Culturally-Informed Co-design of Interactive Digital Tools with Citizen Science Communities

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ABSTRACT

The purpose of this research concerns the integration between Human-Computer Interaction (HCI) and interactive digital tools to increase users' awareness about sustainability in the context of Citizen Science communities. In particular, this research project aims to design and develop meaningful and effective interactive data storytelling and interactive digital narratives based on HCI methodologies for Citizen Science. Specifically, we will investigate how cultural elements can be implemented in the design process to improve significance and sense of ownership of technological tools for scientific communication. Such tools can be critical for scientific communication in the context of the local communities of citizen scientist, as the knowledge that they produce tend to remain in the niche of their group. Interactive digital tools can convey simple, yet meaningful narrations to the public and enhance both awareness and decision-making processes about sustainability.

CCS CONCEPTS

• **Human-centered computing** → *HCI theory, concepts and models*; **Ethnographic studies**.

KEYWORDS

Citizen science, sustainability, Interactive Digital Narratives

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1 INTRODUCTION

Citizen Science (CS) is an age-old practice with roots stretching back thousands of years. In ancient China, for example, residents played a vital role in tracking and monitoring outbreaks of migratory locusts, a practice that spanned over two millennia [2]. A more recent example of CS is the Christmas Bird Count, which emerged in 1900. Frank Chapman, an ornithologist at the American Museum of Natural History, proposed an alternative to the popular "side hunt" activity in New England towns on Christmas Day. Instead of hunting birds, Chapman encouraged citizens to observe and count them. This marked a pioneering effort in establishing a methodology that engaged citizens in recording bird abundance and distribution in specific areas, a tradition that continues today [30].

The term "citizen science" itself didn't appear until January 1989, when it surfaced in an issue of the MIT Technology Review. The article, titled "Lab for the Environment," highlighted Audubon's use of volunteers in what was termed "citizen science" [35]. Following this initial mention, CS began to gain traction across various research fields, leading to the creation of several definitions.

CS is a collaborative approach to scientific research involving the participation of the public. It can be defined in various ways depending on the context and perspective. One definition emphasizes the active involvement of volunteers in scientific projects, describing citizen science as the engagement of non-professional individuals in data collection, analysis, and interpretation. This definition highlights the democratization of science and the potential for widespread participation. This definition, as described by [6], has its roots in Irwin's definition, which sees the active involvement of citizens in scientific research creating an inclusive environment where research is open to the citizen in all its aspects. Another definition focuses on the mutual benefit derived from citizen science, emphasizing the reciprocal exchange of knowledge between scientists and volunteers. In this view, citizen science is seen as a means to empower communities, promote scientific literacy, and address pressing environmental or societal challenges [20]. Lastly, a broader definition includes forms of citizen science that extend beyond natural sciences, incorporating social sciences and humanities. This definition recognizes the multidisciplinary nature of citizen science and its potential to bridge gaps between different fields of study, leading to more comprehensive and holistic understandings of complex issues. Ultimately, these definitions all underscore the central role of citizen participation in scientific endeavors, while varying in their emphasis on collaboration, mutual benefit, and disciplinary scope.

Human-Computer Interaction (HCI) plays a significant role in understanding how to approach CS by addressing various challenges. Firstly, it focuses on community relations and engaging participants in projects [8, 27]. Secondly, scientists require both a large quantity and high quality of data. Consequently, data management becomes a crucial topic, encompassing teaching volunteers how to collect and handle data, as well as understanding how to make sense of it through data visualization (and more) [38]. Additionally, promoting Open Science is a key objective, ensuring accessibility for citizens to both the ongoing research process and its results [29]. Technological innovation serves as a thriving avenue for Citizen Science, providing tools such as smartphones, sensors, CS platforms, social

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media, and blogs, enabling CS activities and the sharing of resulting knowledge [23]. By adopting an HCI lens and embracing CS principles, it becomes possible to maintain open science qualities, including education, self-development, democratic policymaking, and scientific research [24].

In this diverse landscape, design processes take on various forms, facilitating user-centered design, participatory design, and research through design [25]. By considering cultural and social aspects relevant to the specific case or group of interest, successful interactive digital tools can be developed to covey messages through data visualization and data storytelling (interactive digital narratives), meeting both explicit and underlying needs rooted in their cultural contexts [7].

1.1 Data Visualization

Data Visualization has no fixed definition, although it is recognized as a systematic data representation that can convey the significance of a set of data. This is made possible through the employment of techniques that leverage human cognitive abilities and perception to facilitate the communication of complex sets of information [19]. Therefore, Data Visualization can play a drastic role in scientific communication, since it enables users to access complex information in a relatively shorter time and with less effort than through a normal textual form of data representation [9]. For this reason, Data Visualization is a very flexible tool that can be employed in different scenarios and for different users: from academic context and researchers up to the public and non-expert actors. Hence, it may impact different processes of decision-making or even policymaking thanks to the opportunity it provides by exposing patterns, abnormalities or outlying data [9, 12, 16, 19, 34, 37].

Although its flexibility can be a point of strength, it also means that there are no fixed protocols to make 'good' data visualization. Hence, it is crucial to understand what kind of audience we want to communicate with and which level of complexity we aim to provide.

The human is a central element in this matter, hence the key role that HCI has in this scenario [34]. A recent challenge regards, in fact, the adaptability of Data Visualization to different communities based on their peculiar interests [11]. The challenge revolving around engagement through Data Visualization transcends from a user level to a community level, meaning that other than individual needs it is important to focus on the cultural elements that define specific groups of interest [11].

1.2 Interactive Digital Narratives and Gamification

Interactive digital narratives (IDN) are immersive storytelling experiences [14] that through technology engage and involve audiences. Through the use of user interfaces, these narratives invite users to play an active role in the unfolding of a narration and its significance. Through interaction, and dynamic content, individuals can explore the different elements and possibly outcomes. The user feels a sense of agency [26] and participation in exploring the narration through this process. For this reason, the employment of interactive digital narratives can be useful to enhance engagement and interest in users.

The wide term IDNs cover a plethora of artifact that can be employed to represent multifaceted worlds and complex phenomena [4]. In this scenario, we see the opportunity to share data through interactive digital methods. This would allow users to navigate through interconnected content, uncovering different layers of the data through hyperlinks, multimedia elements, and interactive features. Through the development of such platforms we aim at encouraging collaboration and community engagement, as participants can share their experiences, and interpretations, further enriching the overall narrative and learning experience.

Moreover, learning experiences and storytelling have been shaped by the implementation of IDNs and gamification. Both IDN and gamification, are changing the modalities of users engagement, allowing them to play an active role in the narration processes. Gamification applies game design principles to non-game contexts [15], transforming tasks and learning activities into enjoyable and motivating experiences. The active involvement of users can be obtained thanks to game mechanics (such as leaderboards, scoring system, progression system) or even gameplay mechanics [22]. The blending of these elements leads to the active involvement of the users, which in educational (amongst the others) can be considered an added benefit. Game elements in digital narratives or educational experiences, can boost engagement [1][21] both in the short term by encouraging deeper exploration and stimulating the user through challenges [22]; in the long term, they can promote engagement trough rewards (badges, bonuses) [13] and progression system (levels, milestones) [17]. Together, IDNs and gamification have opened up new opportunities in education, entertainment, interactive experiences, and more, changing the way we consume and interact with stories and knowledge.

2 RELATED WORK

The research project started with a comprehensive exploration to examine the existing body of literature in the field of Citizen Science (CS) related to sustainability, co-design, and technological innovation. The focus was not only on general surveys regarding CS, but also on its intersection with the field of Human-Computer Interaction (HCI).

One particular area of interest was the design of technology in the context of environmental digital CS, as investigated by [32]. This study explored various methods used to develop new technologies for citizen scientists. It revealed that this field is still relatively new, with many studies sharing direct experiences from CS projects and feedback from participants.

The educational aspect of CS was also addressed in studies conducted by [24] and [3]. Peter's study collected information from different sources to examine the impact of CS on biodiversity awareness. The findings showed that active involvement in CS leads to increased awareness of biodiversity and sustainability, as well as improved knowledge of scientific methodologies. Similarly, [3] confirmed that participation in online CS projects has positive effects on scientific knowledge too.

Another study focused on surveying existing literature on methods for effective design in CS. It also compiled a list of tools commonly used in CS projects and evaluated their suitability for different types of projects [31]. This research highlighted the importance

of combining HCI expertise with the widespread availability of smartphones and other communication technologies, which facilitate data collection and sharing [25]. This collaboration between HCI and citizen scientists creates fertile ground for designing innovative tools that support Open Science, scientific research, and bottom-up policymaking processes.

3 RESEARCH PROJECT

The main focus of this research is to investigate how HCI methodologies can be exploited to design, validate and evaluate interactive digital tools for scientific communication within the context of three different CS communities characterized by different cultural backgrounds. Finally, by comparing these experiences, we aim at understanding how culture can influence design processes, and how these particular interactive digital tools can favor narration on sustainability and improve sensitivity over this topic. In the following sections, we briefly present the two main theoretical lenses that we consider in order to investigate this issue, eventually presenting the research questions.

3.1 Theoretical framework

3.1.1 Community of practice. A community of practice refers to a group of individuals who share a common interest, profession, or goal and come together to learn, collaborate, and share knowledge within that domain [40]. A community of practice can also be recognized by the dynamic and interactive space where members actively engage in discussions, exchange ideas, and collectively develop expertise. This environment serves as a platform for continuous learning, enabling individuals to deepen their understanding, refine their skills, and stay updated with the latest developments [39]. It fosters a sense of belonging, encourages active participation, and promotes a culture of collaboration, where members support and learn from one another. By creating a community of practice, organizations and individuals can foster thanks to collective wisdom and experience to better pursue a common agenda.

3.1.2 Actor Network Theory. Actor-Network Theory (ANT) has its roots in sociology and later expanded into various disciplines, including Human Computer Interaction. Bruno Latour, father of the ANT, wanted to examine how social interactions and networks form through human and non-human actors' interaction [18]. This theoretical lens equates the human actors and non-human actors (actants). For this reason, this framework provides a unique perspective on how networks interpretation, and how socio-technical relations develop, and how knowledge is produced [36]. Hence, the traditional concept of agency and hierarchy are challenged, offering a new lens to understand the complex social (and technical) interactions. On the other side, the way that ANT ascribes agency to both human and non-human actors (actants) equally. Critics argue that treating non-human actors, such as objects or technologies, as having equal agency as humans may overlook the power dynamics and structural influences that shape social relationships [28]. Additionally, ANT focuses on the individual actors and their associations. This may lead to overlooking the broader social structures and macro-level factors that influence social phenomena.

3.2 Research Questions

In this research, we aim at answering the following RQs:

- **RQ1**: can culturally based interactive narrative methods, favor the enhancement of sustainability awareness?
- **RQ2**: can digital interactive narrative tools, in citizen science contexts, be empowered by implementing characterizing cultural aspects of specific communities of practice?

3.3 Methodology

To answer the RQs, we aim at employing a two-fold method to address a two-fold objective. First, we will use qualitative methods (ethnography, semi-structured interviews) for the research and collect data within the context of three different cultural/demographic contexts.

The three contexts can be summarised in the following archetypes: i) High School students, considered as non-expert actors in scientific methods and data management, ii) Academics, as expert actors in scientific methods and data management, and lastly iii) Consolidated CS community's members, as non-academic experts with non-professional expertise in scientific methods and data management.

First, the research will revolve around data gathering within the three contexts through the use of qualitative methods, such as ethnography [5], semi-structured interviews [10], and workshops. Here, we will investigate how scientific research and related activities unfold and develop. Through the analysis of the gathered data, it will be possible to define the characterizing elements of the different contexts, while also formulating a solid database which will help to shape the co-design processes. The ethnographic work will focus on two aspects: i) the citizen science research activity, and ii) the social and power relations within the CS communities. Second, the focus will shift towards interactive digital methods. Through design-based workshops [33], the participants will design a data interactive digital tool to issue the needs and interests of their community. The result of this process will possibly be prototyped and tested, in order to assess its validity and find space for improvement. Finally, by comparing the experience with these three different communities, we aim at identifying the crucial cultural elements that affect digital social innovation in support of CS activities, specifically regarding data visualization and, more in general, IDN tools. This comparison will also provide insights into the effects that CS can have in increasing awareness about sustainability in different settings.

4 EXPECTED RESULTS

Up to date, ethnographic observation shows that different groups and subcultures need different level of engagement and different 'atmospheres' when they conduct social activities (like the workshops). In some cases, a scholarly approach may be preferred, in others it would not be tolerated. Other elements concern the degree of expertise that the individuals have, where the expertise is greater guidance in the activities tend to be less tolerated, whilst autonomy seems to be favored. In this sense, the workshops are expected to be very different based on the context. Nonetheless, the objective remains the same: a tool for better data/knowledge communication; both within the CS community and to the exterior of its boundaries

(ex: municipalities, governance association, public and citizens). The CS communities, given the lack of a dedicated software and tools at their disposal, demonstrate a discrete interest in the activity, as they see the potential benefits they may gain.

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