Designing for and Identifying Plural Goals in a Science Museum Game Exhibit

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ABSTRACT

Science museums are often interactive spaces where a variety of visitors engage with exhibits in diverse ways. While trying to support participants' behavior in ways that make intuitive sense for these behaviors in a museum context, these exhibits need to support interests and participation in forms that are meaningfully diverse – to make domains accessible to learners belonging to groups minoritized in those domains. In this paper, we present an interactive computational thinking exhibit designed to foster a multiplicity of goals and participatory behaviors. We also present preliminary analysis on how we can use play data to delineate the pursuit of different goals mediated through different pursuits. We also find *care* to be a uniquely valuable aesthetic motivator in gameplay, often overlooked in common design frameworks – with potential to expand perspectives on computing and combat inequity among computing learners.

CCS CONCEPTS

•Human-centered computing ~ Interaction design ~ Interaction design process and methods ~ Activity centered design •Human-centered computing ~ Interaction design ~ Empirical studies in interaction design

KEYWORDS

Play styles, museums, games, game design, science museums, diversity, computer science education, cluster analysis, learning analytics, data mining

ACM Reference:

Matthew Berland, Matthew Cannedy, Vishesh Kumar, Maxine McKinney de Royston, and Leilah Lyons. 2020. Designing for and Identifying Plural Goals in a Science Museum Game Exhibit. In *Extended Abstracts of the 2020 Annual Symposium on Computer-Human Interaction in Play (CHI PLAY '20 EA), November 2–4, 2020, Virtual Event, Canada.* ACM, New York, NY, USA, 5 pages. https://doi.org/10.1145/3383668.3429672

1 INTRODUCTION

Science museums are uniquely positioned to make a broad variety of educational experiences available in shared manners to diverse audiences. Oppenheimer [15] envisioned science museums as a space free from the constraints of school curricula and expectations of controlled behavior, to foster a space for unfettered curiosity, discovery, and learning – rendering potential for learning experiences free from the classroom structures that lead to a variety of inequitable outcomes. Science museums attempt to achieve this vision of responding to issues of inequity in a variety of ways. Attracting diverse visitors and attending to demographics that address issues of equity are two ways of centering museums' ability to improve access to domains that are dominated by specific populations.

Games can be a particularly productive way to provide such equitable learning opportunities in museums. Good games are known to support rich learning

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CHI PLAY '20 EA, November 2–4, 2020, Virtual Event, Canada
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ACM ISBN 978-1-4503-7587-0/20/11...$15.00.
https://doi.org/10.1145/3383668.3429672

across a diverse range of players by supporting varieties of play styles and game choices [8]. Full length games often support different kinds of players by designing for different playstyles. As discussed in numerous taxonomies of play styles [18], players have been observed to play games for social connection, for in-game achievements, for personally meaningful tasks, or to explore a new system (among many other possible categories).

Despite this rich understanding in games work, the diversity of play styles supported in individual museum games remains limited. Games designed for museums are expected to cater to the flexible social configurations that occur amidst visitors [4]. Like most interactive experiences in science museums, they are expected to support active learning, have low entry barriers, and serve flexible engagement times [1]. These design constraints pose a challenge to developing games that have the depth to support a variety of play styles and to consequently support diverse engagement and participation.

Computer science education (CSEd) is a particularly timely domain for designing more equitable games in diverse spaces like museums. The push for making CSEd available across all grade levels across the nation highlights the pertinence of developing games that make CS concepts more accessible [20]. However, computer science as a domain has an overt overrepresentation of certain populations (specifically Asian and White male learners) [13,19].

There have been numerous attempts to address this imbalance, including the design of different learning tools [5], courses at a university [2], school level efforts [12], and a variety of informal environments, games [10], and services [6].

The diversity of work in designing computing education experiences, as well as the breadth of domains which can be enacted across many contexts, helps our foray in designing CSEd games for museums which support a variety of playstyles, and make computational concepts accessible to diverse visitors underrepresented in these computing domains.

To this end, we aim to answer the following questions: How do we design museum games for diverse playstyles, and how can we identify visitors engaging in different playstyles? In this paper, we present Rainbow Agents, a game designed to engage museum visitors of different interests around computational concepts of agent-based modeling and parallel programming. We describe how we designed mechanics to support different kinds of goals and strategy pursuits. We also present a telemetry-data driven analytical description of how player interactions can be identified as engaging in these different goal pursuits.

2 TYPES OF GAMEPLAY

Bartle proposed the famous taxonomy of players - achievers, explorers, killers, and socialisers [3]; a categorization that has been studied and expanded in numerous ways over time. Yee [21] developed an advanced player typology, which categorized motivational components in games which cover different player behaviors and preferences. He describes three overarching groups containing ten sub-elements – Achievement (Advancement, Mechanics, Competition), Social (Socializing, Relationship, Teamwork) and Immersion (Discovery, Role-Playing, Customization, Escapism). The Mechanics-Dynamics-Aesthetics (MDA) framework also presents a set of "aesthetics", which are descriptors for the emotional responses invoked in players while playing a game [9]. These include: Sensation (Game as sense-pleasure); Fantasy (Game as make-believe); Narrative (Game as drama); Challenge (Game as obstacle course); Fellowship (Game as social framework); Discovery (Game as uncharted territory); Expression (Game as self-discovery); Submission (Game as pastime).

3 DESIGNING FOR GOALS, MOTIVATORS, AND LEARNING – RAINBOW AGENTS

Yee's broad categories – Achievement, Social, and Immersion – provide valuable guide posts for ways to invite and engage broader varieties of visitors into rich learning experiences. Museums are particularly known for their rich social environments, as providing access to ways of engagement with friends, family and acquaintances in ways mediated by objects rarely found elsewhere. In earlier work, we have presented the ability of Rainbow Agents to foster a variety of social engagement through different mechanics [16]. In this paper, we discuss the plurality of available goals in Rainbow Agents gameplay, and how that supports a richer variety of gameplay.

Rainbow Agents is a game played over two touch screen controllers placed in front of a large shared screen. The controllers allow players to choose programmable animals (agents), place them in the garden, and program them to conduct different tasks. The different agents are programmed by state machines representing different computational concepts – namely sequential, conditional, and probabilistic logic. The actions agents can perform include planting different kinds of seeds and watering (in specific or randomized locations, depending on the programming cards they choose).

The game was designed to support the creation and cultivation of an **aesthetically pleasing** garden – being able to plant seeds and water the growing plants allows players to develop and care for a flourishing garden. This provides an **Expression** and **Sensation aesthetic / (Discovery** and **Customization) motivator**, which is mediated through a computational interface. It is key that the learning goal of the environment is embedded in engaging with this motivating aspect of the gameplay, and is not a disjoint loop players spend time in (typically seen as players spending time customizing their avatars, but not playing the game itself). Additionally, the continued maintenance and survival of the garden is also a complex task requiring developing understanding, creating an aesthetic of *care* in the game.

Secondly, treasure boxes spawn randomly across the garden. These treasure boxes belong to one of the three different plant types, and have a difficulty setting (from 1 to 3). They are opened by planting and growing plants in their vicinity – of matching kinds and in numbers corresponding to their difficulty. This dynamic leverages the **Challenge aesthetic / Advancement motivator** to engage players who want to accomplish game goals. Unlocking treasure boxes leads to receiving a special rainbow plant which acts as a unique plant, both aesthetically and functionally, and needs to be placed collaboratively by both players in the garden. This reward mechanism acts as a key way to reinforce the different motivational aspects of the game – achievement (receiving more rainbow plants and more easily opening treasure boxes); socializing (working to plan and place plants collaboratively); and immersion (providing more unique and attractive looking plants for a more diverse garden).

Thirdly, the game indicates progress towards attaining a rich biodiversity across their garden. Filling up the three "orbs" indicating the amounts of different kinds of plants, leads to a garden-wide thunderstorm to be triggered. This progress is attained by engaging in all game mechanics that relate to all the motivators/aesthetics – **planting new seeds**, **watering existing plants**, or **opening multiple treasure boxes**.

It is worth noting that the two controller design deliberately intertwines the social layer with these many different game experiences. Pursuing challenges can be done as an individual player or in competition with fellow players. Customizing the garden can derive from a player's personal aesthetic or be conducted in collaboration while socializing with acquaintances or even strangers.

A deliberate design choice included the absence of a **reset** option. This makes the garden a persistent and evolving artifact allowing for an "asynchronous" form of collaboration across visitors who encounter the garden as a result of others' work. This carries unique potential for inviting players to develop on the work of other visitors before them.

Additionally, since pursuing all of these goals relies on the base task of programming agents to place and water plants, choosing any of these pursuits is not a distraction from the tasks that engage domain-relevant learning and practices. They provide for different ways to see value in these practices and tasks.

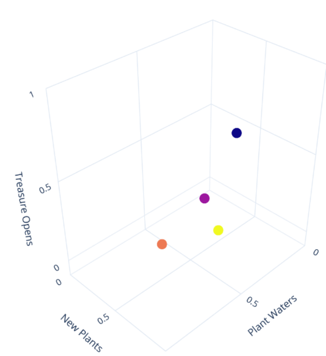
4 IDENTIFYING GOAL PURSUITS AND DIFFERENT PLAYERS – DATA COLLECTION AND FINDINGS

Rainbow Agents is currently set up at two different venues serving unique, distinct demographics - the Lawrence Hall of Science, and the New York Hall of Science. The following analysis is based on telemetry data collected from the Lawrence Hall of Science (as New York City closed earlier due to the pandemic), where the exhibit is located centrally on the floor near the entrance, and sees constant footfall. This analysis is also complemented by an exemplary case of interest from the New York Hall of Science.

We collect player log data that includes visitors' interactions with the exhibit, and game progress - specifically which agents they choose to program with, the location of treasure boxes on the current garden and where they place their agents on the garden, the commands they give their agents, the actions of the agents, and the corresponding changes to the environment (in terms of plants growing, becoming vibrant or withering away in response to how much they are watered), treasure boxes opened, and thunderstorms triggered. This log data does not carry any information about the actual visitor acting at the exhibit. We also have qualitative observational data from small periods of collection when researchers stand near the exhibit, observe visitors' gameplay, and take notes or interview the visitors.

For this study, we operationalized the three different aesthetic engagements - **sensation**, **expression**, and **challenge** - across the game's three key mechanics - **sowing new seeds, watering plants,** and **opening treasure boxes.** Since these mechanics are tightly intertwined, a key question in our analysis is if we can identify players whose engagement favors one or the other motivators.

Dividing the logs into visitors by identifying spans of inaction on the screens, we represented each visitor as a three dimensional point along the axes of number of seeds sowed (New Plants), plants watered, and treasure boxes opened. Running a k-means clustering algorithm for 3 and 4 centers (informed by our expectation of the 3 different goals) on this data, provided us with four distinct cluster centers at points A, B, C, and D (Figure 1). These points are easily interpreted as low actors (close to origin), high waterers, high waterers + planters, and high planters + treasure openers (Figure 1).



a.
b.

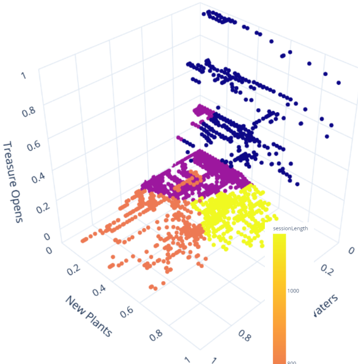
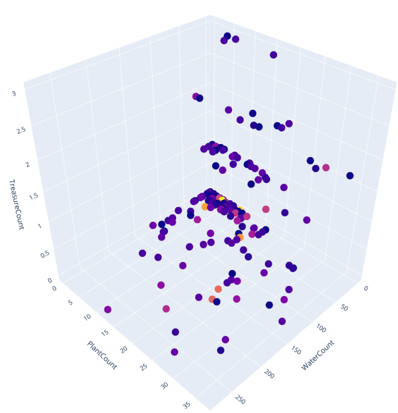


Figure 1. a. The four cluster centers found from our visitor data - central purple being low action; top right dark blue being treasure opener + new planter; bottom left orange being new planters + plant waterers; and bottom right yellow being new planters.
b. Points for individual visitors colored by the cluster they were identified to belong to.

Figure 2 presents a secondary visualization checking whether these different behaviors needed different lengths of gameplay sessions to access. This provides a preliminary view of how museum games designed for a multiplicity of goals and play styles do not need to rely on extended dwell times either.

These four categories not only validate the success of our design in supporting multiplicity of pursuits, but also invites inquiry to further understand what the act of watering without planting signifies. Watering as an action is meant to support the action of planting, but if it is being done in isolation, it means that it is likely an act of collaboration - watering plants that have been planted by others. This could just be engagement with the **fellowship** aesthetic if it takes place in consort with another player. But through the persistent design of the garden, this support role is sometimes enacted even without another player being actively co-present. This fellowship, enacted *at* the plants and garden (which are not another player but just the artifacts of their actions), signify the value of an aesthetic of **care**.



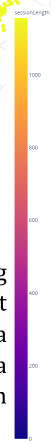


Figure 2. Same dataset colored by length of play session, to demonstrate that treasure opening or specific complex tasks were not preferred just as a result of longer play times.

An example of the unique gameplay facilitated by the persistence of the garden across visitors was evidenced when an African American female high school student reached the exhibit and saw three plants from earlier visitors on the garden that were withering away. She engaged with the exhibit for over 10 minutes attempting to keep those plants alive – with no regard to the treasure boxes or other possible goals in the game. This exemplified how a desire to engage in *care* was made possible by the persistence of public work, which resulted in an asynchronous form of collaboration.

5 FUTURE WORK

Through Rainbow Agents, we see an exemplar of how to design museum games that complementarily implement mechanics that can trigger **sensation, expression,** and **challenge aesthetics.** We also see an example of how to make these mechanics be best supported by different kinds of **fellowship**, or social play. This set of aesthetics is particularly amenable for museum games given their unique constraints of being open to flexible time engagements, as well as social configurations.

The analyses we present using our game data, also complements the studied and accepted power of identifying player styles in commercial as well as educational games [7]. Designing complex museum games which allow for identifying different kinds of playstyles presents rich avenues for developing tools which use this data to facilitate the visitors' experience. Kumar et al. have presented designs for dashboards in other museum exhibits which supported museum explainers to support struggling visitors into a variety of successful pathways suited to their prior engagement at the exhibit [11]. Similarly, information that helps different and complementary styles of players can be used to help players or explainers improve their social experience at the exhibit.

In our current work, we also aim to understand the effect of the different aesthetics/motivators in supporting diversity in museums. Our future qualitative analyses attempt to contribute to a goal orientation understanding of how games succeed and fail in inviting different kinds of visitors and learners.

Lastly, a gameplay aesthetic of care is not a novel discovery but one that is underutilized in learning environments. It has evolved and persisted in popular culture, particularly evident in widely popular toys like tamagotchis – handheld digital pets centered around regularly feeding a digital pet and "nurturing" it from hatchling to adulthood [17]. These tend to be more identified by the result of interest, i.e. the **discovery** [aesthetic] experienced in obtaining grown up adult pets with different features that result from their actions. "Slower" modern games like Walden, also used in literature classrooms to deeply engage in the experience and story of famous writer Henry David Thoreau, have also been designed with highlighting an aesthetic of care [14]. These cases present the juxtaposition of the care aesthetic with **fantasy** and **discovery** – to learn what happens from successful or unsuccessful care. Our work not only presents an initial glimpse into designing for and identifying *care* pursuits in museum games, but also invites further inquiry into its success in inviting Black/Latinx, and female and nonbinary learners into computing disciplines.

ACKNOWLEDGEMENTS

This material is based upon work supported by the National Science Foundation under Grant No. 1713439. Any opinions, findings, and conclusions or recommendations expressed in this material are those of the author(s) and do not necessarily reflect the views of the National Science Foundation.

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