DUST Evaluation: Reusability Assessment of Game Components

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Executive Summary

Intuitive Company researchers and evaluators assessed four components of the DUST Alternate Reality Game for potential reusability: 1) QTE Environment during Collapse, 2) Brain/Health Scanner Mobile App, 3) Microbe Web App, 4) Star Map Web App. We assessed reusability based on five variables (facilitation, user identification, digital access, player type, and timing) along a continuum of informal to formal learning contexts, from museums to after school programs to formal classroom settings. Our assessment revealed that the:

1. QTE Environment during the Collapse is most replayable in its current state in an *after school* setting.
2. Brain/Health Scanner Mobile App is most replayable in a *museum* setting.
3. Microbe Web App is most replayable in an *after school or classroom* setting.
4. Star Map Web App is most replayable in a *classroom* setting.

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Introduction

Brigham Young University (BYU) contracted Intuitive Company (IC) to conduct an evaluation of the reusability of an Alternate Reality Game (ARG) called, *DUST*. The game, funded by the National Science Foundation Advancing Informal STEM Learning program (NSF AISL), sought to reach players through a live, large-scale narrative that unfolded across multiple media channels from January 26 through March 12, 2015.

During the course of the game

- 3,795 players signed up for the game
- 2,466 played the game for 1 day or more
- 360 played for two days
- 227 played for 5 days or more

In order to extend the game's reach beyond its real-time player audience, the research and development teams from BYU and the University of Maryland (UMD) intend to repackage components of the game for reuse in other learning environments such as museums, libraries/after-school programs, and formal classrooms. This report assesses the extent to which four components of the game, identified in collaboration with the BYU/UMD team, are reusable within these other setting types. We assess how replayable they might be in their current format and discuss what modifications might need to be made in order to adapt or extend them for reuse.

We assessed the following four game components:

1. QTE Environment during Collapse: This component includes the interactions that players had with each other and the game characters in the Question, Theory,

Evidence (QTE) area of the Co-Lab website during the during the adult collapse story beat.

2. Brain/Health Scanner App: This component includes the mobile scanner application that players used on adults during the collapse story beat to investigate why adults collapsed and what state they were in.
3. Microbe Web App: This component includes the web-based application that participants used to learn about different types of microbes and their properties in order to identify the alien microbe in the story.
4. Star Map App: This component includes the web-based application that players used to enter data and determine whether a nearby star about which NASA had collected information was in the habitable zone.

Methods

To address the extent to which these four components were reusable in their current form, we identified a set of five key variables (facilitation, user identification, digital access, player type, and timing) likely to impact reusability in other learning settings (see Table 1).

The table below provides a matrix of ways in which those variables shift across learning contexts from informal learning settings like museums to more formal environments like school classrooms.

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Table 1. ARG Reusability Assessment Matrix

Learning Settings → **Variables of Use ↓**	**Museum (Informal)**	**After School/Library (Semi-formal)**	**Classroom (Formal)**
Facilitation	Minimal to none	Partial	Full
User Identification	Minimal	Partial	Full
Digital Access	Personal device or installations	Computer lab-type environment	Computer lab-type environment
Player Type	Solo to small group to large group	Solo to small group to large group	Structured class group
Timing	0-15 min activity within overall visit	30 mins-1 hr activity within 2 hr overall visit	1-2 hrs within 6 hr overall visit

We assessed the ARG component's **facilitation** variable based on the extent to which someone could download the app and do something interesting with it with or without a facilitator. For example, without the narrative context of the game, to what extent could a user find meaning in using the component with or without assistance?

We assessed the ARG component's **user identification** variable based on the extent to which it would be important to know the identity of an author using the component in order for the application to be understood and successful in a given learning context. For example, how critical would it be to know the identity of the person who used the app in a museum setting where players are less likely to know the people around them versus a classroom environment where a player might already be familiar with her classmates?

We assessed the ARG component's **digital access** variable based on the types of devices that would be required in order to access the component (i.e. personal devices,

exhibit/kiosk device, computer lab devices, or other). For example, an after-school environment might be more likely to have a computer lab. Would such access make the component replayable, adaptable, or extensible in that context?

We considered the **player type** most likely to traditionally attend each learning context and compared that type to the players who participated with the component during the live ARG. For example, a museum audience is likely to be more generalized and broad whereas an after school program is likely to be more specific and narrowly defined. To what extent do those factors impact a component's current reusability?

Finally, we assessed the ARG component's **timing** variable based on the amount of time it would take to get something meaningful out of the experience and its fit for a given learning context as a result. For example, a component that requires a lot of time in use to understand would be less reusable in a museum environment without modification, but potentially replayable in a formal school setting.

We considered each of these five variables from the perspective of how players used the ARG component during the live game. We considered what it would take for each component to be reusable (replayable, adaptable, or extensible) in the three learning contexts from museum/informal learning settings to after school settings to formal classroom experiences. We conclude each assessment with a consideration for which learning context the component is best suited for in its current state and then provide suggestions for tweaks or augmentations to the component that would support its replayability, adaptability, or extensibility in each learning environment. We view these

forms of reusability on a continuum and have adapted definitions from Hansen and colleagues' (2013) earlier work on the topic[1]:

- **Replayability** is the extent to which a component could be launched in another context with minimal modification from its current format. It includes the ability for one group of players to use the component without infringing on another group's experience.
- **Adaptability** is the extent to which a component is reusable with reasonable modifications to adapt it to the specific needs of a different group or context.
- **Extensibility** is the extent to which a component is reusable with significant modifications and extended in such a way that it retains the authenticity of its original purpose, but is reusable in a new format.

One important thing to note is that the three learning contexts we considered are not mutually exclusive from one variable to the other. There are museum examples that can be made more formal experiences (through structured programming) and there are classroom experiences that can be less-structured (through free play or student-choice activities). For the sake of this assessment, however, we took fairly traditional views of each learning context to account for the ways in which components of *DUST* might be replayed in diverse settings along an informal to formal learning continuum. Although subjective in nature, this assessment is based on our experience of nearly two decades of research and evaluation of technology projects in informal learning settings.

[1] Hansen, D., Bonsignore, E., Ruppel, M., Visconti, A., & Kraus, K. (2013). Designing Reusable Alternate Reality Games. CHI 2013: Changing Perspectives, Paris, France. ACM Digital Library,1529-1538.

Findings & Recommendations

Game Component #1: QTE Environment during Collapse

Description of QTE Environment during Collapse

The Co-Lab was the epicenter of interaction for the game. Players could interact and collaborate on the web-based forum to collect information and help solve the fundamental challenge of the game: figuring out why the adults had collapsed. During the game, players used Co-Lab to ask questions, collaborate on theories, and submit evidence to support some of the said theories (i.e. QTE). The environment allowed the players to practice science inquiry skills related to theory generation and evidence sharing.

We assessed the Co-Lab interactions that occurred early in the game just at the time of the adults collapsing. We did this by filtering the QTE (Questions, Theory, and Evidence) interactions by the term 'collapse' and focusing on responses from the first few weeks of the game (see Figure 1).

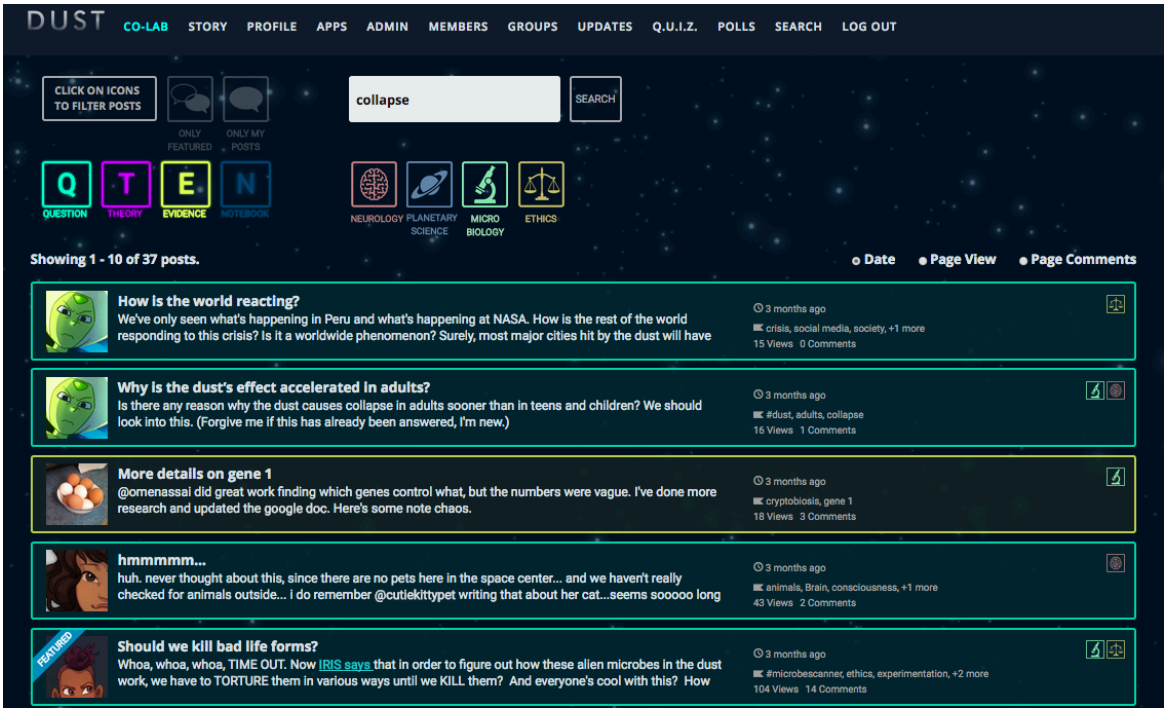

Figure 1. Screen capture of the QTE environment

We identified a total of 37 posts from both players and game runners related to the collapse in the QTE environment of the Co-Lab site from the first few weeks of game play (through mid-February). In comments on the QTE environment, players talked about the evidence they collected and possible reasons for the collapse. Players also asked questions about the collapse resulting in brief discussions around them. Game runners initiated some of the most popular parent posts, encouraging players to think more and analyze the data collected.

Posts that solicited good responses (i.e. views/comments) or represented positive scientific inquiry practices included featured posts from game runners and posts that suggested they contained some evidence/theory to consume or react to: Gram-Negative Xenobacterial Tardigration, Cryptobiosis, Should we kill bad life forms?, Fractal

Patterns, etc. Posts such as these could be reused in other versions of this game component in the future.

Reusability Matrix for the QTE Environment during Collapse

We considered the reusability of the QTE Environment during the Collapse across the three learning contexts:

- The QTE Environment posts that received maximum responses/views were all from game runners suggesting that this component requires at least partial **facilitation** to support the necessary scaffolding that players required. This makes it a good candidate for use in an after school or classroom setting.
- Due to the conversational nature of the QTE Environment, it is helpful to know who is contributing information via **user identification**. Completely anonymous posts might not generate the type of discussion desired. A more structured environment, like a classroom or after school setting, would support this component best, since players would have time to complete a user authentication process.
- The QTE Environment is accessible on both desktop and mobile devices making **digital access** easy across all three learning contexts.
- The QTE environment is easy to access by individuals, small groups, and larger groups. However, the **player type** is harder to control for in a museum setting, so

targeting after school programs for teens or middle/high school classrooms is more likely to generate meaningful learning outcomes.

- The environment requires at least 15-20 minutes for users to read, understand, and contribute in a meaningful way to QTE posts when taken out of context of the larger narrative. This time commitment makes it most replayable in an after school setting, which provides an ideal **timing** duration.

Table 2 summarizes our assessment of the QTE Environment during the Collapse across learning contexts.

Table 2. Reusability Assessment Matrix for the QTE Environment during the Collapse

	MUSEUM	AFTER SCHOOL	CLASSROOM
Facilitation	●	●	●
User Identification	●	●	●
Digital Access	●	●	●
Player Type	●	●	●
Timing	○	●	●

● Requires little to no changes for use in new learning setting

● Will likely work OK in new learning setting, but requires tweaks

○ Unlikely to work well in new learning setting without significant changes/additions

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MUSEUM: As Table 2 shows, in its current format the QTE Environment would be **extensible** in a museum context due to its need for facilitation, user identification, and the amount of time needed to engage with it to have a full experience. The user identification need could be overcome through the use of generic login names or avatars (similar to the Google Drive non-authenticated approach) or through something very simple like a first name and last initial for very basic registration/authentication. As mentioned above, the player type is tough to control for in a museum setting and the little amount of time that visitors have for any one exhibit might not be enough for them to immerse themselves in the larger conversation around the collapse. It would require additional context and broader set of learning materials positioned around the game component for players to get a meaningful experience in this type of learning context.

AFTER SCHOOL: The QTE Environment during the Collapse will be most **replayable** in after school programs; especially ones that have a focus on scientific inquiry and collaboration. This game component allows users to be flexible with the device used and needs some facilitation, which works very well in various types of after-school contexts. Users can participate in the conversation as individuals, small groups or large groups making it ideal for flexible after school collaboration.

CLASSROOM: The QTE environment is **adaptable** for more structured classroom environments with some tweaks. Classrooms allow for 1-2 hours of interaction with the game component but the QTE environment does not require that amount of time. With the addition of a few other curriculum components, it could be adapted successfully within a classroom setting, which would otherwise provide ideal facilitation, user authentication, and a controlled player type needed for the reusability of this component.

Game Component #2: Brain/Health Scanner App

Description of Brain/Health Scanner App

The Brain/Health Scanner mobile app is a simulated data collection and analysis tool that players used during the game to understand what state the adults were in when they collapsed. The mobile app allowed players to "scan" an adult brain and gather information about contamination and the adult's mental state (see Figure 2). During the game, players used the app to speculate about which part of the human brain was infected and the associated microbes that might be impacting the situation, practicing science inquiry skills related to hypothesis generation and evidence gathering. Players used the app in the first few weeks of the game/narrative, although they could return to it at any time during the game.

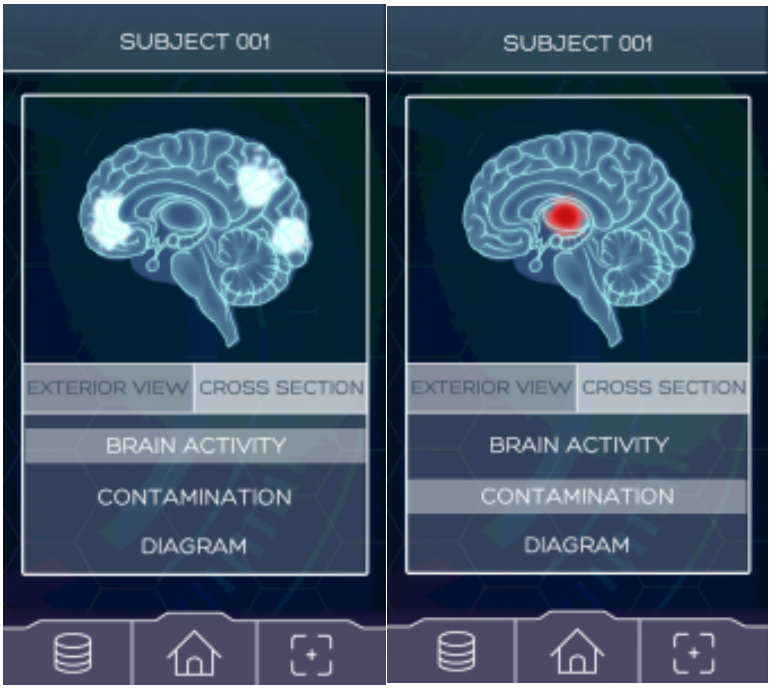

Figure 2. Screen capture of the Brain/Health Scanner mobile application

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We identified a total of 437 posts related to the Health/Brain Scanner app on the Co-Lab site (151 of these posts came from game runners, the remaining 286 came from players). The posts represented comments from 49 unique players.

In comments on the Co-Lab site, players talked about their personal health scanner score and countdown to collapse. Players also asked questions about the app and discussed the results they got from scanning different objects. Game runners facilitated the communication by encouraging players to contribute the data they collected for others to analyze/use.

Posts that solicited good responses (i.e. views/comments) or represented positive scientific inquiry practices included:

- All updates by IRIS as well as featured posts
- Posts that had intriguing titles or calls to action: Is IRIS human?#ImHumanBecause, Collapse connected to brain acuity?, IMPORTANT: THEORY AND ADVICE!!! READ IMMEDIATELLY!, etc.
- Posts that suggested they had new discoveries & explanations: Explanation (Microbes), Micro Scanner microbes in active state, Big micro-organism discovery!, etc.

Reusability Matrix for the Brain/Health Scanner App

We considered the reusability of the Brain/Health Scanner App across the three learning contexts:

- The scanner requires minimal **facilitation,** which makes it a good candidate for use in an informal learning setting like a museum.

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- It is helpful, though not critical, to know who is contributing data via the app through **user identification**, suggesting that a more structured environment, like a classroom, with time to complete a user authentication process would be ideal.
- The app is designed for use on mobile devices making **digital access** easier for a museum visitor than a classroom user (where personal devices are often banned).
- The **player type** is harder to control for in a museum setting, so targeting after school programs for teens or middle/high school classrooms would require the least amount of change to the app for it to be reusable. The app is also more easily accessed by individuals or smaller groups than large groups.
- The ability to move through the app experience quickly (approximately 5 minutes) makes it a good candidate for integrating into a museum or after school experience, which typically have shorter **timing** durations than classroom settings.

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Table 3 summarizes our assessment of the Brain/Health Scanner App for use in other learning settings.

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Table 3. Reusability Assessment Matrix for the Brain/Health Scanner App

	MUSEUM	AFTER SCHOOL	CLASSROOM
Facilitation	●	●	◉
User Identification	◉	◉	●
Digital Access	●	◉	○
Player Type	○	●	●
Timing	●	◉	○

● Requires little to no changes for use in new learning setting

◉ Will likely work OK in new learning setting, but requires tweaks

○ Unlikely to work well in new learning setting without significant changes/additions

MUSEUM: As Table 3 shows, the Brain/Health Scanner app would be most **replayable** in a museum context due to its relatively low need for facilitation, the opportunity for visitors to use either a personal device or a device borrowed from the museum for access to it, and the short amount of time needed to engage with it to have a full experience. User identification can be overcome through the use of generic login names or avatars (similar to the Google Drive non-authenticated user experience) or through something very simple like a first name and last initial for very basic registration/authentication.

An adaptation of the component for the museum context would be to send messages to museum visitors from the beginning of their museum visit through to the end, allowing a similar version of the collapse event from DUST to unfold on their mobile devices during their 1-2 hour museum visit. A key consideration for this context, however, is finding a

museum setting that has the right content for the app to exist within, such as a health exhibit or neuroscience exhibit.

AFTER SCHOOL: With some tweaks or close alignment of the app to an after-school program, the Brain/Health Scanner app will be **adaptable** for various types of after-school contexts such as programs in libraries that are related to health science. It would work well in a program that is loosely facilitated, engages users in an exploration of a brain/health concept, and provides mobile devices for access to the application.

CLASSROOM: With additional context and broader set of learning materials positioned around it, the Brain/Health scanner app is **extensible** for more structured classroom environments. This would require a curriculum that effectively mimics the storyline of *DUST* with structured science inquiry questions and narrative components incorporated into it. The experience could be extensible across multiple episodes (scheduled to fit a school session, like an English period) for different classes in a school where participating schools could compete with each other. This experience can be supported with printed/online resources and narratives provided to students. The schools could also organize events like knowledge tests or short plays to support some of the content being produced to create a more immersive experience similar to the real-time ARG.

Game Component #3: Microbe Web App

Description of Microbe Web App

The Microbe Web App is an online microscope simulation where players can experiment on virtual microbes to learn more about them. Players can zap microbes with radiation, freeze them, salt them, and find conditions where they can survive (see Figure 3). The app also allows players to genetically modify Tardigrades to kill the alien microbes. Players used the app in the earlier weeks of the game/narrative, although they could access it at any time during the game.

Figure 3. Screen capture of the Microbe web app

We identified a total of 21 posts related to the Microbe Web App on the Co-Lab site (20 of these posts came from game runners, and only one from a player). During the game, players and game runners recorded genetic data about the microbes in a Google

spreadsheet. The goal of the spreadsheet was to figure out each gene so that players could understand what genetic code would get the Tardigrade to live in a particular environment.

When we looked at posts on the Co-Lab site, filtered to the term 'microbe web app', we found mostly game runner posts including KSC updates and IRIS updates. Most of these posts did not initiate significant conversation amongst the players (i.e., most posts had 3 or fewer comments). However, the posts that solicited a large number of views included all updates by IRIS, featured posts, and posts that had intriguing titles or indicated new discoveries/explanations: Alien Microbe Weaknesses, ALIEN MICROBE?! WHYYYYYYY?!

Reusability Matrix for the Microbe Web App

We considered the reusability of the Microbe Web App across the three learning contexts:

- The app requires partial **facilitation,** which makes it a good candidate for use in an after school learning setting.
- It is also helpful to know who is contributing information via the app through **user identification**, suggesting that a more structured environment, like a classroom or after school setting, with time to complete a user authentication process would be ideal.
- The app is designed for use on desktop making **digital access** easier for an after school program and classroom users. It would require a kiosk installation or responsive mobile experience for use in a museum context.

- Targeting after school programs for teens or middle/high school classrooms would require the least amount of change for the app to be replayed with a similar **player type**.
- The app requires at least 30 minute time commitment for users to understand the app and contribute meaningful data to the spreadsheet. This makes an after school or classroom experience with a longer **timing** duration ideal.

Table 4 summarizes our assessment of this game component for use in other learning settings.

Table 4. Reusability Assessment Matrix for the Microbe Web App

	MUSEUM	AFTER SCHOOL	CLASSROOM
Facilitation	○	●	●
User Identification	◌	●	●
Digital Access	◌	●	●
Player Type	◌	●	●
Timing	○	●	●

● Requires little to no changes for use in new learning setting

◌ Will likely work OK in new learning setting, but requires tweaks

○ Unlikely to work well in new learning setting without significant changes/additions

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MUSEUM: The Microbe Web App could be **extensible** in a museum context if it were transformed into an interactive installation in a microbe/biology section of a museum experience and if the time commitment could be reduced by cutting out the gene code component. Alternatively, the app could be modified for mobile devices.

AFTER SCHOOL: As Table 4 shows, the Microbe Web App would be most **replayable** in after-school contexts. Such programs provide partial facilitation and longer time durations, making the app an ideal learning tool for this setting type. A key consideration and challenge, however, is finding a program that has the right content for the app to exist within, such as a microbiology program. After school programs could access the app via desktop in their computer labs as a tool for students to collaborate and learn about genetic compositions and health environments for various microbes and Tardigrades.

CLASSROOM: With close alignment of the app to a class curriculum, the Microbe Web App would also be **replayable** in more structured classroom settings. Classrooms allow for 1-2 hours of interaction with the game component, but the Microbe app might not need that amount of time. Thus, with the addition of a few other curriculum components, it could be utilized well within the classroom setting, which otherwise provides ideal facilitation, user authentication, controlled player type and collaboration opportunities for a meaningful learning outcome.

Game Component #4: Star Map Web App

Description of the Star Map Web App

The Star Map Web App allows users to analyze graphs to create virtual simulations of exo-planets going around nearby stars to learn key concepts. The players can name the planets and learn how to do key calculations, like determining whether a certain planet is in the habitable zone or not. Players can submit those planets to the larger *DUST* system for other players to see (see Figure 4 and Figure 5).

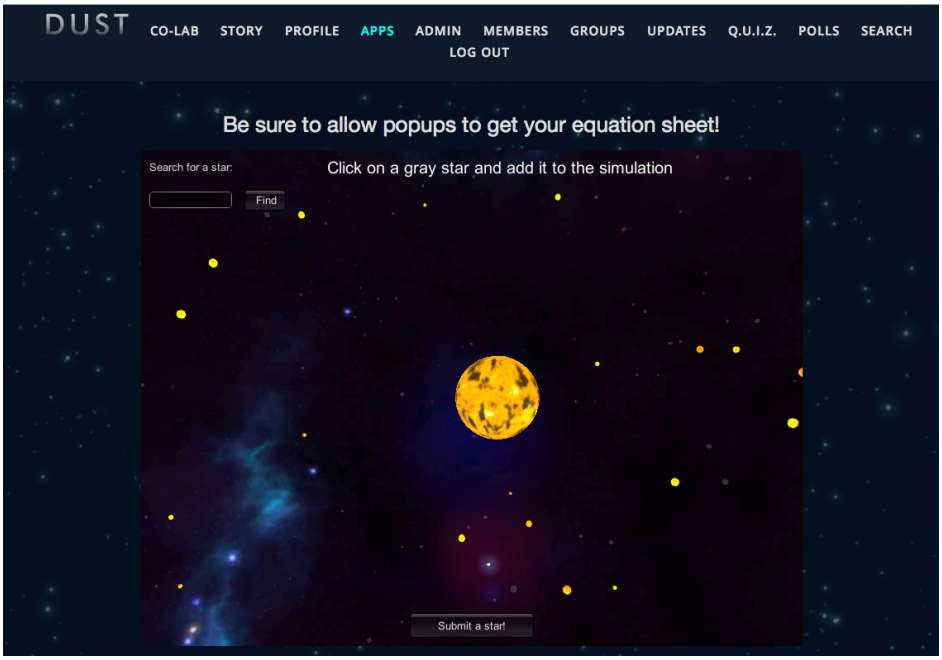

Figure 4. Screen capture of the Star Map app

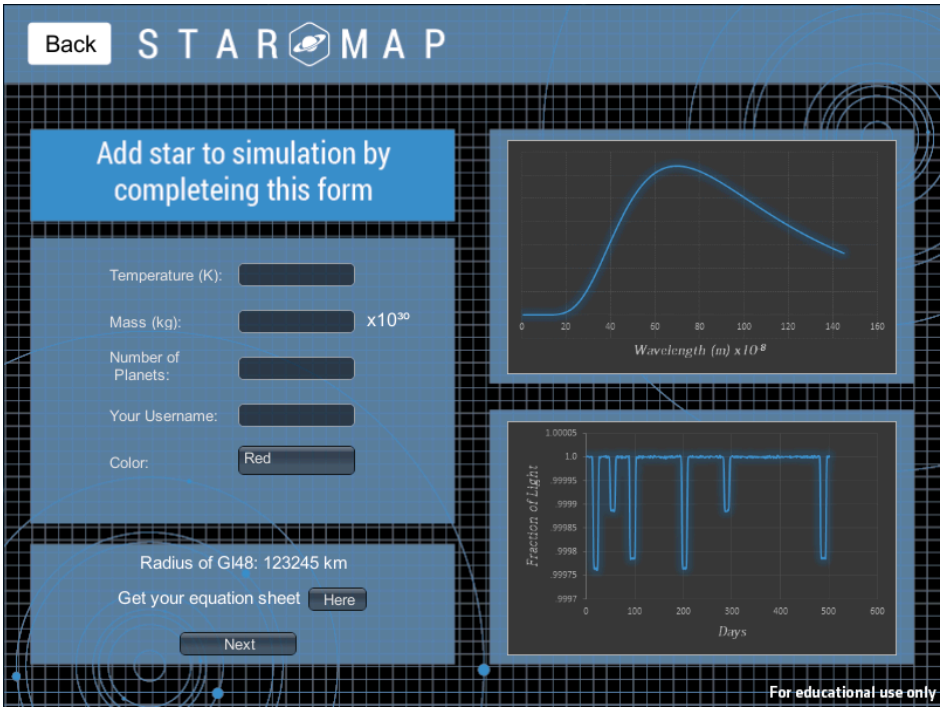

Figure 5. Entering data about the planets in the Star Map app

We identified a total of 26 posts related to the Star Map Web App on the Co-Lab site (22 of these posts came from game runners and only 4 from players). During the game, runners tried to encourage the use of this app by providing tutorials and other information about the app. However, the difficulty of the app and the associated mathematical calculations may have deterred its use by players.

In comments on the Co-Lab site, players asked questions and game runners tried to build upon existing posts to encourage contribution from players. Game runners also seem to push the usage of the formula sheet as reference for the players. However, the app did not allow the players to do these calculations automatically, which could be another factor deterring its use.

Posts that solicited a good number of views or encouraged scientific inquiry included:

- All updates by IRIS, KSC Newsflash weekly reviews, and featured posts.
- Posts that had intriguing titles or calls to action The End... of course it isn't., Microbe App - Help Needed, etc.
- Posts providing tutorials: Star map tutorial (add your tips to comments), Star Map Calculation Tool Beta, etc.

Reusability Matrix for the Star Map Web App

We considered the reusability of the Star Map Web App across the three learning contexts:

- The Star Map Web App requires full **facilitation** for the experience to be meaningful, which makes it most suitable for a classroom setting.
- The collaborative nature of the app, makes **user identification** an important aspect of use, suggesting that a more structured environment, like a classroom or after school setting with time to complete a user authentication process, would be ideal.
- The app is desktop accessible, making **digital access** easier for an after school program or classroom users.
- Targeting after school programs for teens or middle/high school classrooms would require the least amount of change for the app to be replayed with a similar **player type**.

- The app requires about 1 hour for users to understand the app and contribute to the star map in a meaningful way. This makes it a better candidate for an after school or classroom experience, which have longer **timing** durations.

Table 5 summarizes our assessment of this game component for use in other learning settings.

Table 5. Reusability Assessment Matrix for the Star Map Web App

	MUSEUM	AFTER SCHOOL	CLASSROOM
Facilitation	○	●	●
User Identification	●	●	●
Digital Access	●	●	●
Player Type	○	●	●
Timing	○	●	●

● Requires little to no changes for use in new learning setting

● Will likely work OK in new learning setting, but requires tweaks

○ Unlikely to work well in new learning setting without significant changes/additions

MUSEUM: The Star Map Web App could be **extensible** in a museum context if it were transformed into an interactive installation in an astronomy exhibit and if the time commitment could be reduced significantly through something like finding and naming

stars. To increase its accessibility in a museum setting, the app could be developed for mobile devices or installed in a kiosk. However, both (installation and mobile) experiences need to have a built-in calculator to do the required mathematical calculations for the users.

AFTER SCHOOL: With some tweaks or close alignment of the app to an after-school program, the Star Map Web App would be **adaptable** for various types of after-school contexts such as programs in libraries that are related to astronomy or amateur astronomy clubs. It would work well in a program that is facilitated, engages users in an exploration of study of celestial objects, and allows players to use a computer lab for accessing the app.

CLASSROOM: As Table 5 shows, the Star Map Web App would be most **replayable** in a structured classroom environment as a part of curriculum related to astronomy. Classrooms provide facilitation and 1-2 hours of interaction with the game component that is ideal for students to interact with it individually or in groups. At present the app could easily be used as a group-learning tool in a school's computer labs. The required user authentication could also be used as an opportunity to assess efforts of individual students and potentially grade them on the mathematical calculations as part of a homework or in-class assignment.