MASTER PRACTICUM

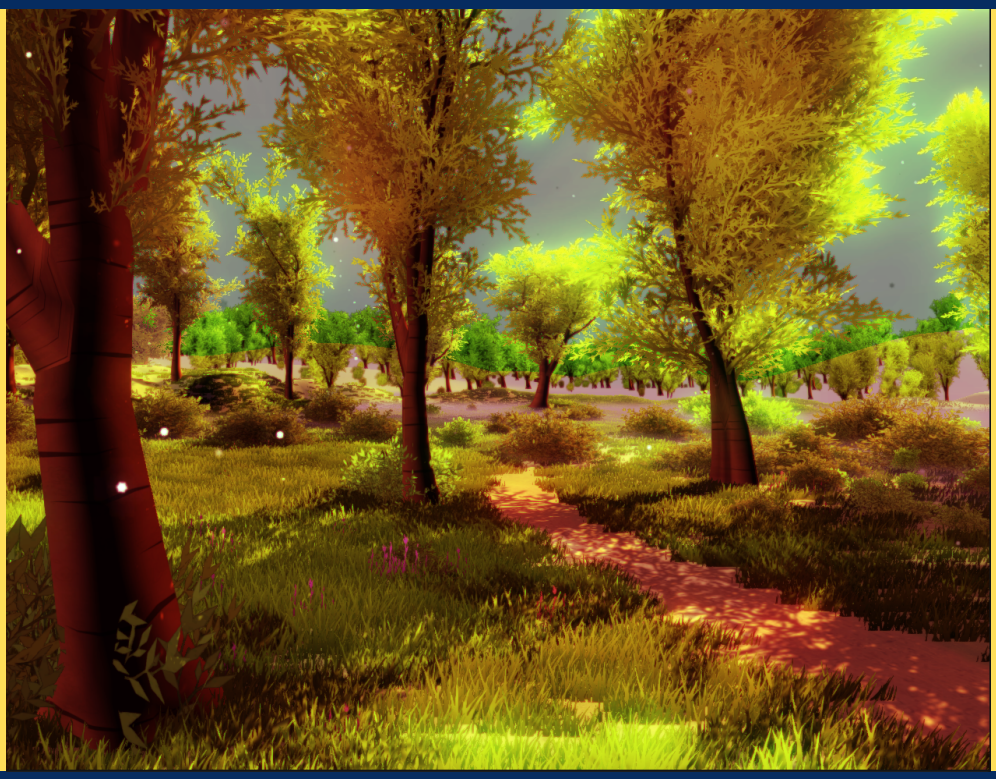
APRIL 2022

FINAL REPORT

ENGAGING DESIGN & PLANNING PRACTITIONERS IN A VIDEO GAME DECISION SUPPORT SYSTEM

BY QIUTONG GE & XUESI SHAO

Table of Contents



ACKNOWLEDGMENTS

Our practicum team would like to express our special thanks of gratitude to our advisor, Mark Lindquist, Assistant Professor of Landscape Architecture at the University of Michigan School for Environment and Sustainability. He gave us the golden opportunity to do this wonderful project on the Video Game Decision Support System. We would also like to thank Dr. Ramiro Serrano Vergel. His guidance and encouragement throughout this project were integral to our success in this project. We are really thankful to them.

EXECUTIVE SUMMARY

The primary purpose of the project was to **evaluate and refine** the Land.Info decision support system (DSS). Land.Info is a 3D immersive video game-based DSS that casts users in the role of designer, allowing them to design park infrastructure in virtual city spaces and receive real-time feedback based on their decisions (e.g. cost, amount of rainwater stored, carbon sequestration, etc. Ultimately Land.Info empowers citizens with decision support for the design of open spaces.

This project builds on an existing prototype of the Land.Info DSSThat was developed by a previous team. The current prototype requires user testing and further refinement to become an intuitive and fully functioning DSS to aid users. This project was built upon a previous team's final deliverables. We continued exploring what are the usability issues of the current version of the DSS; the severity of those issues and recommend prioritizing the major issues to bridge the the gap between the current gaming experience with an ideal one.

We first evaluated the usability of the current DSS by using the Heuristic Evaluation method. The major issues were **Consistency and Standards**, **Aesthetic and Minimalist Design**, and **Instruction and Documentation**. Informed by the results of the heuristic evaluation, we implemented significant features that were missing from the current version so that the DSS would be more intuitive with improved functionality. The features we added include a smoother player perspective with all the movements. We also implemented 4 tutorials for visualizing important effects: rainstorm; snow, grass, and flower blooming, as well as lighting and shade effects. It is recommended that future work conduct a usability analysis of these new features.

- Heuristic Evaluation process and results: examine the game based on Jakob Nielsen's ten general principles and identify the usability issues

- New features implantation on the six tutorials for visualizing: based on the evaluation results, implement essential features into the game that bridge the gap between the current and the ideal tutorial experiences

OUR TEAM

We are a two-person team who have a passion for technology.

Team Member 1: Xuesi Shao

Email: source@umich.edu

Education experience:
University of Michigan- Shanghai Jiaotong University Joint Institute (2017.9-2021.8)
Major: Electrical and computer engineering
University of Michigan
Master of SEAS - Sustainable Systems track
(Expected Graduation 2022)

Experiences:

- Designed a music and light control system that emits light according to the emotions, rhythm, and beat of a song judged by the software
- Peter the Great St.Petersburg Polytechnic University winter program (2019.1-2019.2)
- Intern Experience media (2018.1-2018.3)

Bio: Xuesi Shao has a background in engineering. His major at Shanghai Jiaotong University was electrical and computer engineering, which gives him a background in programming. Also, his talents in video games will help him in developing a fascinating game.

Team Member 2: Qiutong Ge

Email: qiutongg@umich.edu

Education experience:
University of Michigan
Master of Science in Information GPA: 4.0/4.0
Master of Landscape Architecture GPA: 4.0/4.0
(Expected Graduation 2022)

Work experience:
Website Designer at UMich

- Redesigned the official website of the Landscape Architecture Program in SEAS school at the University of Michigan
- Analyzed related stakeholders and user needs to define the priority for web design

Design Intern at Skidmore, Owings & Merrill

- Led user research and collected feedback to turn the conceptual ideas into high-strategic design solutions
- Worked collaboratively with PMs to define the key features and narrow down the scope of the project

Bio: Qiutong Ge is doing a Landscape Architecture program in SEAS school and doing a joint degree in the information field, which gives her a solid design and technology background. This project fits her skill sets and academic interest well

INTRODUCTION

Urban scenes that involve many human interactions and environmental facilities, such as parks, open spaces, green spaces, community centers, etc are not only important for urban resilience but also for social justice. The conventional top-down decision-making approaches can prohibit residents' voices in arranging and managing these landscapes.

Land.info is a gamified software that allows users to get involved in the design of open spaces. It leverages the 3D video-game innovation and a data-driven approach to help with decision-making for designing and planning parks, open spaces, and any other green infrastructures. Land.info currently supports practitioners with planning and designing city, community, and open spaces. This tool allows users to place natural objects (such as terrain, trees) and also man-made objects (such as roads, benches, and green infrastructure) into a city scenario. On the other hand, it utilizes a data-driven approach that calculates the environmental and social impact in real-time, such as rainwater storage and carbon sequestration, etc. The goal of this project is to **evaluate and refine** the current video game. In order to better guide ourselves, we formed the project into two major steps, **Heuristic Evaluation** and **New Features Implantation**.

- Step 1 Heuristic Evaluation: examine the current game based on Jakob Nielsen's ten general principles and identify the usability issues

- Step2 New Features Implantation: based on the evaluation results, implement essential features into the game that bridge the gap between the current and the ideal tutorial experiences

BACKGROUND

Public participation in urban planning and development is a widely used process that intends to enable better decision-making. Stakeholder participation is increasingly being embedded into environmental decision-making processes (Stringer et al., 2007). By involving stakeholders, many benefits have been recognized, for example, the quality and durability of decisions can be improved (Fischer, 2000, Beierle, 2002, Reed et al., 2008).

User and community co-production are important to society however rarely noticed because citizens are only willing to co-produce in a small range of activities that are genuinely important to them. There are also some concerns about the risks that co-production may trigger compared to professionalized service provision. However, the value of co-production has been increasingly recognized. The process has been seen as a way to build trust with communities, promote a better decision-making process, and increase public support. (Bovaird and Loeffler, 2012).

Many technologies have been created and developed in order to improve decision-making and Decision Support Systems (DSS) is one of them. Decision Support Systems have emerged in professional fields ranging from urban designing and planning, public policymaking, and information science since the 1980s (Klosterman, 1997, Arnott & Pervan, 2012). DSS require three components: 1) an interface that allows immediate graphical representation of analysis, 2) a database that includes information from multiple sources, and 3) analytical models that help analyze given inputs and the data (Klosterman, 1997). Such technology was designed to help with decision-making processes by facilitating the analysis of multiple scenarios simultaneously (Klosterman, 1997). As more urban data sets become available, opportunities for data-driven approaches to better support decision-making emerge. Through a data-driven understanding of the existing condition and potential changes, urban designers, planners, and developers can better collaborate and make wiser decisions (Ferreira, 2015).

It has been shown that 3D imagery and interactive environments can change the public's perceptions and increase the sense of responsibility. (Schroth et al., 2014). 3D visualizations can better convey a conceived image or scenario to the participants.

Developed by a research team led by Prof. Mark Lindquist at the University of Michigan, Land.Info can be backed up by the discussions and ideas above. It was developed to support residents in the design of vacant lots to address flooding in their neighborhoods. The video game leverages the DSS and 3D visualizations technologies and was co-produced with residents (Lindquist & Campbell-Arvai, 2021). Land.Info serves as a tool that helps stakeholders and residents to translate their local knowledge and insights into a design decision with a 3D virtual interface (Lindquist & Campbell-Arvai, 2021). The development of this video game has the intention to help city planners and designers to make better designing and planning decisions.

PROJECT PURPOSES

The primary purpose of the project is to **evaluate and refine** Land. Info, a 3D immersive video game that casts users in the roles of designers, allowing them to create park infrastructure in virtual city spaces in order to receive real-time feedback based on their decisions, such as the cost of trees, rainwater storage, and carbon sequestration, etc. It enables interactive evaluation and mutual feedback during users' decision-making process. There is an existing initial hi-fi prototype of the video game, but it requires some polishing work to become an **intuitive, user-friendly, and fully functioning** modern game for users to play.

The first version of the Land.info video game has been developed by the previous team in 2019. In the early phases of Land.info's development, a series of workshops were held to determine important features of the software. One of the features that have been developed is the ability to measure environmental improvements that result from urban designs created in the software, such as planting trees, adding facilities or changing terrains, etc in an open space.

However, the current version of the video game does not offer the best user experience to users. There are still significant usability issues to solve and many opportunities to improve to make the video game more intuitive and user-friendly. Therefore, this project would be built upon the previous team's final deliverables. We will continue improving the user experiences and exploring the potential of using video game methods to support more sustainable and engaging communities.

In order to better guide ourselves throughout the process, our project was framed in two steps: firstly to **evaluate the usability** of the current game to identify the major usability issues and rank them in severity, and secondly, to **add necessary and significant new features to refine** the current game based on the evaluation results.

METHODS & FINAL DELIVERABLES:

Step.1 Evaluation of the current game

Method: Heuristics Evaluation

We approached the Heuristics Evaluation of Land.Info by utilizing the popular method proposed by Jakob Nielsen. Although Jakob Nielsen offers 10 heuristics for usability analysis, he acknowledges that additional heuristics may be equally well-suited and while some of the suggested heuristics may be less applicable for certain interfaces. We evaluated the system through all ten of Nielsen's heuristic principles, however, we also made some miro changes to the criteria under each category to make the ten principles more suitable for our video game.

Ten Heuristics to evaluate:

- Visibility of System Status
- Match Between System and the Real World
- User Control and Freedom
- Consistency and Standards
- Error Prevention
- Recognition Rather Than Recall
- Flexibility and Efficiency of Use
- Aesthetic and Minimalist Design
- Help Users Recognize, Diagnose, and Recover From Errors
- Help and Documentation

To guide our analysis, we created user flows and tasks to complete as if we were users. The current version of the video game is simple and does not have too many interactions, therefore we applied a linear user flow, as the image below shows.

Figure 1: Linear user flow
Full version: https://drive.google.com/file/d/1WnzV41LpTAAloXBBWOg0vsh1PINNMit7/view?usp=sharing

Starting from log-in, users land in the default scene where they need to rotate the view and walk towards the two pieces of open space in the environment. After users arrive at the open space, they need to add items to the space. In order to do that, users first need to select a certain type of item from the top bar and then go through all the options from the card top up on the screen. They secondly pick one certain item and put it in an open space, they can move the item around, delete the item and undo/redo it for one step. We went through all these key interactions through the liner user flow we picked and the image below shows the details of them.

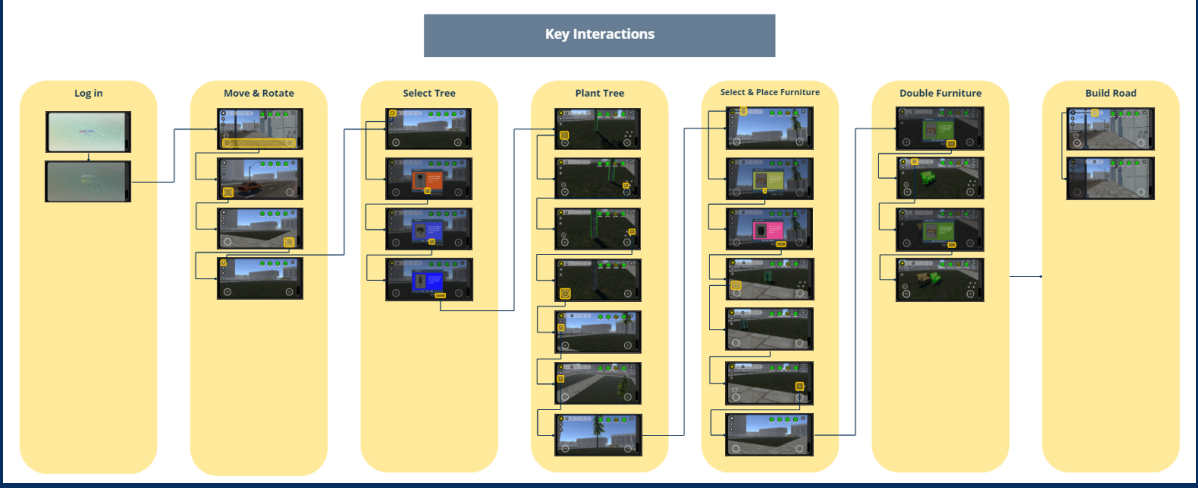


Figure 2: Key interactions of the user flow
Full version: https://drive.google.com/file/d/1XrZXB23n1U2itmAIlJrQTcRpoQo5h4Xr/view?usp=sharing

We conducted a heuristics evaluation based on these interactions and screens. In order to ensure we were aligned with the evaluation process and on the same page, we had a kick-off meeting to go through the Heuristic Evaluation Principles. From there, we created a Heuristic Evaluation Checklist for each of the ten heuristics to ensure we were applying the heuristics to evaluate Land.Info and deliver actionable results.

#	Review Checklist	Yes / No / Not applied	Step	Comments	Screen
#1 Visibility of System Status					
1.1	Does every interface begin with a title or header that describes page contents?	N/A		Does not apply to Mobile video game design	
1.2	Is there a consistent icon design scheme and has it been used consistancy thoughout the design?	No	Select an Item	The icons are applied the Unity Default style, doesn't have proper grid design system; A mixed use of dots, squre button and circle button	
1.3	Is selected icon / element is highlighted from other icons / elements which are not selected in the application	Yes	Select an Item	When each type of iem is selected, it will be highlighted	
1.4	Error promotes at the very place the action takes place and it is consistance through out the application	No	Place an Item	Does not prevent users from placing the items at the wrong place, for example, a trash bin can be placed on the road	
1.5	In user onboarding does the interface tell where the user is at any given moment?	N/A		Does not have a proper onboarding process	
1.6	If pop-up windows are used to display error messages, do they allow the user to see the field in error? or does it overlay the the fields	N/A		Does not provide users error message	
1.7	Dose the feedback change according to the type of error or notification intended?	N/A			
1.8	When click on an action button or complete a process, does the system provide a feedback to the user?	Yes	Place an Item		
1.9	Does the user get notified when a group of actions completed successfully and indicate the next set of actions to be taken in order to complete the task / achive the goal	No	Place an Item	No instruction to guide them through in the entire process, which makes sense in the case, because there will be people from the lab to educate participants in person	
1.10	Does the elements clearly show which can be clicked and which can not be clicked?	Yes	Select an Item	When each type of iem is selected, it will be highlighted	
1.11	Does the element shape / color change when the element being selected or cursor on top the element	Yes			
1.12	If multiple options can be selected in a multiselect menu, is there visual feedback about which options are already selected?	Yes	Select an Item	When each type of iem is selected, it will be highlighted	
1.13	Is there visual feedback when objects are selected or moved?	Yes	Place an Item	When an item being selected and can be moved, it will be highlighted in green	
1.14	Is the current status of an icon and element clearly indicated?	Yes			
1.15	Does the system provide a feedback when primary actions are clicked?	N/A			
1.16	Is the user being informed of the system delay's (more than 400ms) on system progress via feedback?	N/A			
1.17	Are response times appropriate to the task?	N/A			

Figure 3: Heuristics Evaluation Checklist
Full version can be found: https://docs.google.com/spreadsheets/d/1InevvM22ZcMTzg8-UYWPbH1pRVnZ7y7_/edit?usp=sharing&ouid=101986354738210466400&rtpof=true&sd=true

We then scored the problems we identified based on heuristics evaluation. Severity scores were on a scale of 0-5, with 0 being a “No problem” and 5 being a “Catastrophe” to Land.Info. The severity score was based on the frequency the problem occurs, the impact of the problem, and the persistence of the problem. (Nielsen, 1994)

Severity Score:
0 = No problem or usability strength
1 = Cosmetic only, low priority
2 = Minor issue, fix as time allows
3 = Major issue, important to fix
4 = Catastrophe, imperative to fix

Land.Info 3D Video Game
Heuristics Evaluation Severity Ranking
Reviewer Names: Qiutong Ge

Problem Identified	Heuristic Used	Severity	Recommendations
No instruction & documentation easy to acce	10. Help & documentation	4 = Catastrophe (imperative to fix)	Add tutorials up front
No instruction & documentation easy to show	10. Help & documentation	4 = Catastrophe (imperative to fix)	Add tutorials up front
Instruction & documentation are not easy to r	10. Help & documentation	3 = Major issue (important to fix)	Add tutorials up front
There is not any type of instruction or tutorial	10. Help & documentation	4 = Catastrophe (imperative to fix)	Add built-in instructions
No clear UI system and design guidline	4. Consistency	3 = Major issue (important to fix)	Add UI design system
The numbers under metric icons are center-j	4. Consistency	1 = Cosmetic only (low priority)	
There are 13 different icons on the same scre	4. Consistency	2 = Minor issue (fix as time allows)	Have less icons on a single screen
No clear UI system and design guidline	4. Consistency	3 = Major issue (important to fix)	Add UI design system
It uses the Unity default style, works but not a	4. Consistency	3 = Major issue (important to fix)	Add UI design system
Ther is no color categories	8. Aesthetic & minimalist	2 = Minor issue (fix as time allows)	Build a proper color coding system
No color coding throughout the system	8. Aesthetic & minimalist	2 = Minor issue (fix as time allows)	Build a proper color coding system
Color contrast is not good enough and cause	8. Aesthetic & minimalist	4 = Catastrophe (imperative to fix)	Improve the accesssibility issues
Light green to highlight the 4 metrics as defa	8. Aesthetic & minimalist	4 = Catastrophe (imperative to fix)	Improve the accesssibility issues
There is not enought color contrast between	8. Aesthetic & minimalist	4 = Catastrophe (imperative to fix)	Improve the accesssibility issues
Not clear and enough white space between g	8. Aesthetic & minimalist	2 = Minor issue (fix as time allows)	Add more white space
No "breathing space" around them	6. Recognition over recall	3 = Major issue (important to fix)	Add more white space
White space is not used to create symmetry a	6. Recognition over recall	3 = Major issue (important to fix)	Add more white space
Items have not been grouped into logical zon	6. Recognition over recall	3 = Major issue (important to fix)	Group and category the icons

Figure 4: Severity Score Ranking
Full version can be found: https://docs.google.com/spreadsheets/d/1P9R0AI-qeEDdBiwkxvgzDULXWIE01_Lk/edit?usp=sharing&ouid=101986354738210466400&rtpof=true&sd=true

Based on the ranking of the severity scores, we categorized the problems we identified into 4 tiers so that we have a better vision of which potential improvements are on a higher priority and should be done soon and which improvements can be future steps.

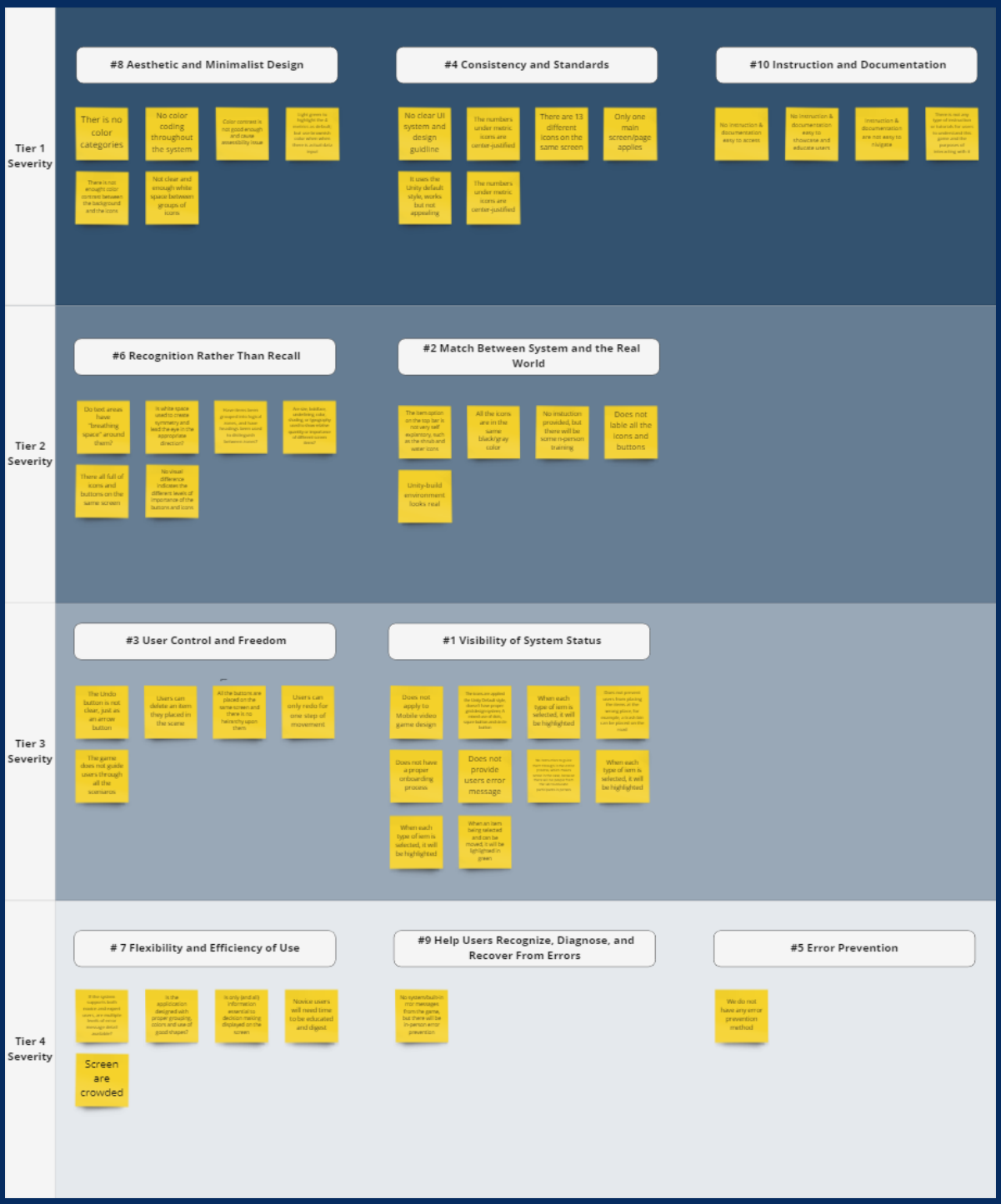


Figure 5: Issues in tiers
Full version can be found: https://drive.google.com/file/d/1TZmtGfd_bdoRaSolGXvFV4pTLzxYipH0/view?usp=sharing

Result: Findings and Recommendations

1. Instruction for users' comprehension

Finding #1.1
There are not any type of tutorials to educate users on the purposes and key functions of the game. A well-designed tutorial allows us to efficiently introduce new users to even very complex processes. In our case, educating users that certain design decisions can affect which aspects of the environment seems important to introduce ahead of time.

Recommendation #1.1
Add a quick tutorial process for users to review the environmental impact in different scenarios so that they have a better understanding of the goals of this video game and can interact with it better.

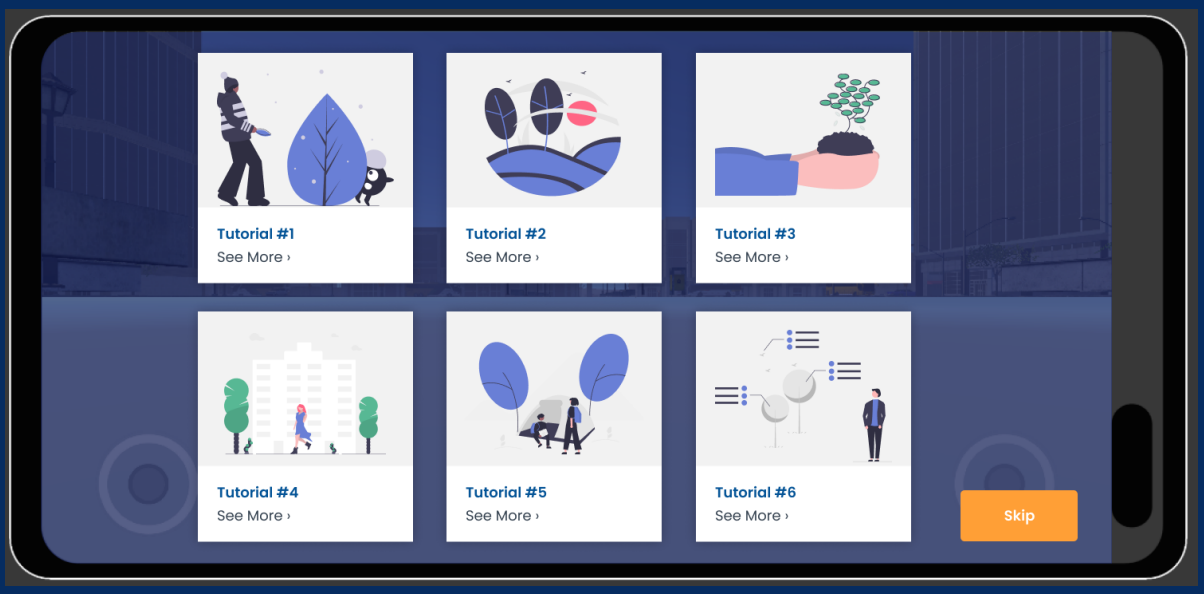


Figure 6: Tutorial mock-up

Finding #1.2

There are no built-in instructions to guide users on how to interact with the game. For example, when users land the game and open the default scene, they can see this city view, however, they are not informed that they should go to the open space to place items onto it and start the game.

Recommendation #1.2

Adding tooltips for key interactions throughout the entire gaming process to guide users to the next step so that they can be more aware of the situation.

Figure 7: Tooltips mock-up

Finding #1.3

There is no label on each icon to explain its meaning. This is problematic because users might have trouble recognizing the icons and thus can not select the right icons/button to interact with the game. Although this can be eliminated by the in-person education in a real workshop for data collecting, it still would be more efficient if users can recognize the icons by themselves.

Recommendation #1.3

Add labels on each key interactive icon or have a very quick one-time tutorial at the very beginning to go through all the icons users might interact with.

Figure 8: One-time tutorial mock-up

2. UI aesthetic and consistency

Finding #2.1

Color contrast is not enough for the item icons when they are deactivated because of the lower opacity.

Figure 9: Accessibility issue

Recommendation #2.1

Rather than having the icons on a low-opacity background, we can keep the background color always solid and assign the deactivate icons a lower opacity. In that case, we can till keep the difference between active and deactivate icons and won't cause accessibility issues at the same time.

Figure 10: Improved accessibility mockup

Finding #2.2

There is not a clear category for the icons and buttons on the screen and there are over 13 of them. It is considered overcrowded when there are more than 12 icons on a single screen, especially when they are not properly grouped based on the logic categories.

Recommendation #2.2

Adding tooltips for key interactions throughout the entire gaming process to guide users to the next step so that they can be more aware of the situation.

Figure 11: Improved icons category mockup

Finding #2.3

The UI issues are mainly caused by not having a clear design system to guide the design through the interface. The primary benefit of design systems is their ability to replicate designs quickly by utilizing premade UI components and elements. Teams can continue to use the same elements over and over, reducing the need to reinvent the wheel and thus risking unintended inconsistency.

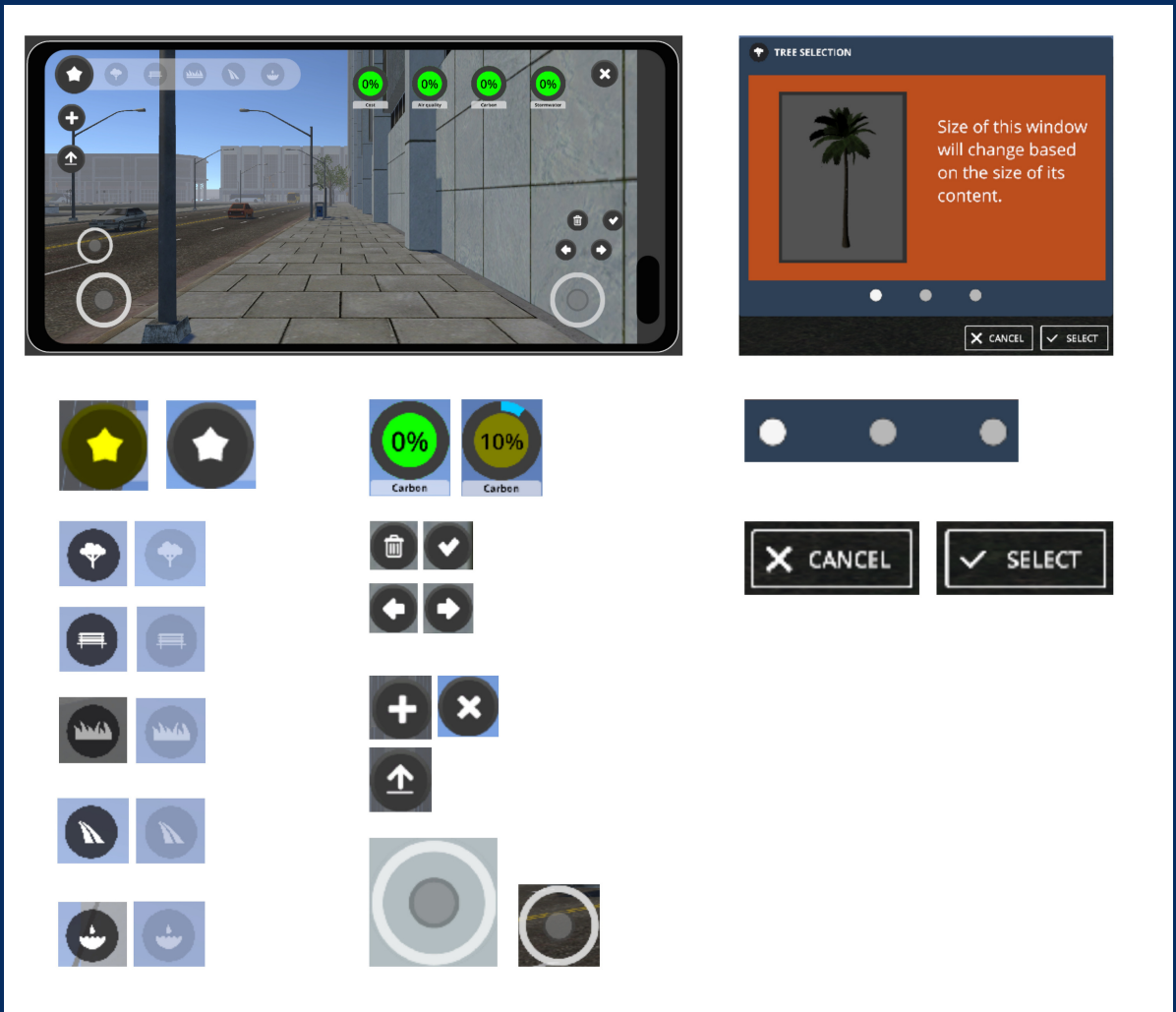


Figure 12: Current UI

Recommendation #2.3

Among all different types of design systems, Component Library seems to be the most appropriate approach in our case. Component libraries contain predetermined, reusable UI elements and serve as a one-stop shop for designers and developers to select and implement specific UI elements.

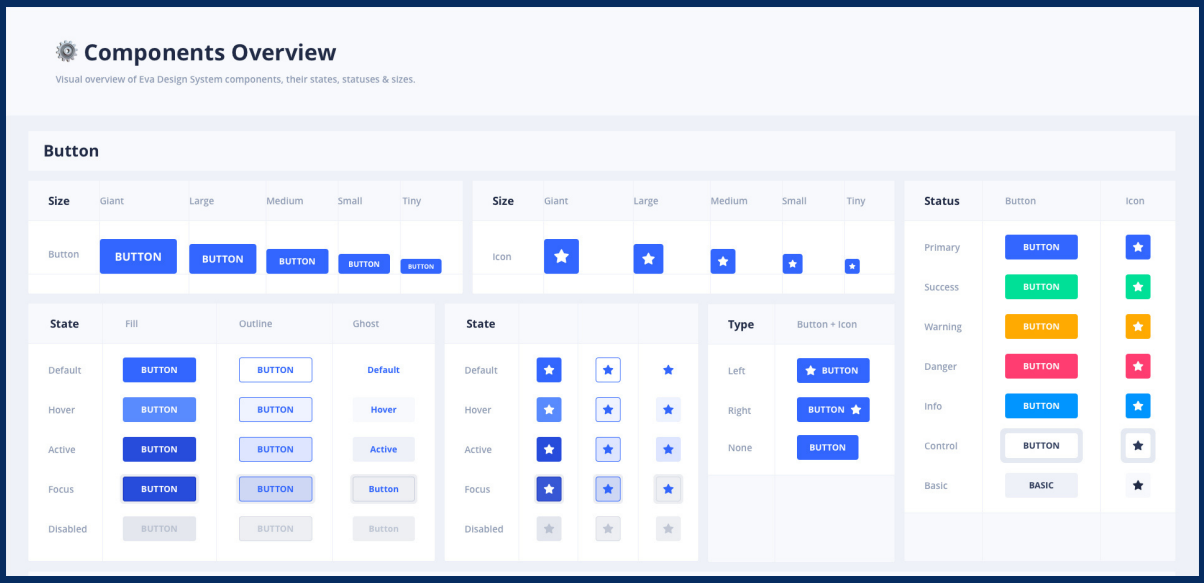


Figure 13: Component Library example
(Source: https://www.uistore.design/items/eva-design-system-for-sketch/)

3. Error prevention

Finding #3.1
We currently do not have any error prevention when users place the items in the wrong place. It's important to note that there are two types of errors that users make: slips and mistakes. Slips occur when users intend to perform one action, but end up doing another (often similar) action. Mistakes occur when a user has developed a mental model of the interface that isn't correct and forms a goal that doesn't suit the situation well (Nielsen Norman Group, 2015). In our case, the error type is considered a Mistake.

Recommendation #3.1
We can give users a Confirm Message before Destructive Actions. When users delete an item or place the items at an inappropriate spot, the system will trigger a pop-up dialog with an error message on it. This can be an effective, simple, and familiar way to give the user a final chance to stop and double-check if they really want to take the action.

Step.2 New features implementation

Method: Unity Development

Based on the Heuristic Evaluation results and the instructions from our mentor, Dr. Ramiro Serrano Vergel, we decided to improve and implement 6 visualizing tutorials in the Unity scenes for future incorporation into the game.

The first two, stormwater and snow, are weather contexts that will be incorporated into the game. Different weather conditions can have different outcomes for planting different trees in the scene. The third one is the shade, where users should be able to experience and realize the timescale of the game. The fourth one is flowering, which allows users to visualize the growth and blooming of their plants. The fifth one is similar to flowering, we also wanted to show users how the plant gro fruits. The last one is carbon sequestration, where an animation should be created to visualize the process of carbon being fixed into the ground. We chose to prioritize the first four tutorials due to the time limit.

On top of all the tutorials implementation, we also updated the camera movement function, so that we can make sure users can move around and look around in the newly implemented and old scenes at a comfortable speed and sensitivity.

Result: Implemented 4 Tutorials

1. Stormwater

The stormwater feature is accomplished through the Unity asset WeatherMaker (Jeff Johnson). The testing background is based on the Nature Starter Kit 2's Demo terrain. In the test scene, raindrops start falling down after a trigger, and the intensity can be adjusted through a sliding bar or automatically through a script. After a period of time, water will start to accumulate on the earth's surface to form puddles. The water surface will rise if the intensity of rain is high enough. For the rain that is over a certain threshold value, fogging effect will start to appear to make the terrain covered with water vapor.

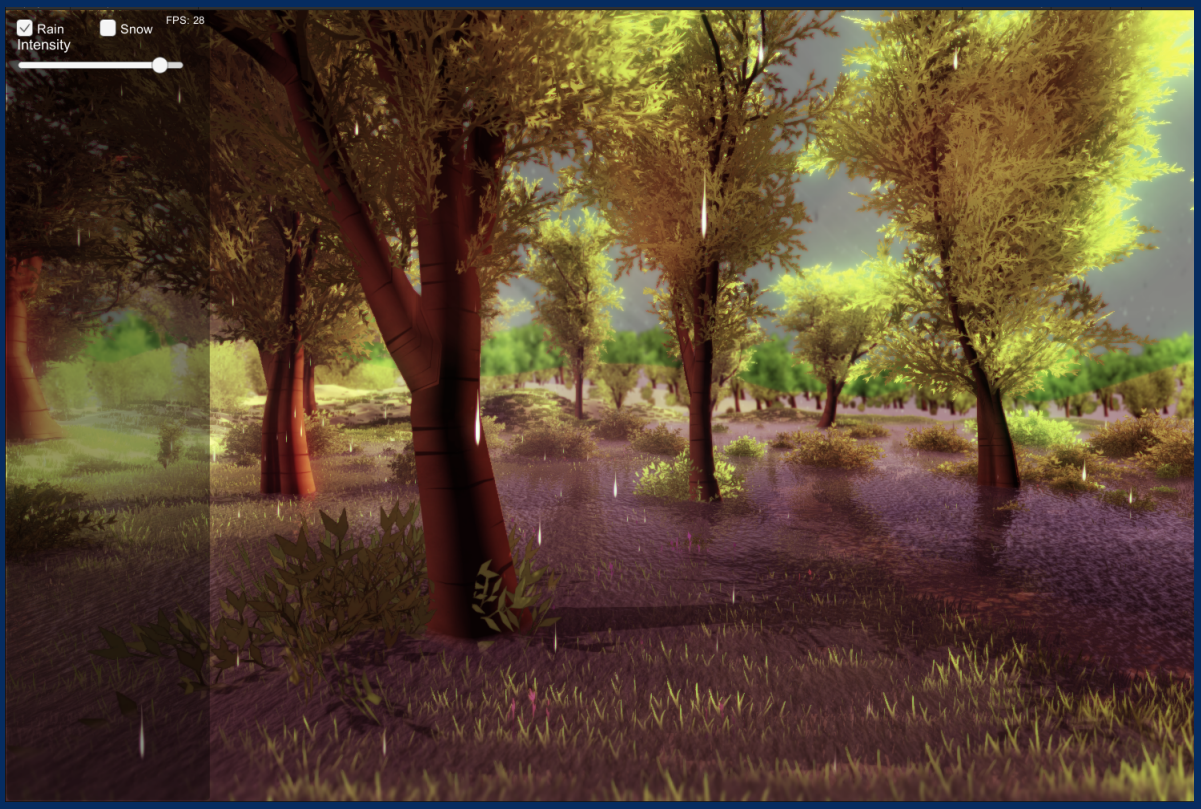


Figure 14: Game View of the rain scene

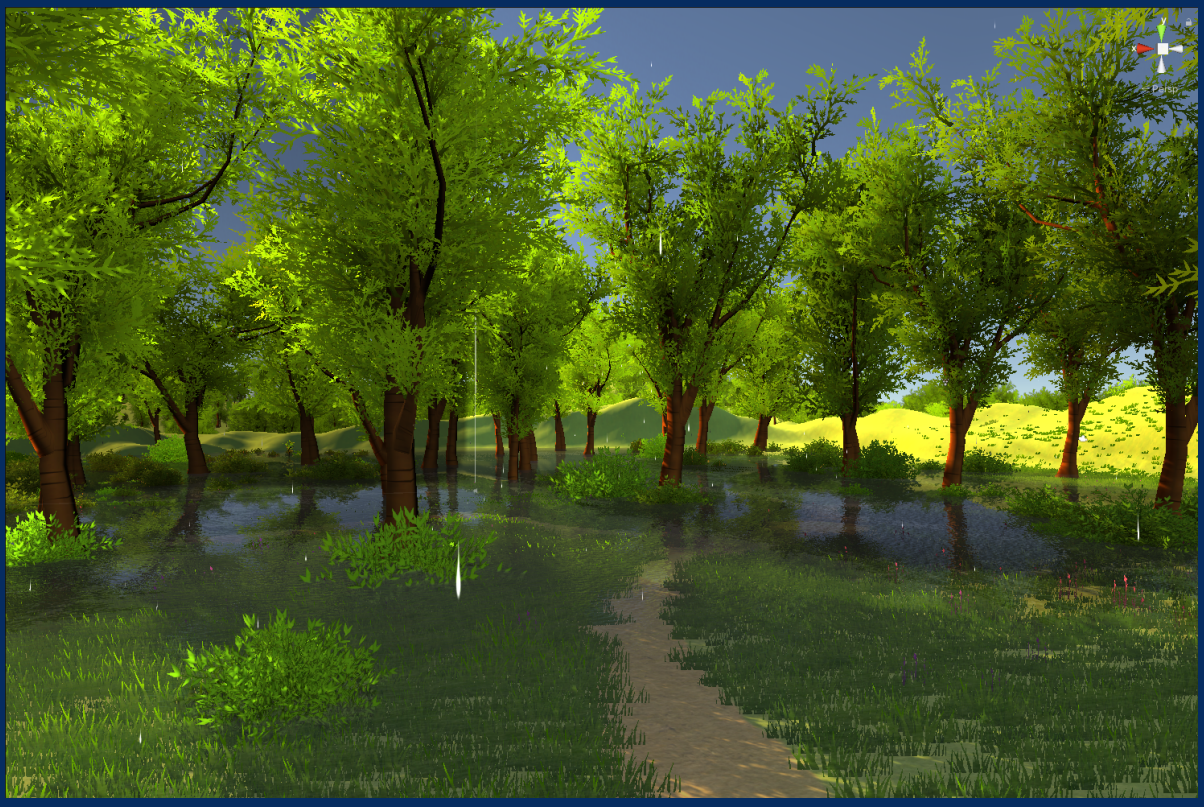


Figure15: Scene view of the rain scene

2. Snow

The snow features are also accomplished through WeatherMaker based on the demo terrain of Natural Starter Kit 2. Similar to rain effects, the snowstorm is also controlled by a sliding bar signaling its intensity. In order to accumulate snow, a snow overlay effect is triggered through a script to cover the terrain with white snow textures. The overlay will change its texture according to the intensity of the snow. Also, snowflakes will tend to be attached to any object (trees, grass) in the terrain. A snowstorm is created when the intensity of the snow is high enough, and similarly, fogging effects will appear just the same as the rainy scene.

Figure 16: Game View of the snow scene

Figure 17: Scene View of the Snow Scene

3. Shade

The Shade feature is also based on the WeatherMaker demo scene. The scene is given a timescale context where a light source rotates above the terrain like a sun. Therefore, shades are created according to the different positions of the “sun”. The timescale can be manually manipulated or just played at a set speed by a script.

The following pictures depict 4 different times of the scene, night, morning, noon, and afternoon. There are also dusk and dawn times when the sun glows pink.

Figure 18: Shade in the morning

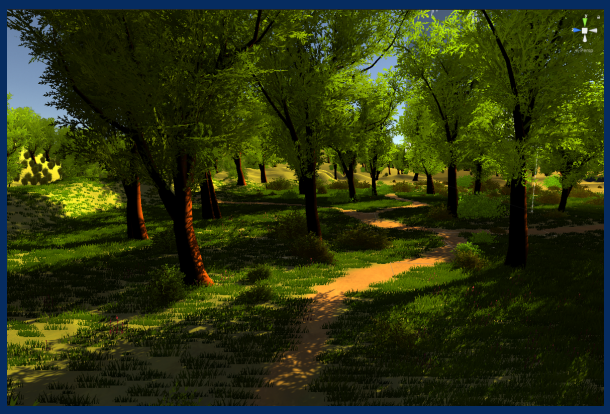


Figure 19: Shade at night

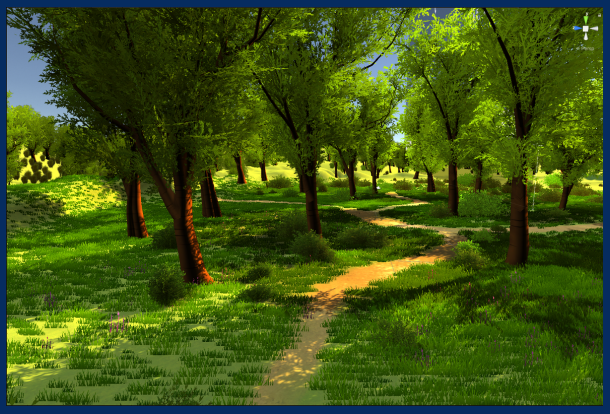


Figure 20: Shade at noon

Figure 21: Shade in the afternoon

4. Flowering

The flowering effect can be divided into two minor categories, flower bloom, and grass bloom. The flower bloom effect is realized through Garden Flowers and Herb's assets by Greenworks. The flower is able to bloom according to the light source. Petals can freely open and close according to a sliding bar.

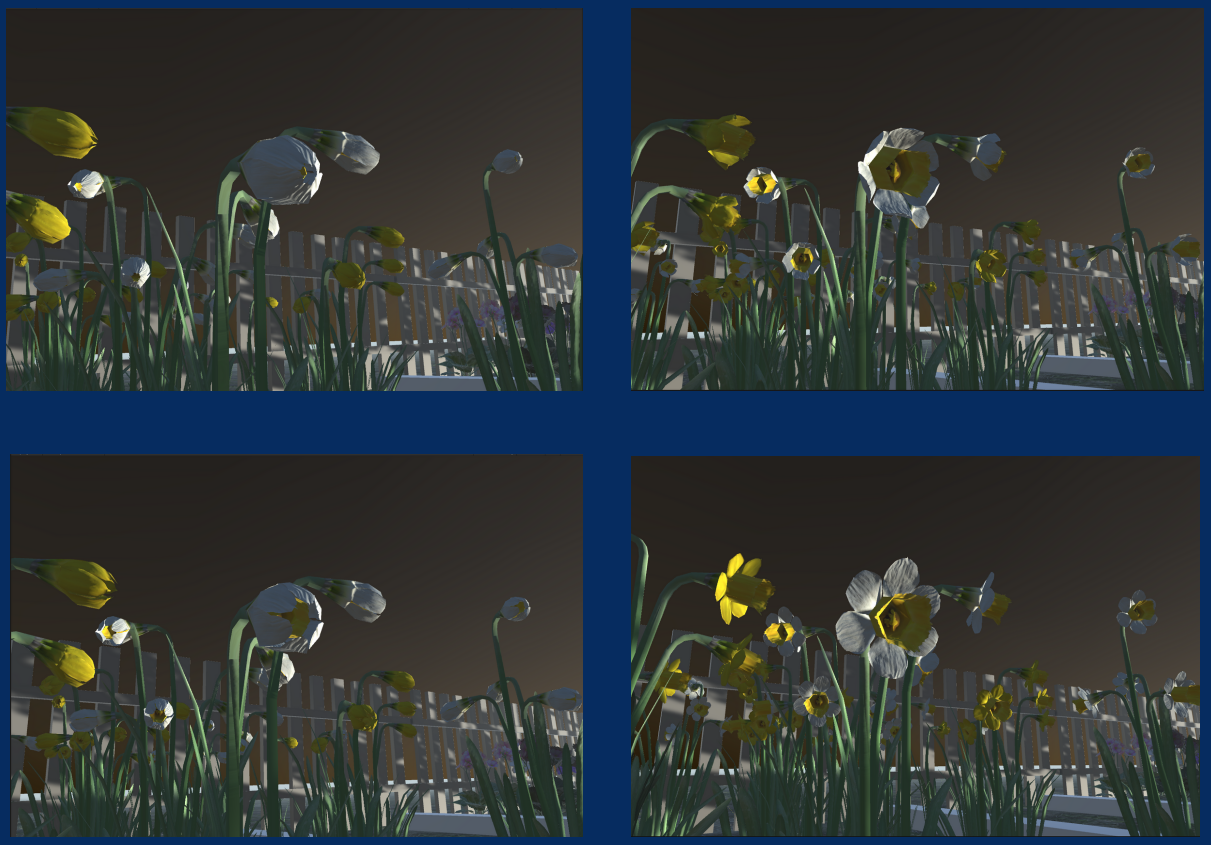


Figure 21: Flower blooming Stages 1-4

The grass bloom effect is achieved by the Plant Growing Asset by Dmitry Raskalov. Similarly, the grass is able to grow out of the farmland scene gradually until mature.

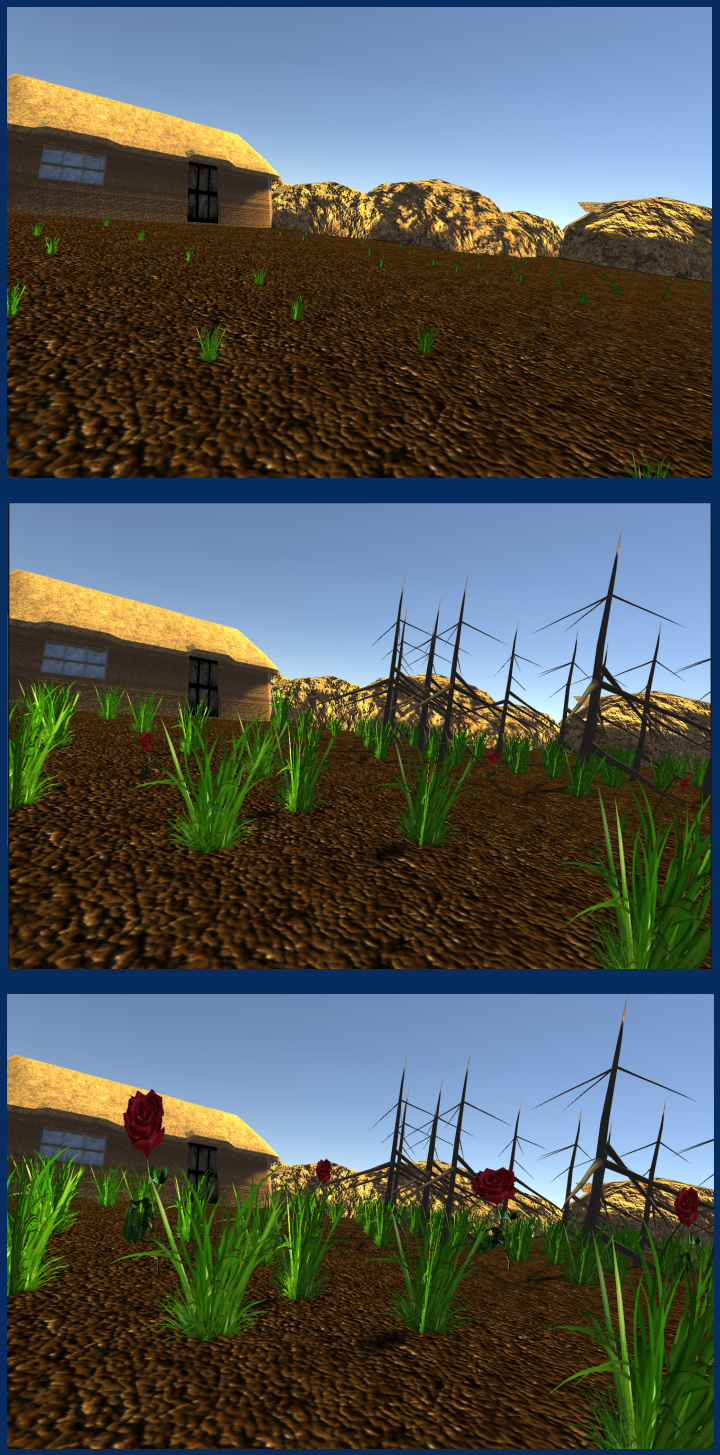


Figure 22: Grass Growing process 1-3

CHALLENGES AND LIMITATIONS

During the heuristic evaluation, there were a number of limitations we encountered throughout the heuristic analysis process. It is important to note that many Land.Info features haven't been fully implemented yet, and we are only focusing on the key screen and major features that are essential for collecting data from users. However, this didn't interfere with our ability to conduct the full heuristic analysis. Also, we are a group of two, the limited number of team members and time may make our finding biased to some extent. If there are more designers and developers involved in the process, we will be able to identify more usability issues more accurately and profoundly.

A lot of challenges also occurred during the implementation process. The first one, and probably the most challenging one, is to read through all the previous code in Unity. The massive number of lines of codes had different references to different game objects, which confused us a lot. Another challenge that was worthy to mention is that we do not develop models, so it is quite difficult to find a suitable model from the asset store that fits the project. In fact, in the process of choosing assets, we encountered many assets that seem pretty well from pictures but have uncompilable scripts.

NEXT STEPS

We have implemented the 4 prioritized tutorial scenes based on Dr. Ramiro Serrano Vergel's guide and the heuristic evaluation results. There are two more scenes we can continue working on to implement, the carbon sequestration visualization and the fruiting animation. After the implementation of all the tutorials we need, we can have usability testing on the animations with real users to see if those are intuitive for people who have no environment science or urban design background. Then we can make changes upon the feedback from the target users.

From the evaluation process, we have identified other issues for Tier 1, which have the highest priority other than the 'Instruction and Documentation' issue. there are some other categories that require improvements, such as the UI redesign and having a complete design system to better guide the future design and implementations for this game. As the project moves on, our team plans to produce a new design system and finish up the other implementations to give the tutorial a whole new look.

REFERENCES

Arnott, D. and Pervan, G., 2012. Design Science in Decision Support Systems Research: An Assessment using the Hevner, March, Park, and Ram Guidelines. Journal of the Association for Information Systems, 13(11), pp.923-949.

Balram, S., Dragićević, S. and Meredith, T., 2004. A collaborative GIS method for integrating local and technical knowledge in establishing biodiversity conservation priorities. Biodiversity and Conservation, 13(6), pp.1195-1208.

Bovaird, T. and Loeffler, E., 2012. From Engagement to Co-production: The Contribution of Users and Communities to Outcomes and Public Value. VOLUNTAS: International Journal of Voluntary and Nonprofit Organizations, 23(4), pp.1119-1138.

Geißel, B., n.d. Frank Fischer: Citizens, Experts, and the Environment. The Politics of Local Knowledge. Pp.25-46.

Lindquist, M. and Campbell-Arvai, V., 2021. Co-designing vacant lots using interactive 3D visualizations - Development and application of the Land.Info DSS. Landscape and Urban Planning, 210, p.104082.

N. Ferreira et al., 2015. Urbane: A 3D framework to support data driven decision making in urban development, 2015 IEEE Conference on Visual Analytics Science and Technology (VAST), pp. 97-104.

Nielsen Norman Group. 1994. Heuristic Evaluation. In J. Neilsen and R. L. Mack, eds. Usability Inspection Methods. John Wiley & Sons, New York, New York.

Nielsen Norman Group. 2022. Design Systems 101. [online] Available at: <https://www.nngroup.com/articles/design-systems-101/#:~:text=The%20primary%20benefit%20of%20design,and%20thus%20risking%20unintended%20inconsistency> [Accessed 24 April 2022].

Nielsen Norman Group. 2022. Preventing User Errors: Avoiding Conscious Mistakes. [online] Available at: <https://www.nngroup.com/articles/user-mistakes/> [Accessed 24 April 2022].

Paar, P., 2006. Landscape visualizations: Applications and requirements of 3D visualization software for environmental planning. Computers, Environment and Urban Systems, 30(6), pp.815-839.

REFERENCES

Reed, M., 2008. Stakeholder participation for environmental management: A literature review. Biological Conservation, 141(10), pp.2417-2431.

Reed, M., Dougill, A. and Baker, T., 2008. PARTICIPATORY INDICATOR DEVELOPMENT: WHAT CAN ECOLOGISTS AND LOCAL COMMUNITIES LEARN FROM EACH OTHER. Ecological Applications, 18(5), pp.1253-1269.

Schroth, O., Angel, J., Sheppard, S. and Dulic, A., 2014. Visual Climate Change Communication: From Iconography to Locally Framed 3D Visualization. Environmental Communication, 8(4), pp.413-432.

Stringer, L., Reed, M., Dougill, A., Seely, M. and Rokitzki, M., 2007. Implementing the UNCCD: Participatory challenges. Natural Resources Forum, 31(3), pp.198-211.

UNITY ASSETS

https://assetstore.unity.com/packages/tools/modeling/plants-growing-system-107128

https://assetstore.unity.com/packages/3d/vegetation/flowers/garden-flowers-and-herbs-2-112113

https://assetstore.unity.com/packages/3d/environments/nature-starter-kit-2-52977

https://assetstore.unity.com/packages/3d/vegetation/trees/realistic-tree-9-rainbow-tree-54622

https://assetstore.unity.com/packages/tools/particles-effects/weather-maker-volumetric-clouds-and-weather-system-for-unity-60955

APPENDIX

Evaluation Severity Ranking

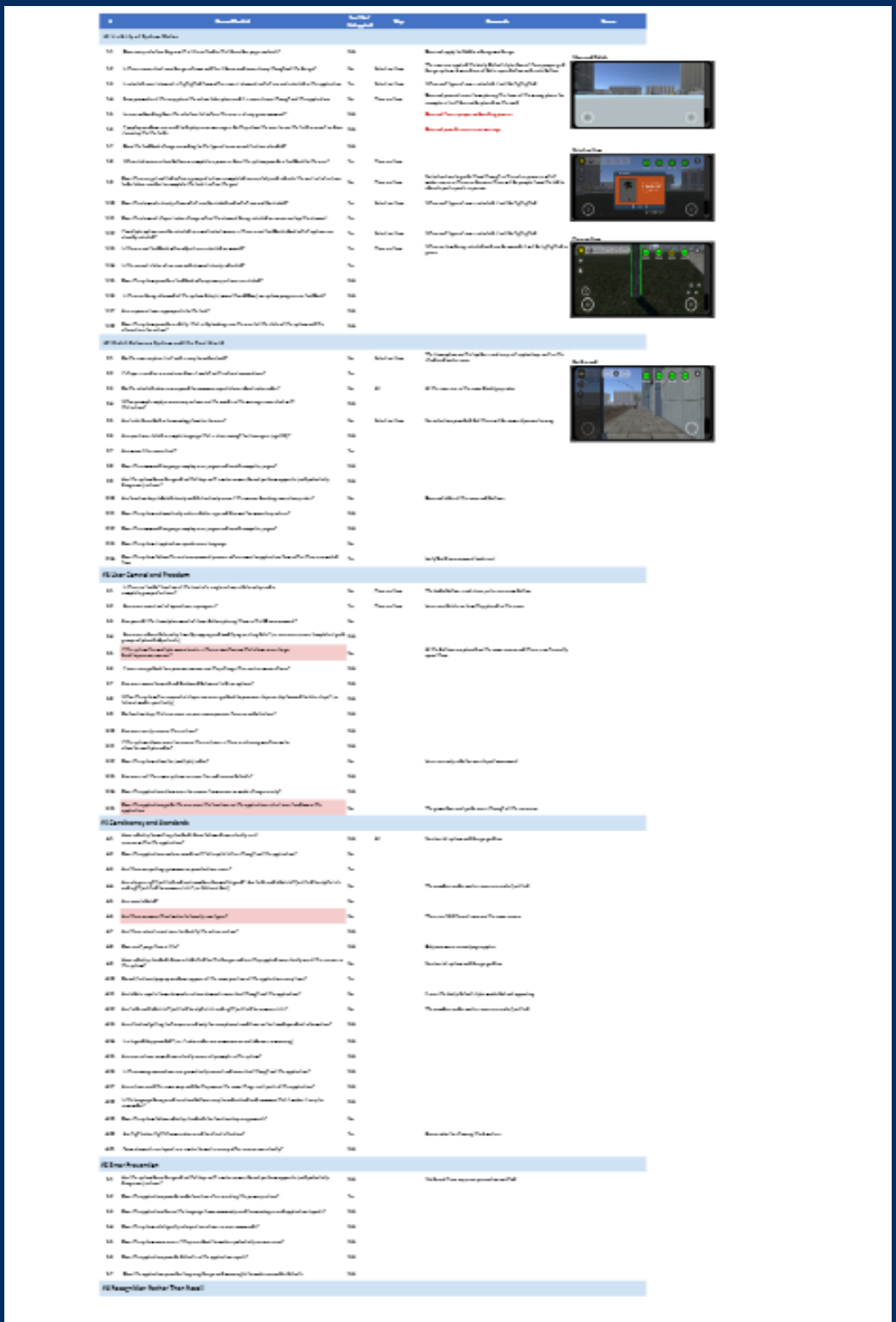
Land.Info 3D Video Game
Heuristics Evaluation Severity Ranking
Reviewer Names: Qiutong Ge

#	Problem Identified	Heuristic Used	Severity	Recommendations
	No instruction & documentation easy to acces	10. Help & documentation	4 = Catastrophe (imperative to fix)	Add tutorials up front
	No instruction & documentation easy to showc	10. Help & documentation	4 = Catastrophe (imperative to fix)	Add tutorials up front
	Instruction & documentation are not easy to fi	10. Help & documentation	3 = Major issue (important to fix)	Add tutorials up front
	There is not any type of instruction or tutorials	10. Help & documentation	4 = Catastrophe (imperative to fix)	Add built-in instructions
	No clear UI system and design guidline	4. Consistency	3 = Major issue (important to fix)	Add UI design system
	The numbers under metric icons are center-ju	4. Consistency	1 = Cosmetic only (low priority)	
	There are 13 different icons on the same scre	4. Consistency	2 = Minor issue (fix as time allows)	Have less icons on a single screen
	No clear UI system and design guidline	4. Consistency	3 = Major issue (important to fix)	Add UI design system
	It uses the Unity default style, works but not ap	4. Consistency	3 = Major issue (important to fix)	Add UI design system
	Ther is no color categories	8. Aesthetic & minimalist	2 = Minor issue (fix as time allows)	Build a proper color coding system
	No color coding throughout the system	8. Aesthetic & minimalist	2 = Minor issue (fix as time allows)	Build a proper color coding system
	Color contrast is not good enough and cause a	8. Aesthetic & minimalist	4 = Catastrophe (imperative to fix)	Improve the accesssibility issues
	Light green to highlight the 4 metrics as defaul	8. Aesthetic & minimalist	4 = Catastrophe (imperative to fix)	Improve the accesssibility issues
	There is not enought color contrast between th	8. Aesthetic & minimalist	4 = Catastrophe (imperative to fix)	Improve the accesssibility issues
	Not clear and enough white space between gr	8. Aesthetic & minimalist	2 = Minor issue (fix as time allows)	Add more white space
	No "breathing space" around them	6. Recognition over recall	3 = Major issue (important to fix)	Add more white space
	White space is not used to create symmetry al	6. Recognition over recall	3 = Major issue (important to fix)	Add more white space
	Items have not been grouped into logical zone	6. Recognition over recall	3 = Major issue (important to fix)	Group and category the icons
	There all full of icons and buttons on the same	6. Recognition over recall	2 = Minor issue (fix as time allows)	Add more white space and Group and category the icons
	No visual difference indicates the different leve	6. Recognition over recall	2 = Minor issue (fix as time allows)	Group and category the icons
	The item option on the top bar is not very self	2. User control & freedom	3 = Major issue (important to fix)	
	All the icons are in the same black/gray color	2. User control & freedom	3 = Major issue (important to fix)	
	No instuction provided, but there will be some	2. User control & freedom	2 = Minor issue (fix as time allows)	
	Does not lable all the icons and buttons	2. User control & freedom	1 = Cosmetic only (low priority)	Add lables to icon when necessary
	Unity-build environment looks real	2. User control & freedom	1 = Cosmetic only (low priority)	
	The Undo button is not clear, just as an arrow	3. Real-world mapping	3 = Major issue (important to fix)	
	Users can delete an item they placed in the sc	3. Real-world mapping	2 = Minor issue (fix as time allows)	
	All the buttons are placed on the same screen	3. Real-world mapping	3 = Major issue (important to fix)	Group and category the icons
	Users can only redo for one step of movement	3. Real-world mapping	3 = Major issue (important to fix)	Fix the undo and redo function

APPENDIX

If the system supports both novice and expert	7. Flexibility	2 = Minor issue (fix as time allows)	Add tutorials up front
Novice users will need time to be educated an	7. Flexibility	2 = Minor issue (fix as time allows)	Add tutorials up front
Screen are crowded	7. Flexibility	3 = Major issue (important to fix)	Add more white space

APPENDIX



APPENDIX