



Rain Gardeners

Design Manuals

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Entertainment Technology Center

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Rain Gardeners

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For more information on the development of this product as a graduate project, visit the team's website at <https://projects.etc.cmu.edu/rain-gardeners/>

Introduction

About Rain Gardeners

Rain Gardeners consists of 4 second-year students from CMU ETC. Working with our client, The Western Pennsylvania Conservancy, we are creating a fun and intuitive digital tool using AR technology for educators at Lincoln School who wants to educate 3-5 grade students about the ecology of a rain garden.

Our client

The Western Pennsylvania Conservancy has been dedicated to protecting and restoring the region's exceptional natural places since 1932. As a member-based nonprofit organization, we work in cities and towns across Western Pennsylvania and rely on the help of thousands of members, partners and volunteers. We are making a difference in our region's water, land and life. We do this work for the benefit of wildlife and people who call Western Pennsylvania home, and for future generations.

Rain Gardeners' goal

The goal is to help students have a better understanding of how rain gardens work, how plants benefit from water management and the ecosystem by making an AR experience on tablets. This is a project that supports and enhances the educators' teaching experience.

Our team

Name	Role	Contact Info
Alexa Wang	Producer, UI/UX Designer	xiaoyinw@andrew.cmu.edu
Leah Lee	UI/UX Designer, 3D Artist	eunchael@andrew.cmu.edu
Alyssa Tang	Programmer	shiqingt@andrew.cmu.edu

Harlan Liang	Programmer	hliang3@andrew.cmu.edu
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Design and Art

Overview

Our team designed two independent experiences. One for an on-site experience and the other for an indoor experience.



Target Audience

The target audience for this project is 3-5 grade students at Lincoln Elementary School. The students have prior knowledge of how rain gardens work.

Goal

The goal of this project is to support and enhance the educator's teaching experience. Visualized 3D animation in an AR environment can help students have a better understanding of the ecology behind the rain garden

Here is the photo of the rain garden:



Indoor AR Card Experience

Instruction

Recommended game play: 3-5 students in one group

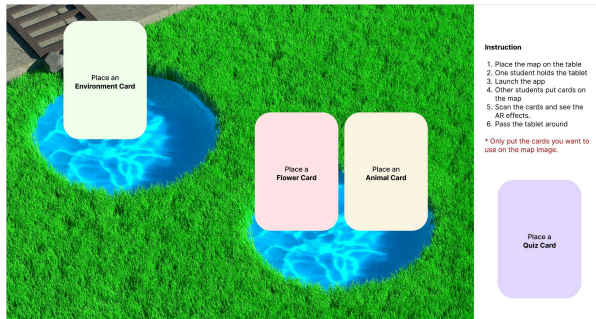
10-20 minute expected game play

- Place the map on the table
- One student holds the tablet
- Launch the app
- Other students put cards on the map*
- Scan the card to play the AR effects
- Tap the 3D object on the screen to view more information
- Pass the tablet around
- Scan the quiz cards and answer the questions

* Note | Only put cards on the designated area.

Materials

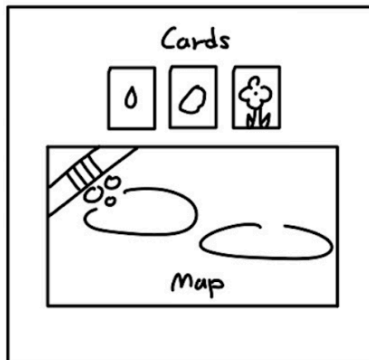
- 13 Cards (2 environment cards, 4 plant cards, 2 animal card, 5 quiz cards)
- 1 Map



[Link to download the map image](#)
[Link to download the card images](#)

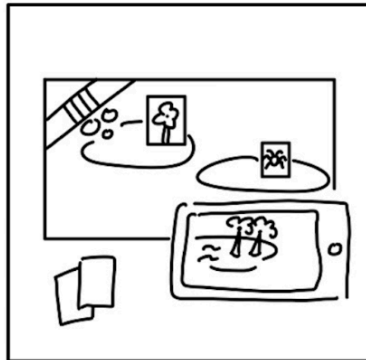
Experience Design

What we provide



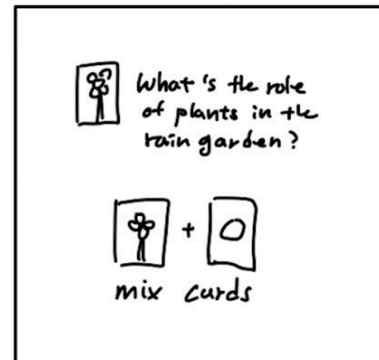
We provide printable cards and the rain garden map

What students do



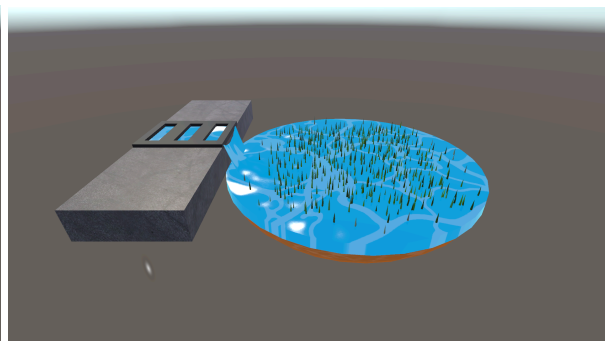
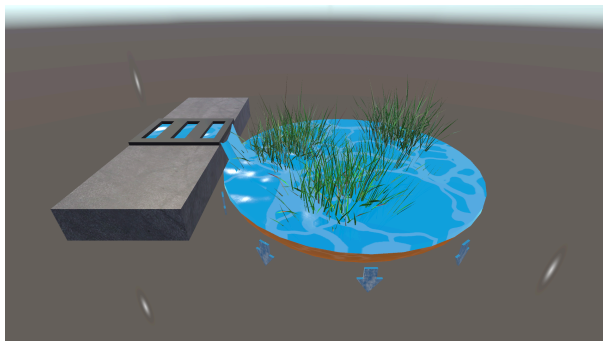
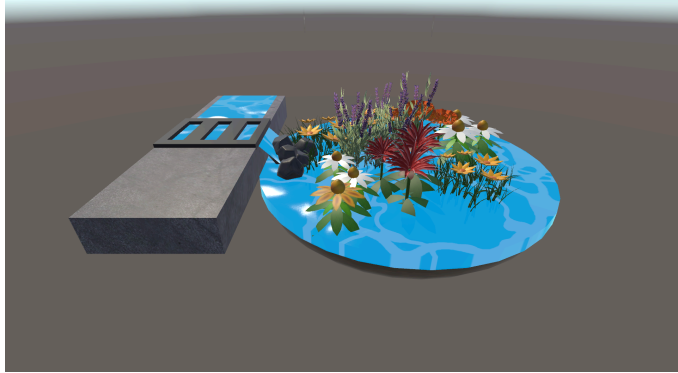
Students put cards on the map and view what happens using tablets

What students discover

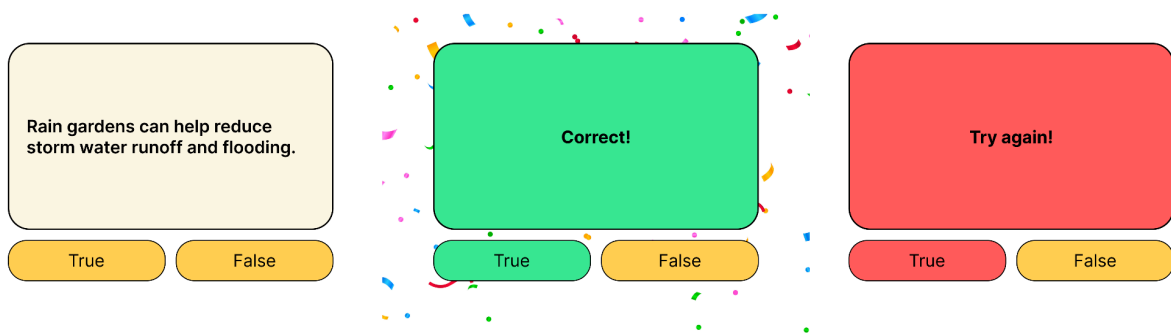


Students discover what the role of each component in the rain garden

3D Design



Quiz Design



Info Panel



On-site location-based AR Experience

Instruction

Recommended gameplay: 3-5 students in one group

10-20 minute expected gameplay

Loading part:

- Group people at the rain garden
- One student holds the tablet
- Launch the app

Exploring part:

- Find a wooden sign and scan it
- Other students use fingers to rotate and zoom in/out
- Find the clickable item and click them.
- Go through the introductions
- Pass the tablet around

Changing spot part:

- Find all three items

- Go to another spot
- Finish all three spots

Materials

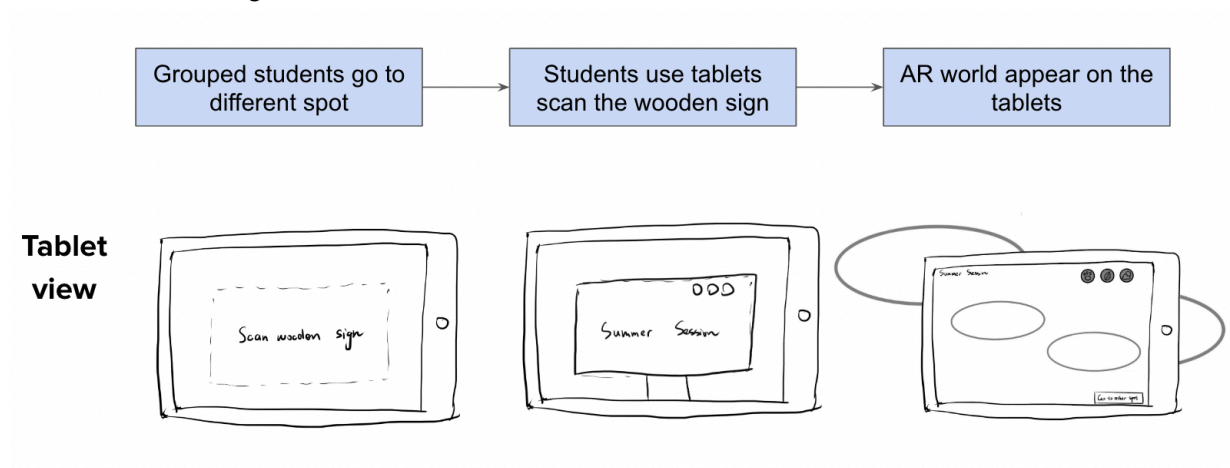
- 3 wooden signs(summer/snow/rain)



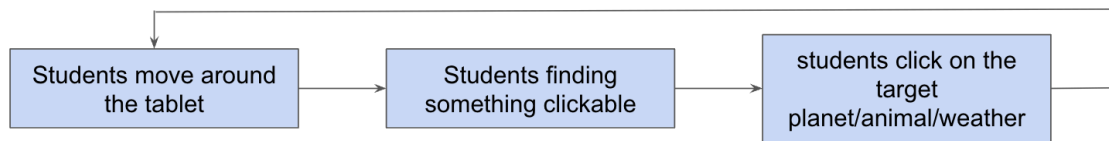
[Link to download the wooden signs](#)

Experience Design

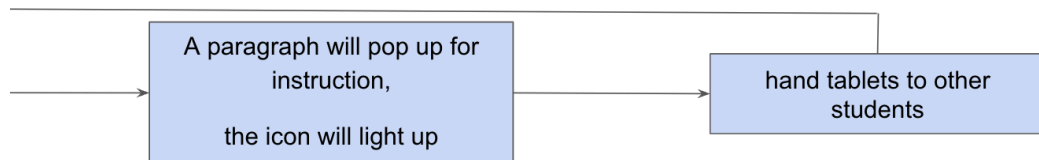
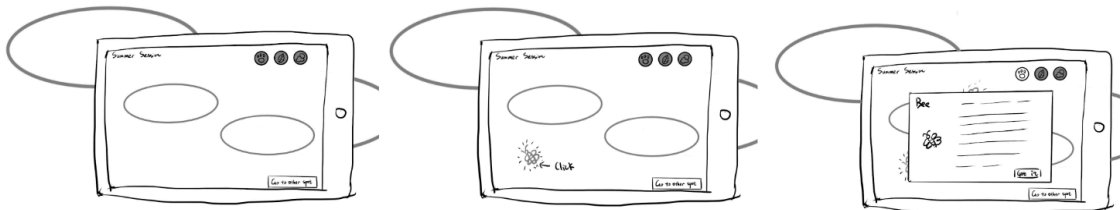
- Scan the sign



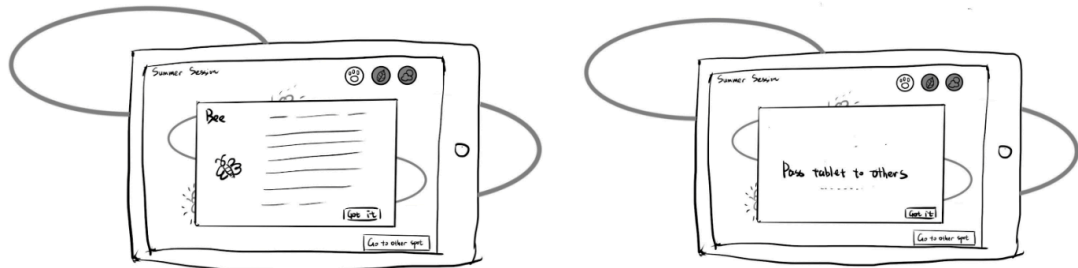
- Exploring & Finding



Tablet view



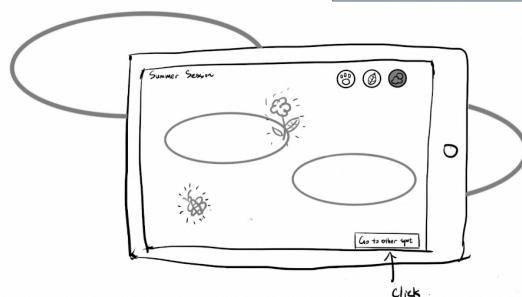
Tablet view



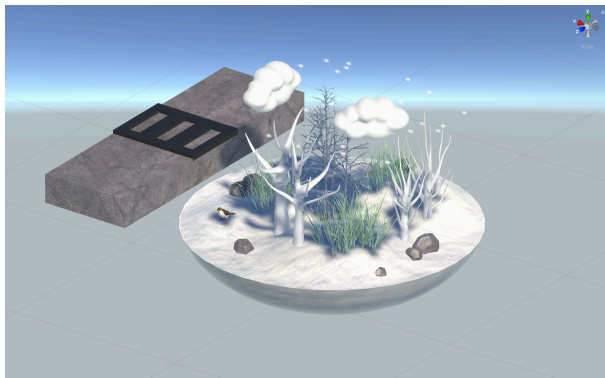
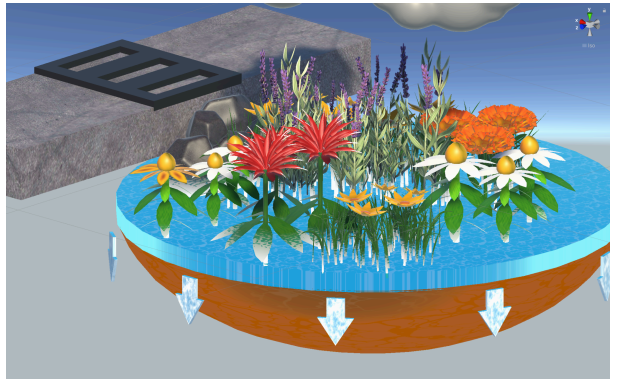
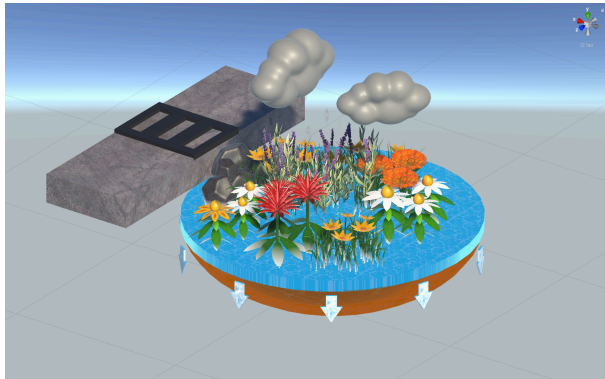
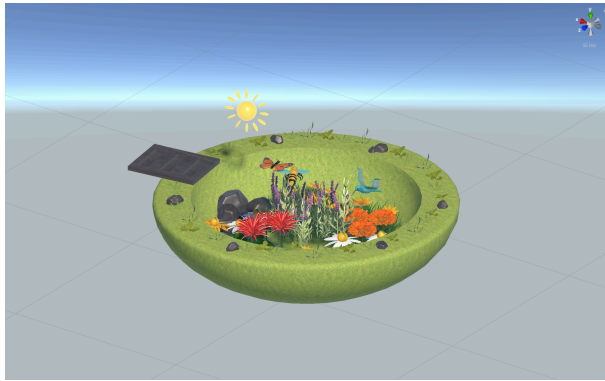
- Changing spot



Tablet view

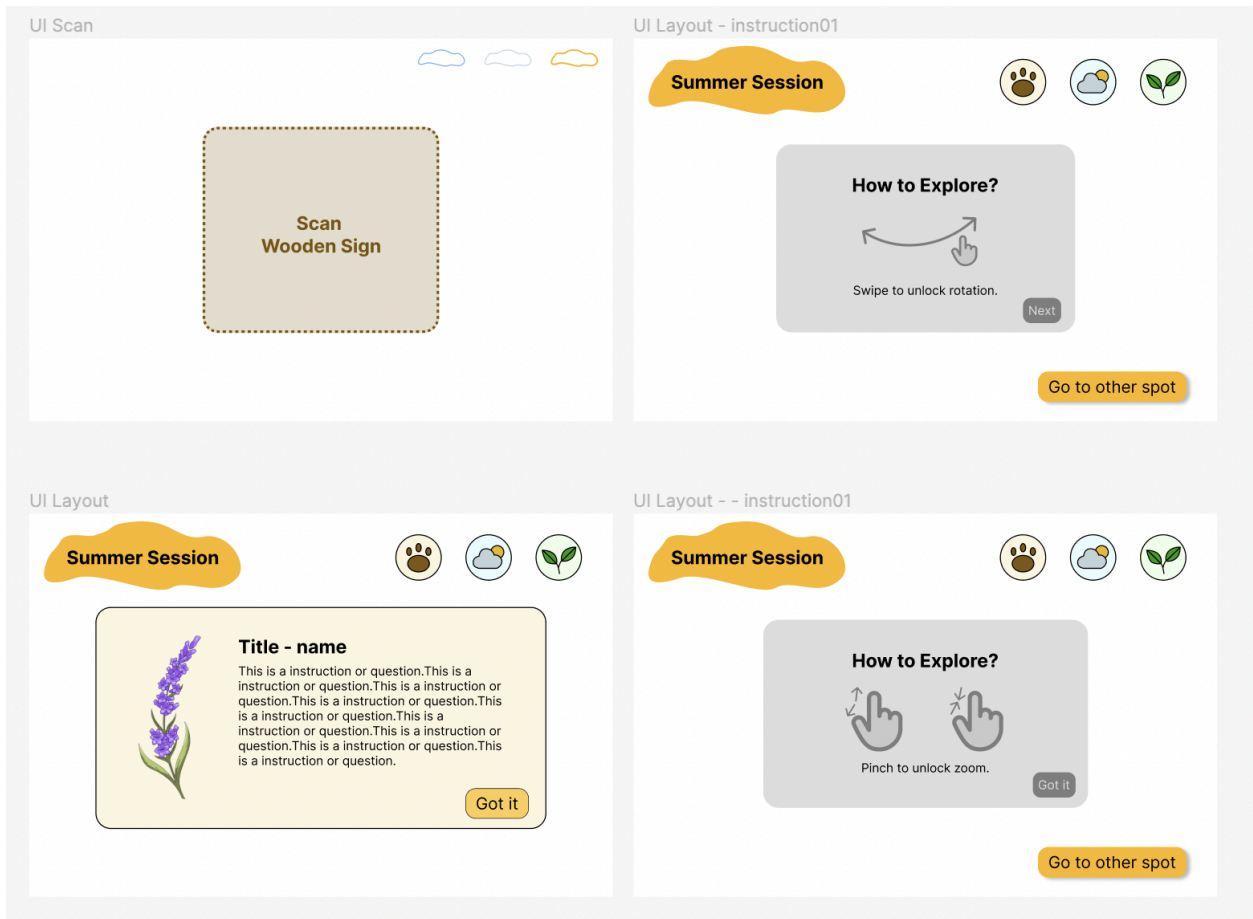


3D Art

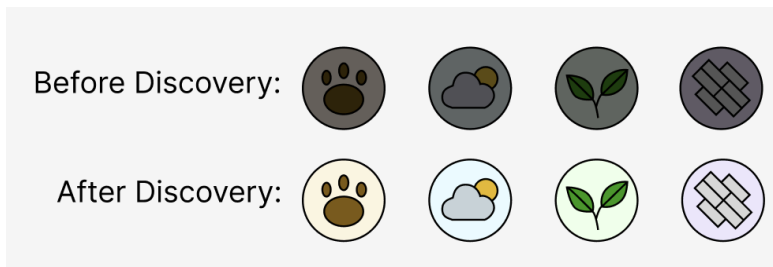


UI Design

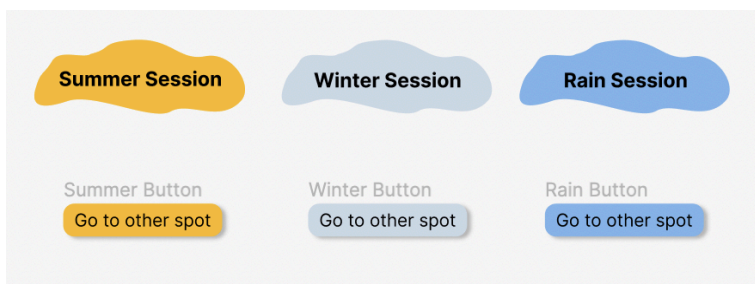
UI Layout



Clickable item icons:

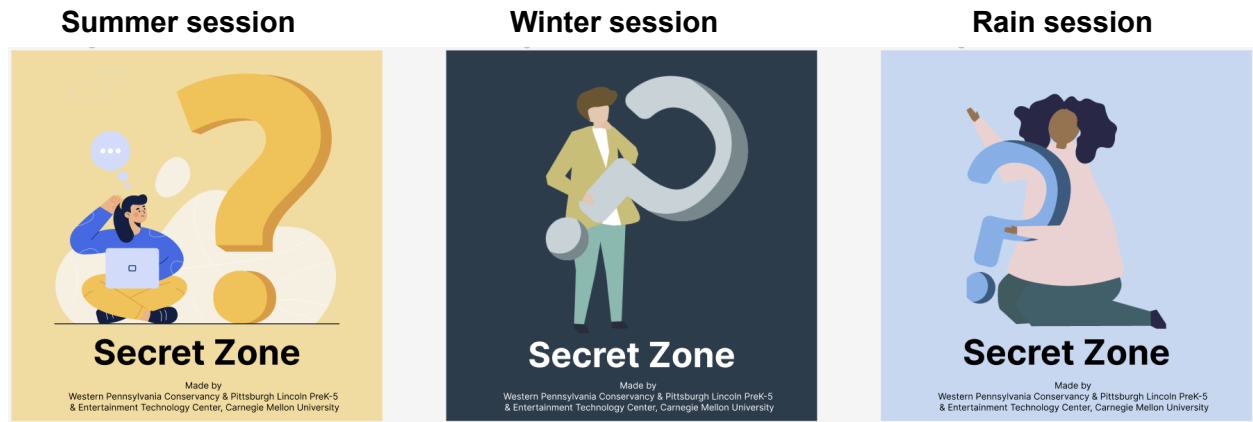


Different session icons:



Wooden Sign Design

Preview

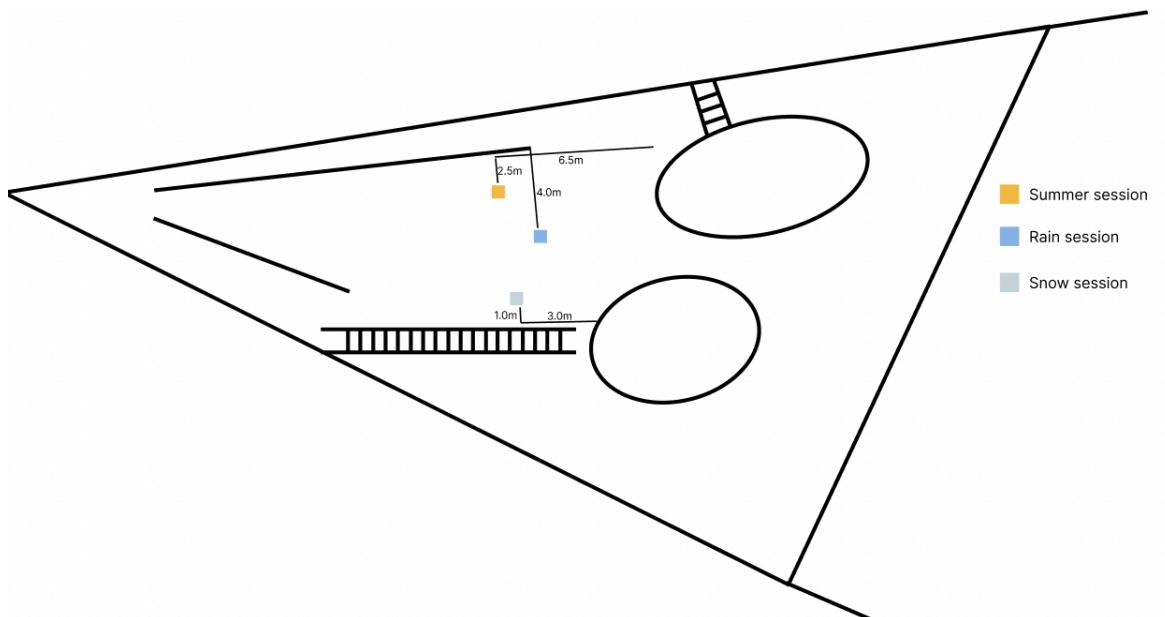


Height

The height should be **50 inches (127cm)**.

Location

Top-view map



Sample photos

- Summer session



- Rain Session



- Winter session



Production Design

Logo



Rain Gardeners

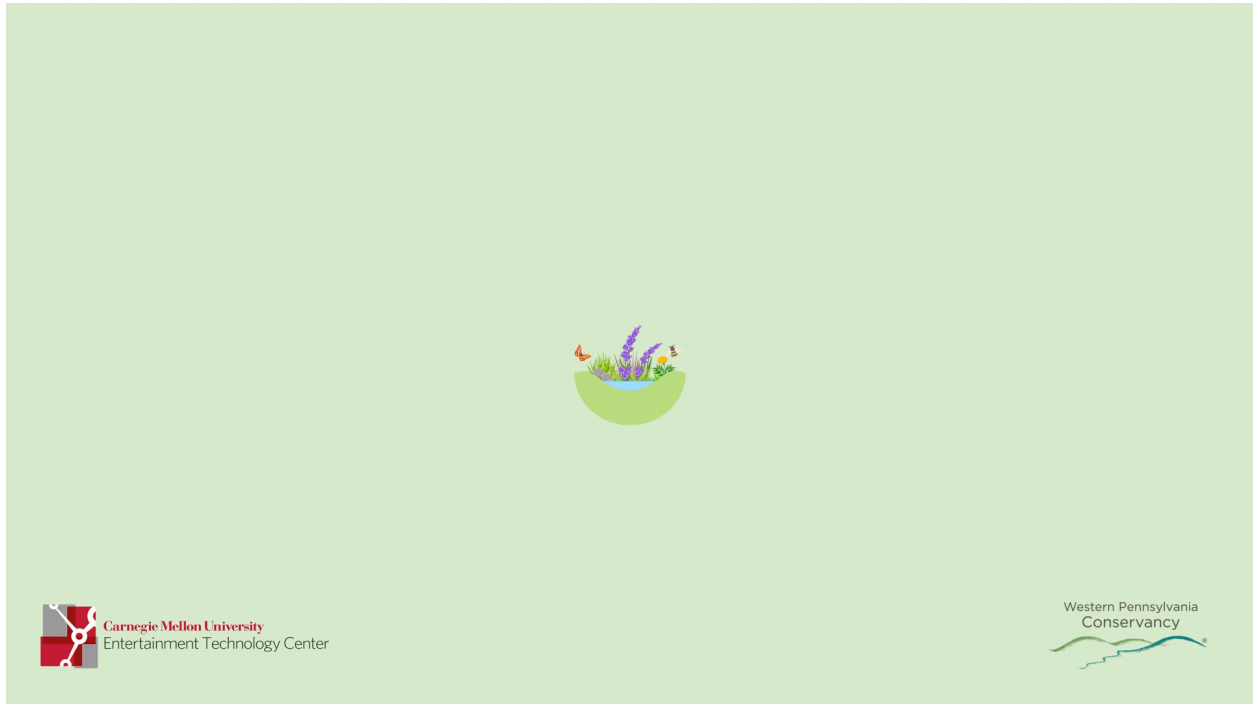


Rain Gardeners

Poster / Half-sheet Design



Loading Screen Design



Playtesting

Before Half - 10/07/2022

Overview:

By half-way through the production process, the team held two playtests that helped to guide future design adjustments.

For these playtesting we had only 5 cards for prototyping. 1 animal card, 2 plant cards and 2 environment cards. The quiz questions were printed on the map for the students to explore.

Lincoln Elementary School - 23 5th graders

The team first held a playtesting with our client - Lincoln Elementary School. The students were 5th graders who had prior knowledge of rain gardens.



Mary Queen of Apostles School - 25 6th graders

We also held a playtesting with Mary Queen of Apostles School. The students were 6th graders who had prior knowledge in water cycles and ecosystems.



Testing Results:

We got a lot of positive feedback from both the students and the instructors.

1) Positive:

During the playtesting, the students were exploring various combinations of cards freely, even more than the preset pairs. Since each group consisted of 3 - 5 students, they were having active discussions and **cooperating within the team**.

Most of the students were able to understand the concepts we were trying to deliver and teach, and answered the quiz questions correctly. They reported the AR experience to be novel and greatly **helpful to illustrating** scientific concepts related to rain gardens.

2) Improvement:

The clients mentioned that it would be necessary to link the outdoor experience with the card games. And the students were expecting more cards and more combination possibilities to play with.

Final Playtesting - 10/07/2022

Overview:

Towards the end of the semester, we set up a second playtesting with Lincoln Elementary School, with a final version of the project.

For the outdoor experience, we have three sessions - Summer, Rain and Winter, each containing three mysterious items for the students to hunt for.

For the indoor card game, the card pool consists of 2 animal cards, 4 plants cards and 2 environment cards. Also we had 5 quiz cards, each leading to one question about the concepts involving animals, plants and structures of the rain garden.

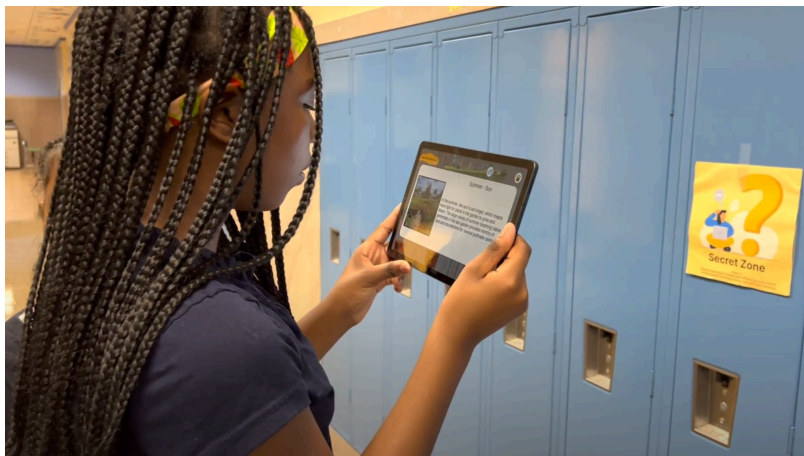


Testing Results:

Compared to the playtestings before half, we are providing a brand new outdoor experience, and more cards to play with in the indoor part.

Due to weather conditions, we were unable to have the students be onsite in the rain garden on the date. But students said the AR experience made them “feel being outside”.

For outdoor testing, students were able to collect all 9 items in the sessions, and we observed many groups paying attention to the information.



They reported to have special likes of the zooming function, the reading part, and exploration when collecting items. The experience was easy to navigate, and they were getting scientific concepts about rain gardens and ecosystems through reading the information.

For the indoor testing, since the testing group got exposed to the game before half, it was really natural for them to scan cards and make various combinations.

Students reported that the quiz concepts were easy to get. They were able to see the link between questions and the animated prefabs, and were playing with, observing the cards to get the right answers.

As for the number of cards, the students thought 10 is a quite moderate number for the experience.

Tech and programming

Indoor Tech

AR for Android

We are using AR Foundation + AR Core combined with Unity in this project.

To enable AR, download AR Foundation and ARCore plugin in Package Manager. Delete the Main Camera in the scene. Add the new AR game objects to your scene: right-click the Hierarchy pane and select XR. Add a new AR Session and a new **AR Session Origin** game object. Right now the AR Camera serves as the camera.

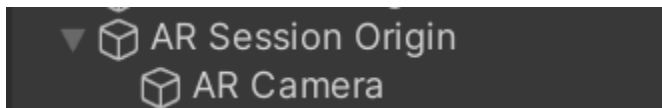
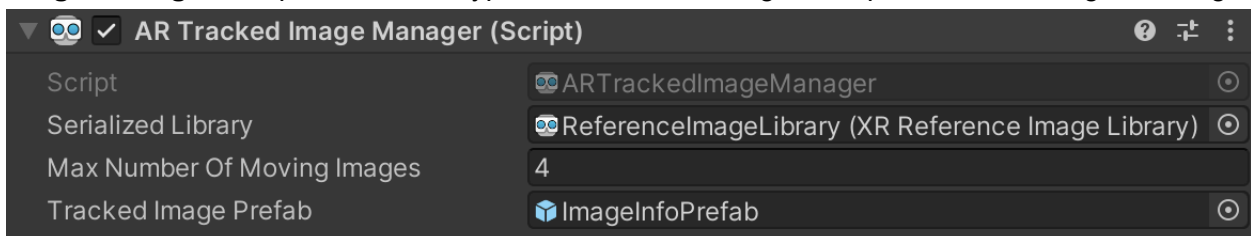


Image Recognition

AR Foundation provides image recognition and tracking functions by using the **AR Tracked Image Manager** component. It is a type of trackable manager and performs 2D image tracking.



The ARTrackedImageManager has a "Tracked Image Prefab" field; however, this is not intended for content. When an image is detected, ARFoundation will create a new GameObject to

represent it. The tracked image manager creates GameObjects for each detected image in the environment. That's how we bond 3D models to 2D cards.

Before an image can be detected, the manager must be instructed to look for a set of reference images compiled into a **Reference Image Library**, from which it will detect the pictures.

The **Name** field in the library should be in alliance with the prefab name. Or it will lead to null Object exception.

Note: Specify the physical size when bonding the prefab. Not setting it will lead to prefabs instantiating at wrong random positions.

Inspector

Reference Image Library (XR Reference Image Library)

Open



Select

Name

Bee

Specify Size

☒

Texture Size (pixels)

X 530

Y 751

Physical Size (meters)

X 0.06

Y 0.08501887

Keep Texture at Runtime

☐



Select

Name

Butterfly

Specify Size

☒

Texture Size (pixels)

X 530

Y 751

Physical Size (meters)

X 0.06

Y 0.08501887

Keep Texture at Runtime

☐



Select

Name

Lavender

Specify Size

☒

Texture Size (pixels)

X 531

Y 751

Physical Size (meters)

X 0.06

Y 0.08485875

Keep Texture at Runtime

☐



Select

Name

Marigold

Specify Size

☒

Texture Size (pixels)

X 531

Y 751

Physical Size (meters)

X 0.06

Y 0.08485875

Keep Texture at Runtime

☐

Subscribe to the ARTrackedImageManager's trackedImagesChanged event to be notified whenever an image is added (that is, first detected), updated, or removed:

```
public void OnEnable()
{
    arTrackedImageManager.trackedImagesChanged += OnImageChanged;
}

Unity Message | 0 references
public void OnDisable()
{
    arTrackedImageManager.trackedImagesChanged -= OnImageChanged;
}

2 references
public void OnImageChanged(ARTrackedImagesChangedEventArgs args)
```

Card Types - Animal, Plant and Environment

Animal cards and plant cards are “interactive” objects since they can be combined to trigger animation. While environment cards are just initiating objects bonded to them, including rock, sidewalk and 5 quiz cards. Add the prefabs to the AR Session Origin - Image Recognition script to specify the categories.

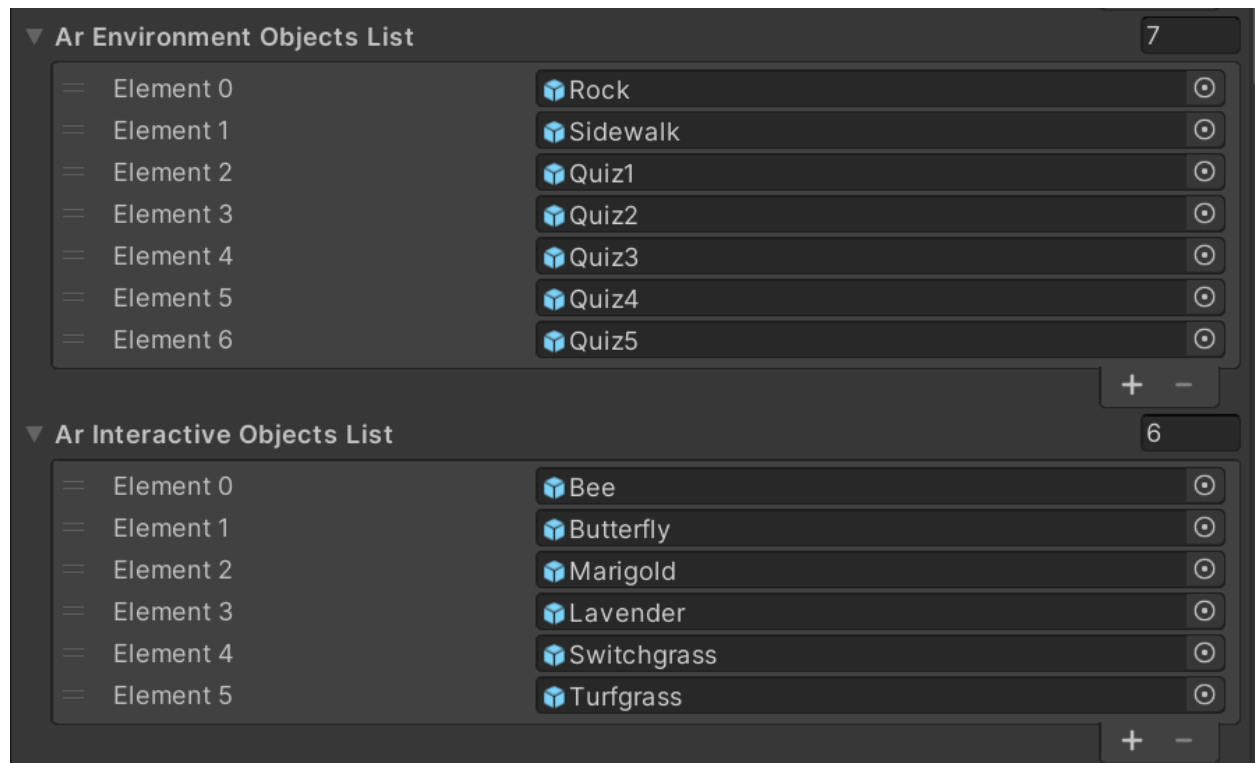
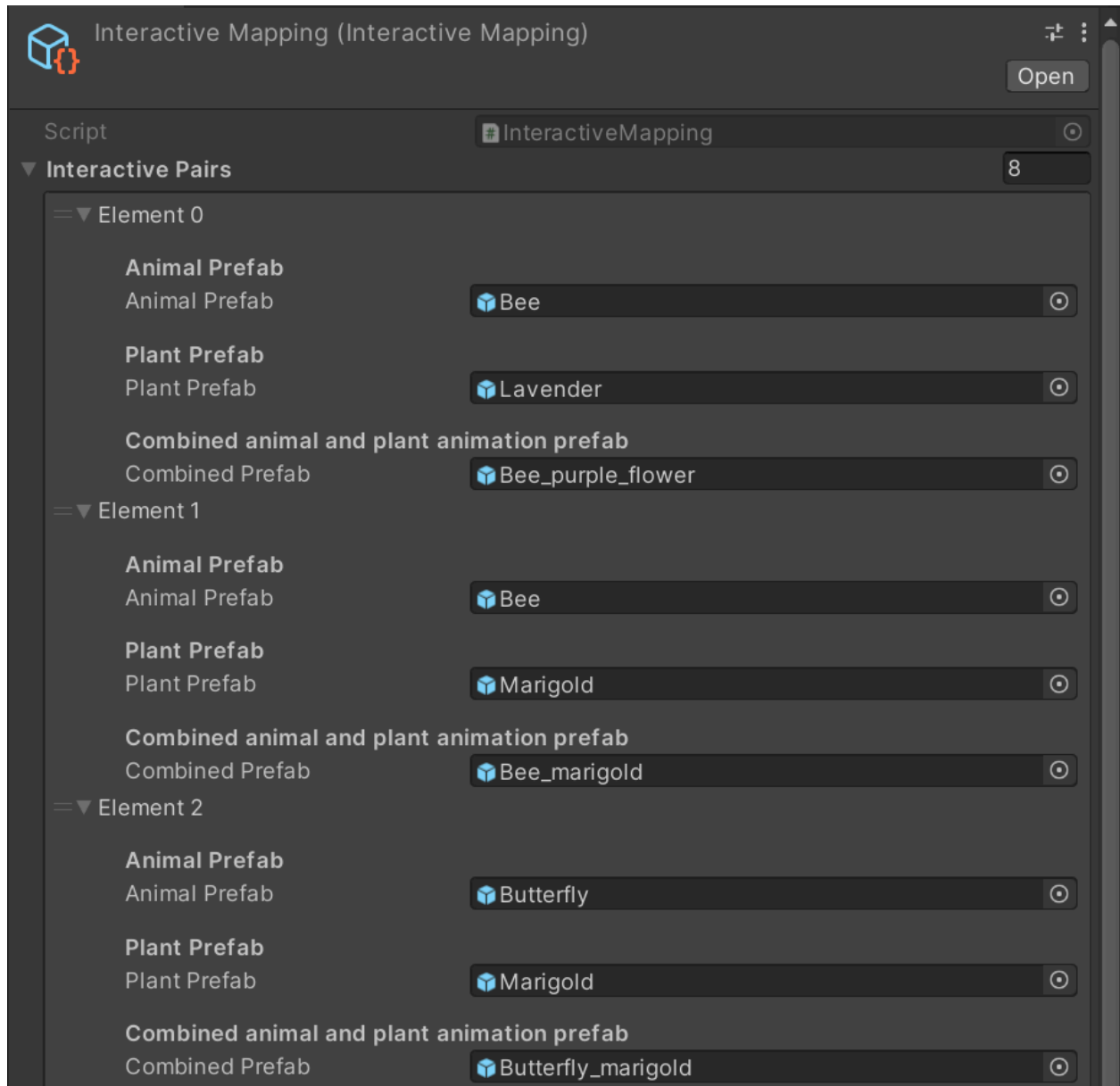


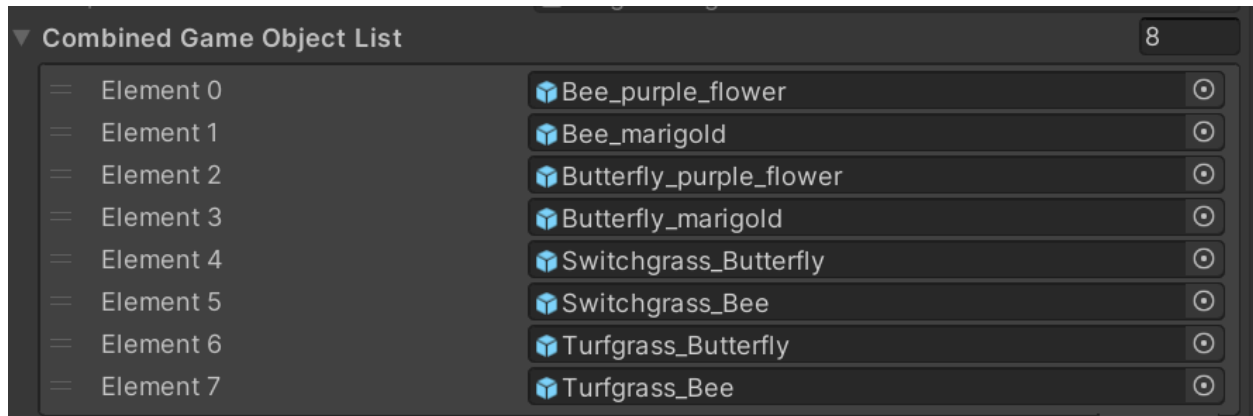
Image Recognition

When two interactive cards (must be one animal and one plant) are close to each other, they trigger a combined animation of the animal interacting with the plant.

Add combinations of two initial animal / plant cards and the combined prefab in Resources - **Interactive Mapping**. The **GameController** script reads the name of interactive prefabs as strings and gets the result in the Dictionary to find the combined prefab.



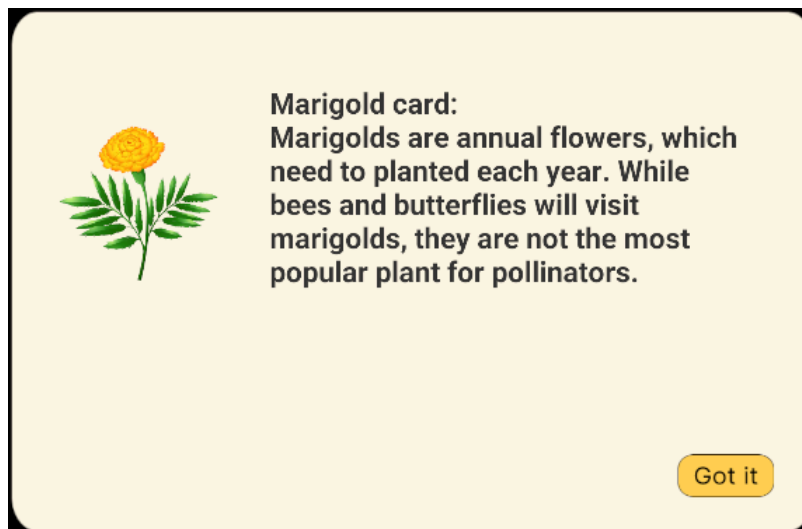
Add the combined animated prefabs in AR Session Origin - Image Recognition script - **Combined Game Object List**.



Note: When more than two interactive cards are recognized at the same time on the screen, a prompt window will appear showing too many cards are put on the map. Only one combination is allowed at the same time.

Info Session

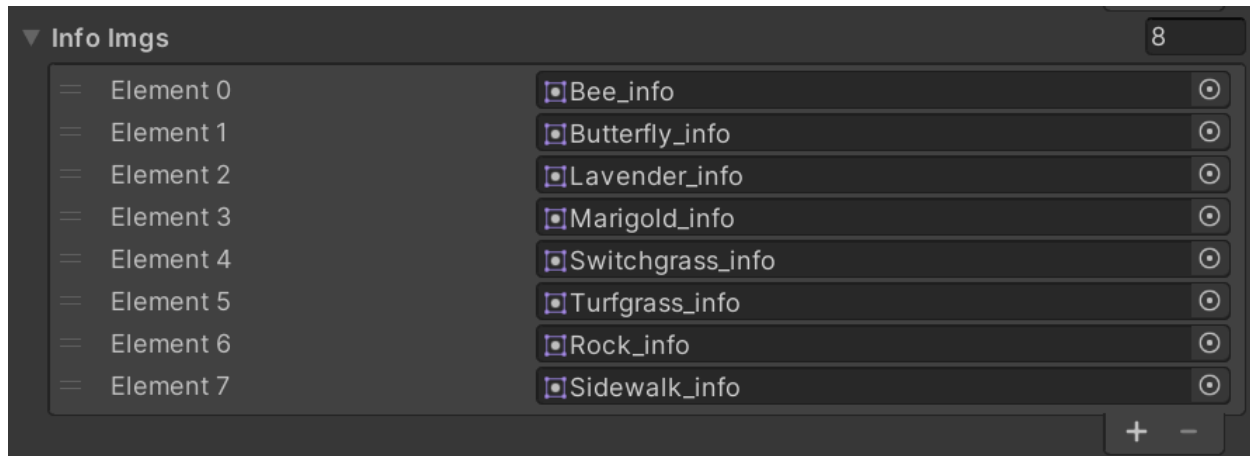
By tapping on the 3D prefab, the users can see the info panel showing the introduction of each element in the rain garden.



We are also using Dictionary (InfoImgDict) to link the prefab with info messages and texts.

```
private void setInfoImgs()
{
    foreach(Sprite var in InfoImgs)
    {
        InfoImgDict.Add(var.name, var);
    }
}
```

Add the Info Images in TouchScript - **Info Imgs**. Note that the images should be converted to 2D sprites instead of pngs.



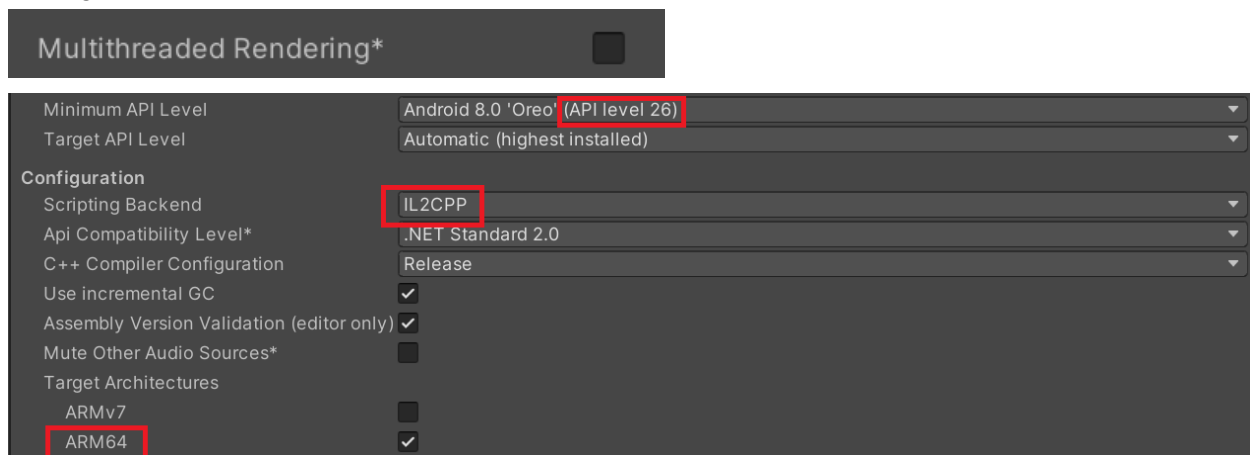
Build Settings

Link the tablet to the PC and build the app for the detected Android device. Make sure Developer Mode and USB Debugging are enabled on the tablet.

For the stability of the application, we must use IL2CPP and ARM64 for the Scripting Backend.

Note: Using Mono will make the app crash after launching in about 1 minute. IL2CPP takes longer to build but guarantees the app to run stably.

For AR Foundation to work, disable “Multithreaded Rendering” and use “API level 26” in Player Settings.



Outdoor Tech

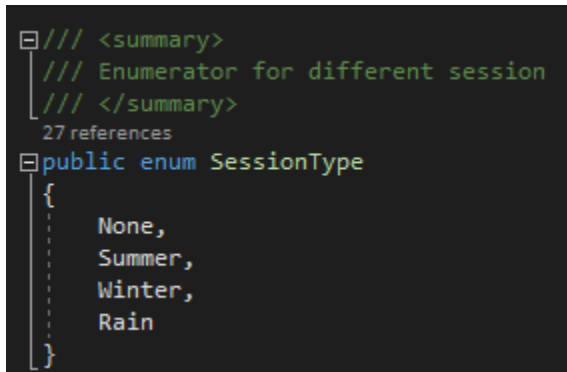
AR Core and Build Settings

Similar to the indoor tech, the outdoor experience is also built with AR Core and AR Foundation in Unity platform. The detail of setting up and building instructions can be referred to the “Indoor Tech” part.

Add more sessions

So far there are three sessions - Summer, Winter and Rain

To add more sessions, the first thing is to modify the SessionType enumeration in “Util.cs” file under “Assets/Scripts”.

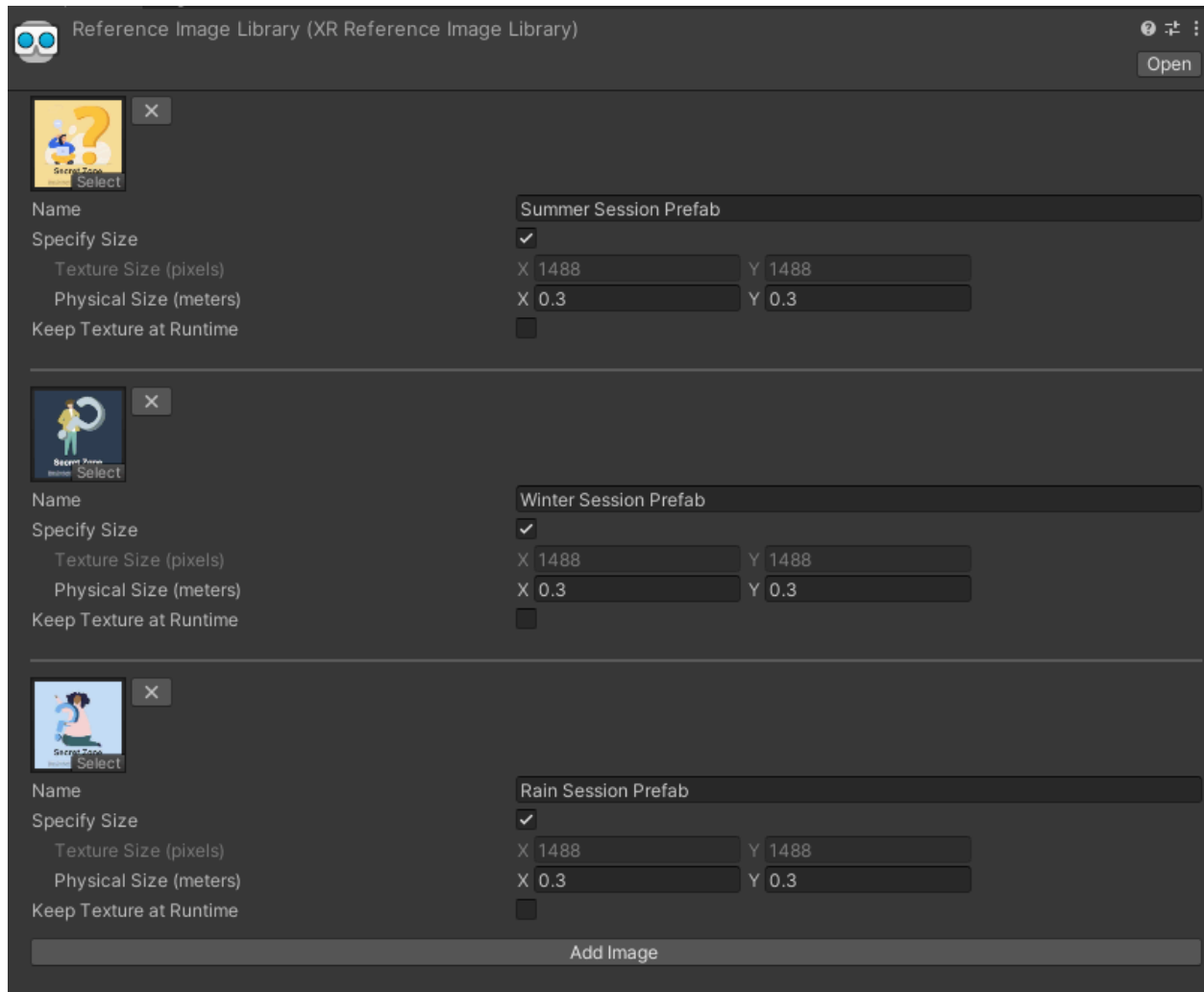


```
/// <summary>
/// Enumerator for different session
/// </summary>
27 references
public enum SessionType
{
    None,
    Summer,
    Winter,
    Rain
}
```

How to change reference images

Like the “Indoor Tech” part mentioned above, we use the AR Core Reference Image Library for image tracking reference. The “Reference Image Library” file is located in “Assets/ReferenceImageLibrary”.

Currently we have three reference images for three different sessions.



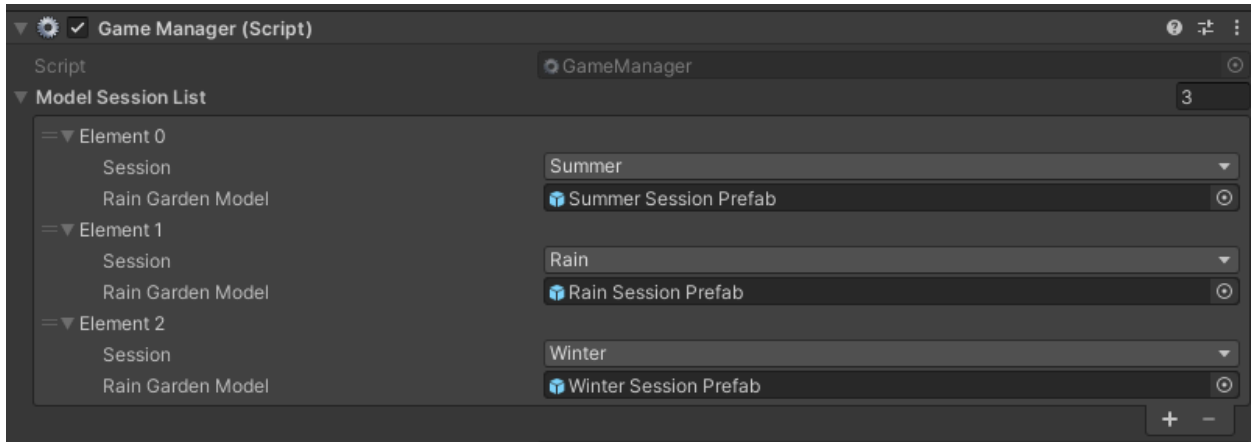
- 1) The image is the image you want to recognize by the camera.
- 2) Name should be the **same** as the prefab you want to show when you scan the image.
- 3) The physical size is the size of the reference image.

To add more sessions, just click the “Add Image” button then it will create a new entry for reference image.

To change the reference image, just drag and replace the image.

How to change the session prefab

Outdoor experience requires users to hold the tablet to scan three signs. Each sign corresponds to a prefab that will be instantiated when the program recognizes an image.

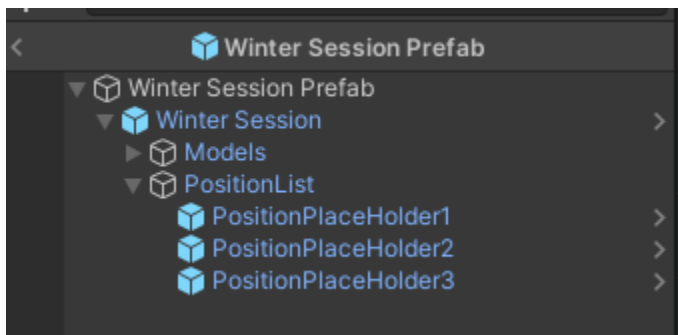


The “Model Session List” in the **Game Manager.cs** file holds the prefab for different sessions. Each element has two components:

- 1) Session: is the session type for the model.
- 2) Rain Garden Model: the prefab you want to use for this session.

To change the prefab for each session, simply create a new prefab and replace it with the one in the Rain Garden Model.

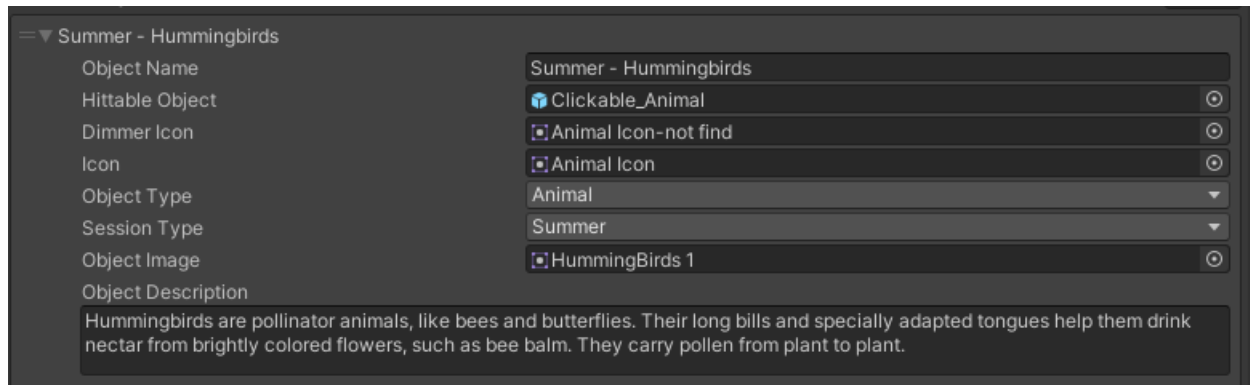
Note: When the program runs, it will create three clickable objects on the Rain Garden Model. The Rain Garden Model prefab should have a child component named “PositionList” which holds the positions that clickable objects will be. The file structure of Rain Garden Model should look like this:



Note: In order to rotate and scale the Rain Garden Model, each Rain Garden Model also attached a script named “FingerTouch.cs”. This script enables the user to swap the model to rotate and pinch the model to change the scale. The “minScale” and “maxScale” holds the scale limitation for the Rain Garden Model.

How to change/update clickable objects

Clickable objects are instantiated from the editor file named “Hittable Object Editor” under the folder “Assets/Resources”. You can modify or create clickable objects using this file.



Each clickable object consists several components:

- 1) Object Name: the name of the object, will be shown on the information panel.
- 2) Hittable Object: the prefab of the hittable objects, can be replaced.
- 3) Dimmer Icon: the dimmer version of the icon on the top right of the screen.
- 4) Icon: the light-up version of the icon.
- 5) Object Type: there are three types of objects: Animal, Plant and Weather.
- 6) Session Type: the session that this object belongs to.
- 7) Object Image: the image that will be shown on the information panel.
- 8) Object Description: the description that will be shown on the information panel.

The information provided above will be shown when user clicks on each clickable object:



Things to be aware of

The outdoor experience works well in most cases, but there are still several things that should be aware of when further developing.

- 1) When scanning the sign, the rain garden model sometimes will be instantiated at random positions. The correct position should be a few meters behind the wooden sign. The reason for this problem might be the scanning angle and the distance.
- 2) Image recognition score. The AR Core official provides a tool to evaluate the image that is used as the reference image. The tool is named “arcoring.exe” under the “Assets/PreferenceImageLibrary” folder. To use the tool, just run the following command in any command line tool

“\$./arcoring eval-img --input_image_path=IMAGENAME.jpg”

The score range is from 0 - 100 indicating the quality of the image from low to high. 75 is the recommended score for a usable image.

Teachers' Guide

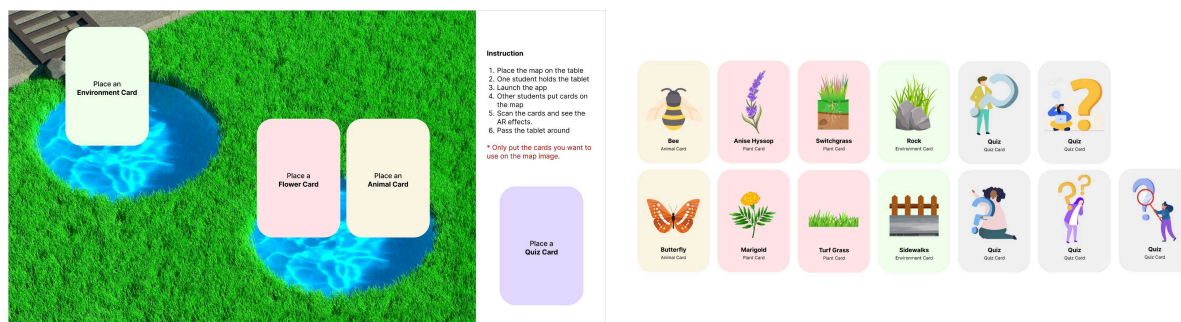
Indoor AR Card Experience

Overview

Recommended game play: 3-5 students in one group
10-20 minute expected game play

Materials

- 13 Cards (2 environment cards, 4 plant cards, 2 animal card, 5 quiz cards)
- 1 Map



[Link to download the map image](#)

[Link to download the card images](#)

[Link to download the Indoor Demo](#)

Instruction for students

- Place the map on the table
- One student holds the tablet
- Launch the app
- Other students put cards on the map
- Scan the card to play the AR effects
- Tap the 3D object on the screen to view more information
- Pass the tablet around
- Scan the quiz cards and answer the questions

* Note | Only put the cards you want to use on the map image.

On-site location-based AR Experience

Overview

Recommended gameplay:

- In the rain garden
- 2-5 students in one group
- 10-20 minute expected game play

Materials

- 3 wooden signs



[Link to download the wooden signs](#)

Instruction for students

Loading part:

- Group people to the rain garden
- One student holds the tablet
- Launch the app

Exploring part:

- Find a wooden sign and scan it
- Other students use fingers to rotate and zoom in/out
- Find the clickable item and click them.
- Go through the introductions
- Pass the tablet around

Changing spot part:

- Find all three items
- Go to another spot
- Finish all three spots