each evaluation aspect. The overall evaluation result is shown in Figure 6 below. A one-sample test was conducted. All the indexes are significant higher than 3 (all $p < 0.000$). So all the indexes are important for design. Interactivity index got the highest score, which indicates that human communication with humans or objects and scientific knowledge link among connected things are very important to people when they visiting the zoo.

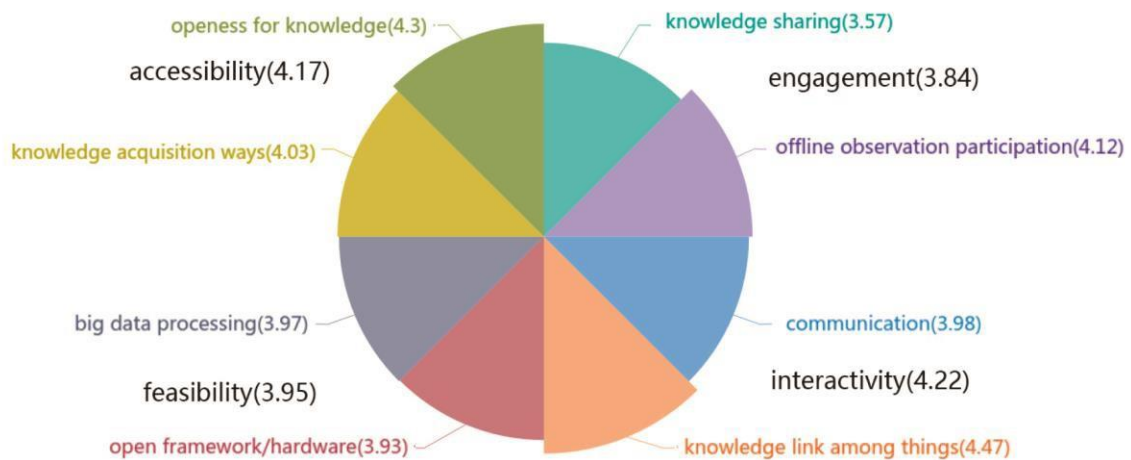


Figure 6: Evaluation Result of “ZooseeFun” Program

Case2: THU Bird --Bird Observation in Tsinghua University and citizen science for natural observation

This research focused on the crowdsourcing application and service design for nature observation by taking the birding activities in Tsinghua University as an example for design research. The aim of this research is to improve nature observation experience, change the time-consuming and indirect learning process into a flexible and instant observing and learning activity, and provide a data source which is crowdsourced, continuously updated and close to users' daily life. The final solution also improved the recording process for observation to make it more convenient and fast. The overview of this program is shown in Figure 7.

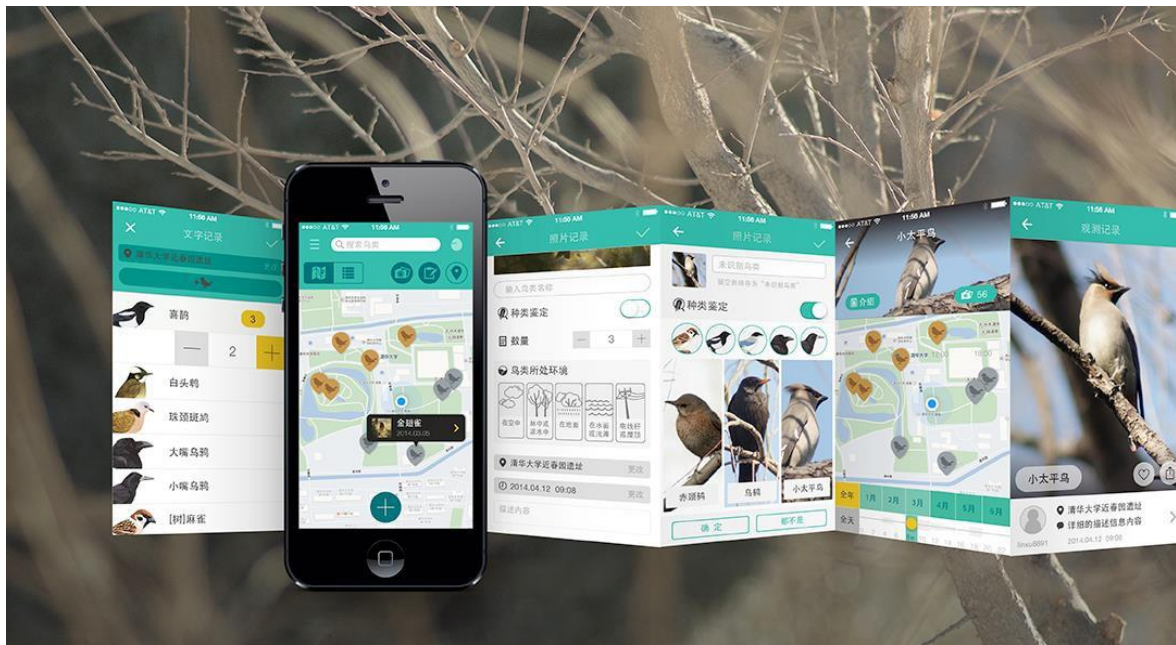


Figure 7: Overview of “THUBird” Program

Citizen science content model of THU Bird

In this program, we specify three elements of citizen science content model, “Environment” as “Campus”, “People” as “Bird observers” and “Tech” as “crowdsourcing”. Four aspects of design checklist of activity theory are used to identify how “THU Bird” achieves new citizen science experience.

Means and ends: This program divides bird observers into four groups, Entry level, beginner level, intermediate level and advanced level. According to observing characteristics of each level, for example, the interest in observing birds on campus, the frequency of observing birds and the familiarity with observing tools, finally users of beginner level and intermediate level are chosen as main users. The young students who are interested in nature history and biodiversity were considered as target users for detailed research on user needs, especially the ones who are active in related student communities. To change the time-consuming and indirect learning process into a flexible and instant observing and learning activity, and provide a data source which is crowdsourced, continuously updated and close to users' daily life, web application and phone application for bird observing activity are developed and their main functions include recommendation and navigation based on crowdsourcing data map, bird data filtering by

time and location, species identification ,bird data browsing and bird data recording and publishing. LBS, database and other ICTs technology make all this functions feasible and create a co-observing behavior and environment on Tsinghua Campus.

Environment: It is more appropriate to choose Tsinghua campus as the environment of data collection and experiment. According to the analysis of the distribution characteristics of the wild animals in our country, it is found that there are similar environmental conditions in the campus of Tsinghua University, which is one of the areas where the wild birds live. From the beginning of 2007 to the end of 2013, Tsinghua campus has recorded a record of the activities of 100 different birds, and with the continuing observation of school staff activities, this data is expected to continue to rise.

Learning and cognition: There are many bird species on campus but students don't know what they exactly are and where to observe them. This program makes best use of crowdsourcing data map to show bird data and offer advice for possible observation cites and provide recording tools assisted by species identification to create better citizen science interface to get students to better know current station of birds on campus. Consequently, more students will be attracted to take an active part in observing activity organized by Tsinghua Animal Protection Association thus to further improve awareness of protecting animals.

Development: Social platform integration is not a major feature of the design point in bird observation program, but it shows that the use of the current mainstream social media resources in the process of data sharing and resource calls. Users can share data which they are interested in. In the future, the application can also be targeted to grab bird data from social media to be displayed on the map, or through social media to launch a wider range of bird data collection activities and bird data platform promotion activities.

Citizen science design model of “THU Bird” program

Seven pairs of design features of “THU Bird” program, the design opportunities are discussed as follow.

Table 3: Design Opportunities of “THU Bird” Program in Design Model

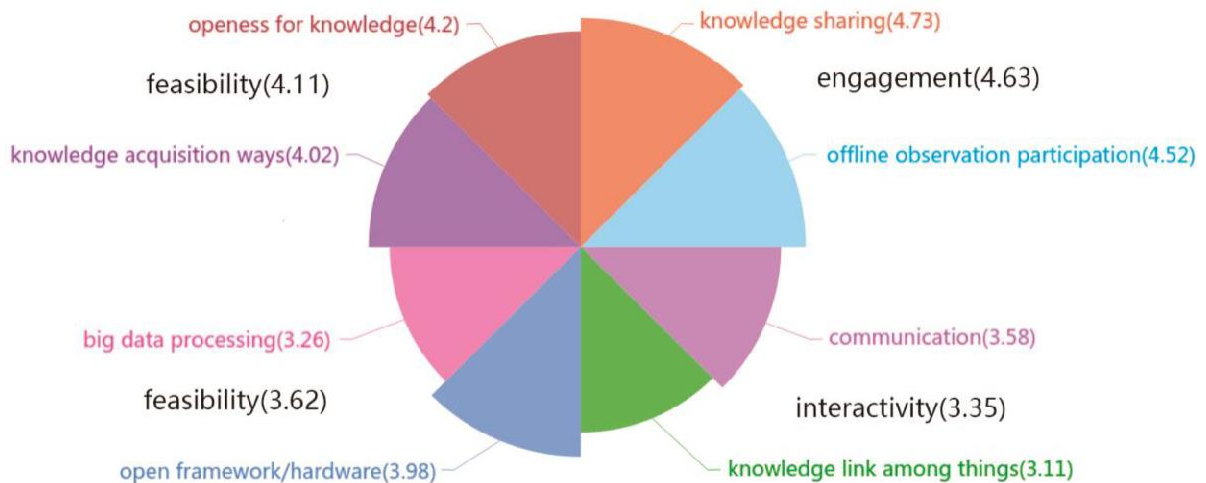
Element	Pair features	Design opportunities
Social network	Online/Offline	For online feature, database and data storage makes it easy for students browse bird data and record bird observation activity, which inspires us to design a online information map on which people get access to bird knowledge in different time, space and technologies. For offline feature, online community helps us to form bird observation offline activity, which inspires us to design message push systems to inform users of offline bird observation activities.
	Collective/Individual	Collective feature and individual feature enlighten us to do users group partition including beginner level, intermediate level and expert level. Enough individual participants record individual observing and publish bird data to achieve new citizen science experience by crowdsourcing.
Connected things	Platform/Product	Platform feature tells us to create an open and collaborative platform for bird science on campus. Product feature inspires us to notice that smart hardware product for bird science on campus can be a great design choice in the context of Internet of Things.
	Result/Process	Result and process features inspire us focus on not only people’s acquiring bird knowledge, but also the process of bird science acquisition such as where to find observation site, what to do when birds don’t show up.
	Light/Heavy	Light feature means simple and interesting ways to get bird science on campus are needed such as data map and bird data filtering. Heavy feature in this program is abandoned in accordance with light application expectation.
Scientific field	Open/Customized	Open feature inspires us to create a open but appropriate environment for students to do bird observation. Customized feature inspires us to design application which is able to meet customized bird observation needs such as contextual navigation and message push of bird migration.
	Original/Reformed	Original and reform features remind us to design an iterative bird science systems where bird science is updated from the original state.

Citizen science evaluation model of “THU Bird” program

According to eight detailed evaluation aspects for each evaluation index, 50 Tsinghua university students are chosen to join in evaluation survey. We also used the 5-point scale to evaluate the design (1=totally disagree, 5=totally agree).

The total evaluation score for each evaluation aspect is also set 5 and the overall evaluation result of “THU Bird” program is shown in Figure 8 below. Engagement index got the highest score, which reveals that sharing birds’ knowledge including where and when to observe birds and what birds are in Tsinghua University plays an important role in conducting bird-observing activity.

Figure 8: Evaluation Result of “THU Bird” Program



Discussion and Future Works

We propose a citizen science design framework including a citizen science content model based on activity theory, based on which a citizen design model is taken into shape. We dig out some design points and opportunities. However, there exists variability of participants' competency because amateurs take part in citizen science projects maybe motivated only by interest which hardly compensates lack of relevant professional skill requirements and it leads to the reality that volunteers vary significantly in their training, accuracy, understanding of project's aims and ramifications, which has unexpected influence of process of citizen science projects. At the same time, in a stricter view, sampling bias problems are also our concerns because verifying the strict adherence to data collection protocols rarely happens under the circumstances that amateurs aren't informed of rigid citizen science protocols which they regard as friendly.

In future works, not only should we explore new innovative design opportunities, but also more interesting interactive ways with citizen science projects and surprising feedback such as reward organism are expected to be created to stimulate participants' interest in expressing their thoughts and taking a more active part in scientific process rather than merely browsing and not responding at all, which is a considerable design approach to tackle inequality of contribution. When evaluating whether to fulfill citizen science, four evaluation aspects discussed above are regarded as persuasive factors but what will affect accuracy of these evaluation factors are also vital for building a new citizen science experience evaluation systems. As a result, current citizen science evaluation model is supposed to be enriched by adding extra evaluation variables such as participants' competency and participation continuity.

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