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From Data to Data Games: Exploring Public Engagement with Scientific Information through Serious Game Design Workshops

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Abstract

We explored the use of Serious Game Design Workshops as a tool for engaging citizens in the dissemination of scientific knowledge to the public. Using research data on forest ecosystems and their dynamics, we ran four workshops which sought to bridge the gap between complex environmental information and public understanding. During these workshops, a total of 88 participants—all non-experts concerning forest ecosystems—created storyboards for 20 diverse game concepts which to varying degrees integrated scientific content into different types of gameplay. A preliminary analysis of the produced game concepts suggest that our workshops were able to foster creativity, enhance environmental education, and promote public engagement with scientific knowledge. However, challenges such as variability in participants' prior knowledge and workshop materials affected outcomes. We conclude by discussing future refinements and suggesting methods to improve the educational and communicative potential of serious games workshops for scientific dissemination.

CCS Concepts

• **Human-centered computing** → **Visualization; Human computer interaction (HCI); Participatory design.**

Keywords

Serious Game Design, Science Communication, Environmental Education, Game-based Learning, Public Engagement, Data Visualization, Research through Design

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1 Introduction

The growing challenge of adapting to climate change requires us to make complex scientific data accessible¹. One of the core challenges lies in transforming scientific data into formats that engage non-specialist audiences. Traditional dissemination methods, like scientific articles or static infographics, often fall short in fostering meaningful public understanding or involvement. Scientific information is often presented in ways that are difficult for non-experts to interpret, leading to a disconnect between the scientific community and the broader public [20].

The history of the transmission of scientific information has gone through several stages, during which the receiving citizen was either passive and a spectator, or active but only for reproducing confirmed experiments. Although today's researchers are experimenting with new ways of giving access to their research—through the arts, for example [18]—this dissemination is still the brainchild of researchers, and citizens are often only passive spectators of the new tales of research. The complexity of the data related to climate change requires innovative approaches that not only convey the information clearly but also encourage active participation [20].

In recent years, the principles of Open Science have gained traction, emphasizing the need to make scientific knowledge more accessible and promoting the removal of access barriers and encouraging transparent, collaborative research practices [13, 20]. Citizen science projects increasingly engage both experts and the public in scientific discoveries, addressing for example, but not exclusively, global challenges like climate change. Non-expert participation fosters inclusivity in knowledge creation, inviting diverse perspectives that can lead to innovative solutions [9].

Gamification—the application of game design elements in non-game contexts [5]—has emerged as an effective method to facilitate learning and engagement. By transforming complex data into interactive experiences, gamification makes scientific information more approachable [7]. Studies show that it can enhance student engagement and motivation, by making learning more dynamic and participatory [2, 6, 8, 21]. This is especially relevant in environmental science, where public understanding and action are essential for addressing urgent ecological issues [11, 14].

In this article, we explore one such solution where members of the general public are invited to participate in the creation of

¹We use the term 'scientific data' broadly to include various types of scientific information, such as protocols, spreadsheets, raw datasets, and graphs.

scientific outreach material, that is, in contributing themselves to generating new forms of communication that they themselves find engaging. Specifically, we explore the use of serious-game workshops in which groups of non-experts generate game concepts based on scientific data on forest ecology. We report here on observation and findings from three phases of our research: (1) designing the workshop with the scientific data to use, (2) running workshops with non-experts in ecology, and (3) discussing with researchers in ecology to assess the games designed during the workshop. With this paper, we want to propose game design workshops as a way to bridge the gap between complex information and public understanding, offering participants a platform not only to engage with pressing environmental issues but also to explore innovative ways to represent and communicate that information to a wider, non-expert audience. The workshops were part of the ECODOC research project, which studies the circulation between different types of knowledge and scientific information appropriation by citizens in times of environmental transition.

2 Related work

The use of gamification and serious games has become a popular strategy to enhance engagement and accessibility in education, including scientific dissemination. Gamification introduces game elements like points and challenges into non-game contexts, aiming to foster engagement and interactivity [5]. However, it is crucial to distinguish between gamification and serious games, as serious games are specifically designed to educate or train, going beyond pure entertainment [16].

Workshops are increasingly recognized as a valuable platform for creating serious games that foster both education and engagement. However, much of the existing literature highlights the need for expert guidance throughout these workshops [17, 19], suggesting that non-experts often require significant support. While our workshops provided structured materials, such as booklets and storyboard templates, the limited involvement of experts challenges the idea that constant supervision is necessary. Our method advocated for a “learn by doing” [7] approach with light expert guidance, allowing participants more creative freedom.

Additionally, previous studies emphasize the importance of iterative design and the use of structured frameworks, such as MDA (Mechanics, Dynamics, Aesthetics), to ensure successful educational outcomes [10, 24]. Our workshops applied these principles, but we went further by focusing on how non-experts interact with real scientific data to develop game concepts. This approach fills a gap in the existing literature, which often overlooks how non-experts can contribute meaningfully to scientific dissemination.

By providing participants with structured but flexible tools, we addressed some of the challenges highlighted in the literature—particularly the need for frameworks that support creativity while maintaining educational value [3, 23].

3 Serious Game Design Workshop

The main objective of our Serious Game Design Workshops was to engage participants in transforming complex scientific data into interactive, educational games. The workshops provided a structured environment in which participants, regardless of their prior

knowledge, could creatively work with environmental data related to forest ecosystems and tree dynamics. The goal was to explore whether the game concepts developed could effectively make this scientific information accessible to non-experts.

3.1 Workshop Structure

For the four Serious Game Design Workshops, the same structure was followed, inspired by the framework outlined by Walsh Andrew (2015) [22]. Each workshop was structured as a 2-hour session, beginning with a 15-minute presentation that introduced participants to the scientific context and data. To ensure all participants had easy access to the necessary information, they were provided with printed copies of the presentation. These materials outlined the game creation process, defined games and serious games, and included detailed instructions and practical recommendations to guide game development. Additionally, booklets containing scientific data on three environmental themes: drought stress on trees, fruiting phenology of oak, and general tree phenology were distributed [15]. Participants were then organized into groups and invited to select one of these themes as the basis for their game concept.

To support the creative process, participants had approximately 85 minutes to develop their games. Storyboarding templates were used in order to encourage participants to think critically about the rules, mechanics, and format of their games, providing a visual and structured approach to the design process. These tools were intended to help participants organize their thoughts and explore how complex data could be translated into engaging gameplay. Workshop facilitators, including three of the co-authors, were available throughout the session to answer questions and provide guidance. To document the workshops, we took photographs, ensuring that proper authorization was obtained from participants.

3.2 Booklets

The booklets played a crucial role in making research projects understandable for participants. Each booklet was carefully composed to make the purpose, methods, and productions of a research project understandable for non-expert participants so that they could engage with key topics and put them into context of a larger research project [1] (see Figure 1 for an example). The booklets followed a consistent structure, beginning with a short introduction that outlined the project’s objective and listed the names of the researchers and the associated lab. This was followed by several key sections, presenting research documents made available by researchers that reflected the current stage of their project:

- Contextual Information: Documents able to provide an overview of the project’s setting to help participants understand the environmental and scientific background: maps, lists, etc.
- Methods and Protocols: Documents detailing the procedures and methods employed by the researchers, detailing how the scientific data included later was generated: pictures, definitions, consolidated knowledge, etc.
- Data Collection and Analysis: Key data sets, including tables, images, to show what the data are and enhance understanding.



Figure 1: Example material from the booklet “Fruiting Phenology of Oak” [15]. Left: Layout and Structural Overview. Middle: an overview map to help readers orient themselves in the forest and associate material in the booklet with the location where it was collected. Right: example photos of material collected by researchers, e.g. acorns in different states of development and nets used by researchers to collect and count leaves and fruits falling from trees.

- Results: Documents showing the study’s findings and preliminary conclusions, as graph, maps, paper or code, to give an overview of current research results.

3.3 Materials and Process

Throughout the workshops, participants were encouraged to think creatively about transforming scientific data into engaging and interactive game experiences. To facilitate this creative process, participants were provided with various tangible tools, such as storyboards, whiteboards, and electrostatic whiteboards. These tools allowed them to lay out and iterate on their game concepts by drawing, attaching images, and adapting their ideas in real-time. The ability to sketch, modify, and represent their ideas dynamically contributed not only to the creativity of the game concepts but also to how the games themselves were represented and communicated. Facilitators were available to provide support when needed, while participants were granted the freedom to experiment with a variety of ideas.

In the final phase of the workshop, participants presented their game concepts to the group, detailing how they integrated the data and the educational objectives of their games. These presentations offered a valuable opportunity for constructive feedback.

4 Workshop Outcomes and Analysis

Four Serious Game Design Workshops were conducted with a total of 88 participants. The first workshop involved 12 participants, mostly Master or PhD level students, with a background in either computer science or design. The subsequent three workshops engaged a total of 76 students, all in their second year of studying Information and Communication Sciences (undergraduate level). Notably, none of the participants had a background in ecology or biology. However, some participants had prior exposure to the data through other educational activities. Information regarding participants’ prior knowledge of game design techniques was not collected. All groups, each consisting of three to six participants, successfully

proposed a game concept regardless of their academic background or area of specialization. In total, 20 games were created, but only 19 were analyzed using storyboards and presentation notes. The excluded game lacked sufficient explanation in its storyboard and was overly complex in its design.

4.1 Methodology of the Analysis

We analyzed games to explore how participants integrated the booklet content in their game concepts and to confirm, at least informally, with the researchers in ecology that none of the games misinterpreted the booklet content in a misleading way. Each game was first reviewed using the storyboards created by participants, with notes from the final game presentations capturing the key ideas behind each game concept. After this initial review, a synthesis was compiled to highlight the core elements and recurring themes across the games.

This was followed by a more detailed analysis, where information from the synthesis, storyboards, and presentations was systematically organized into a spreadsheet. This process provided a clearer understanding of the game propositions and enabled their categorization based on various factors, such as format, type of gameplay, the game mechanics used, estimated playtime, number of players, and target player age.

After completing the Serious Game Design Workshops and analyzing the game propositions, we conducted interviews with the researchers who provided the data for the booklets. The primary aim of the interviews was to ensure that the educational objectives of the games aligned with the intended learning outcomes of their research. By presenting the games to the researchers, we aimed to confirm that the data was used appropriately.

5 Results and Discussion

5.1 Creativity and Engagement

One of the most notable outcomes of the workshops was the participants’ creativity in designing a wide range of game formats, from



Figure 2: Integration of booklets in the creative process.

traditional board and card games to digital game concepts. Each group successfully proposed unique game concepts (Figure 3–left), with unique defined as the specific combination of format, gameplay, and learning objectives. Although some games shared similarities in format or learning objectives, their gameplay mechanics were never identical, making each concept uniquely crafted. While each game was distinct, we observed that they could be classified into five gameplay categories:

- Simulation games: Players must master a specific mechanism that enables them to apply the knowledge acquired.
- Quiz games: Players must answer questions correctly under time pressure, combining accuracy and speed.
- Memory games: Players rely on their ability to combine acquired information with short-term and visual memory of the game board.
- Spot games: Players are required to structure sequences of information received at different times.
- Luck-based games: Knowledge acquisition is mobilized randomly, driven by chance or luck rather than through successive layers of information.

While memory and spot games share similarities in principle, they differ in their mechanics, particularly in how they utilize time and space, justifying their classification into separate categories. This diversity in gameplay and formats demonstrates that the provided booklets could be adapted in numerous ways, enabling the creation of varied game experiences tailored to different player preferences and learning styles.

The structured yet flexible nature of the workshops encouraged participants to reinterpret complex data and engage with the educational objectives in creative ways. The 20 groups autonomously generated unique game ideas, suggesting a high level of engagement with the scientific content. This finding provides preliminary evidence that, under the right conditions, non-experts can contribute meaningfully to game creation and the democratization of scientific data. While earlier research emphasized the necessity of expert intervention during game development [19], these

workshops suggest that a supportive framework and appropriate tools may enable non-experts to navigate this process more autonomously. However, further studies are required to explore the depth of non-experts' engagement with the data and the long-term impact of such participatory approaches.

5.2 Educational Potential and Knowledge Transmission

When presenting the created game concepts to the researchers who provided the data for the workshops, they confirmed that the games accurately conveyed the intended scientific content, regardless of the game format or winning strategy. They showed particular interest in two of the simulation games, suggesting that one could potentially be used for the dissemination of their scientific project, as these games addressed questions similar to those explored in their own research. The researchers recommended modifications to certain elements of these games to improve their scientific accuracy, underscoring their potential for use in outreach efforts. While the researchers also appreciated games from other gameplay categories, they observed that these games did not address specific scientific questions and seemed easier to develop. Importantly, the researchers' feedback validated the alignment of the games with the scientific data but did not extend to their educational effectiveness for non-expert audiences. Since they could not evaluate how accessible or effective the games might be in facilitating learning for a broader public. This underscores the need for further testing with non-expert audiences to fully assess the games' potential to transform complex scientific concepts into accessible, knowledge-transmitting experiences.

5.3 Collaborative Dynamics

Collaboration was a crucial factor in the success of the workshops (Figure 3–right). The group-based structure encouraged participants to share their ideas, combine their skills, and create more diverse and comprehensive game concepts. While this collaborative environment appeared to support the game design process, the



Figure 3: Left: Game proposition using storyboards. Right: Group collaboration and interaction during the workshop.

extent to which it enhanced participants' understanding of the scientific data remains uncertain, as no direct feedback was collected from participants. Observations during the workshops suggest that the exchange of ideas within groups facilitated the refinement of game mechanics and promoted creative problem-solving.

We have also observed that some team members, who had had access to the data in previous workshops, acted as trainers for the rest of the team, summarizing the booklets and explaining terms thus facilitating the reappropriation of the data for their group members. In other groups, some used their drawing skills to create a highly detailed graphic environment for a 2-hour workshop. Group work benefited from the mobilization of individual skills within the team.

5.4 Use of Booklets and Visual Preferences

A key observation from the workshops was participants' strong reliance on the more visual parts of the provided booklets. Participants consistently found photographs and visualizations easier to work with than raw or complex datasets, often in table formats, which allowed them to integrate scientific content more smoothly into their game designs. This observation is consistent with the literature on graphical perception arguing to use visual formats to make data more accessible [4]. This insight is particularly relevant for future Game Design Workshops involving scientific data, as it highlights the potential of visually engaging formats to foster participant creativity and engagement.

Moreover, the visually rich protocols played a crucial role in guiding participants through the information, supporting their creative process, and fostering a deeper connection with the material, the data. Participants showed a clear preference for documents about the researchers' protocols and visual aids, particularly as those documents were mainly photographs accompanied by detailed explanations. When asked about this, the researchers who supplied the data for the workshops explained that this preference for protocols may be attributable to their structured nature, which

reduces uncertainty and makes them easier to work with. The clarity and reliability of these protocols allowed participants to engage with the scientific data more confidently.

The booklets and storyboard templates both played crucial roles in this process, guiding participants in organizing their ideas and helping them translate the scientific data into game mechanics and narratives that would resonate with non-expert audiences. (Figure 2). It is unclear how much the variations in the booklets had an influence on the outcomes of the workshops. Each booklet included essential information on context, protocols, data collection, analysis, and results, yet the format and level of detail varied between them. These differences complicate direct comparisons between the games created using different booklets, indicating that more meaningful comparisons could be drawn among games developed from the same booklet. However, this also confirms that creativity goes beyond the form given to the booklet, and that participants were able to identify data of the same nature (relating to protocol and consolidated knowledge) regardless of how the booklet was presented.

5.5 Limitations and Future Work

Several participants had previously worked with the booklets during a different workshop focused on slam writing. While not all used the same booklets in both workshops, prior experience with the data may have helped some create more elaborate serious games, giving them an advantage over those encountering the data for the first time. Future workshop iterations could include follow-up discussions to gain deeper insights into participants' experiences, particularly their prior relationships to data and workshop learnings. These discussions could reveal which scientific data they chose, found accessible, and why—providing valuable information for refining future workshops to better align with participants' needs.

Due to the short time frame of the workshop (two hours), none of the games were implemented and tested. While the researchers confirmed that the games neither oversimplified nor misrepresented the scientific data, it remains unclear whether the games effectively promote learning in a way that balances educational value with engagement. Future work should focus on further developing the prototypes and conducting tests to assess whether the games successfully deliver both enjoyable and educational experiences [12]. Additionally, involving participants in follow-up discussions could provide more detailed insights into their design choices and further enhance the development process.

6 Conclusion and Perspectives

The Serious Game Design Workshops demonstrated that non-experts can successfully engage with scientific data and envision educational games incorporating scientific information. Future work will need to investigate the balance between engagement and educational effectiveness. Specifically, future research could test and refine game prototypes, possibly involving participants in a participatory design process to gain insights into their design choices. Exploring different workshop formats, such as setting predefined learning goals or using a wider range of different data sets, could provide further opportunities for enhancing both creativity and pedagogical outcomes [24]. The interest expressed by the researchers in using some of these games for public outreach of their research demonstrates the potential broader impact of this approach in science communication. Addressing these limitations and building on current findings can enhance the role of serious games design as a tool to make scientific knowledge more accessible and engaging.

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