A CIRCLE-GEOCACHING GAME BASED ON CLASSIFIED SPECIMENS

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Title

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The Supervisory Committee certifies that this ***disquisition*** complies with North Dakota State University's regulations and meets the accepted standards for the degree of

MASTER OF SCIENCE

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ABSTRACT

This paper describes a CIRCLE-Geocaching extensible system played for the purpose of rehearsal learning. The system operates over a classification tree built by an instructor or a group of students engaged in classification, identification and learning of real world objects. Geocaching involves gathering specimens, naming specimens, recording GPS coordinates, and performing experiments on each specimen.

It is assumed that student motivation is increased, as it is an outdoor activity to locate specimens using coordinates, allowing students to learn about features during game play.

Implementation of this game draws on the Model, View and Template architecture (MVT). Client software is a series of web-based interfaces to complete each task, and supports formal interaction between instructor and students through faculty and student accounts. Data pertinent to project is stored on CIRCLE server, an NDSU Linux platform. Project Data is served through a series of messages implemented using the JavaScript Object Notation (JSON).

ACKNOWLEDGEMENTS

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I'm grateful to Dr. Pratap Kotala for taking out the time to be a part of my supervisory committee and providing valuable comments.

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1. INTRODUCTION

It is generally agreed that educating participants through a recreational activity while using a game helps them to enjoy the learning activity. Geocaching (O'Hara 2008, Geocaching 2018) is an outdoor activity in which participants find a hidden "cache" by using GPS coordinates (latitude and longitude) in their handheld devices. After locating the cache, the participants visit the location either in groups or as individuals.

CIRCLE-Geocaching (CG) is a gaming application developed to educate students on specimens, like trees or animals, in the real world. This application follows retrieval practice, or as it is often called, rehearsal learning (Karpicke et al. 2012). Rehearsal learning involves recreating something that students have already learned through classwork, reading, or some other previous exposure. This recreation, or bringing it to mind, is the "rehearsal" in rehearsal learning. To recite immediately what student have learned by either reading or by teacher instruction is sometimes difficult. Learning through game play, however, may make a student more likely to remember the material (Deterding et al. 2013). CG employs a rehearsal technique to a game in order that students have the opportunity to learn more about specimens in the real world.

CG is an online web based application in which instructors must first record the GPS coordinates, take images, and add experiments for students to perform on the specimens. When the total number of specimens are recorded, these specimens then form a "goal set" for students to achieve. After collecting the specimens from the goal set, the instructor documents the findings into a text file. This text file works as a binder for the instructor to use to build the CG game.

Students can then login to the CG portal using credentials given by instructors. There they are assigned a "goal set" for the particular course. Students choose a specimen from the set, use their handheld device to enter GPS coordinates, and go to the indicated location. Once students find the geocache, they take pictures with their handheld devices and perform the experiments assigned to them in the CG portal. The CG application gives a list of options to select the result of the experiment for each specific specimen. If students choose an incorrect option, they get a pop up error message until they choose the right option. This educational approach forms the basis for "rehearsal learning" (Karpicke et al. 2012).

CG uses the Classification, Identification, and Retrieval–based Collaborative Learning Environment (CIRCLE) for its available binders. While using these binders on the instructor portal, an instructor creates a CG game by choosing specimens, GPS coordinates, and experiments for students to perform. In summary, all the data regarding the specimen is accessible in a binder available to students in the student portal in the form of a game, in which students use GPS coordinates to go to locations, perform experiments to learn about specimens. The instructor will add experiment results and choices in the instructor portal as a separate entity. Then students will go to the student portal to get experiments that are organized under the specimens. After the students perform the experiment, they will choose and answer from a drop-down list. They will then receive a pop up message indicating whether or not the answer is correct. If the answer is incorrect, the students must keep trying until they answer correctly. This kind of learning, in which trial and error is used, is part of a game and can help the overall learning of specific content. Thus, this fun learning outdoor activity with gamification can help students learn and increase their understanding of the specimens.

2. THEORETICAL BACKGROUND

2.1. Location based games

Computer games are exceptionally popular around the world. Location Based Games represent a new category of games that take place in real world locations. These Location Based Games [LBGs] include several technological problems, such as wireless network issues (Barkhuus et al. 2005**)** and problems with reliability and trust (Benford et al. 2006). Regardless of their success, numerous LBGs are developed in such a way that makes them difficult to copy in new locations or to sustain long term (Capra et al. 2005).

However, one of the LBGs that has been sustained for many years and also managed to maintain player commitment is Geocaching, a GPS based treasure hunt (O'Hara 2008). Since its beginning in 2000, Geocaching has developed to incorporate more than 4 million players worldwide with more than 1.5 million discoverable geocaches available (Geocaching 2018). Given its popularity, people have extended the game to diverse environments, including virtual platforms and multiplayer games online.

2.2. Mobile learning

While games on mobile phones are common, they are not usually used for learning disciplinary content. This mobile learning system uses the capabilities of the latest generation cell phone to develop the games that help students learn. Modern mobile devices are equipped with GPS (global positioning system) functionality, which has a great potential for utilization in learning. Geocaching enthusiasts could utilize this GPS feature on mobile devices to locate a hidden specimen disguised some place in the landscape (Clough et al. 2009).

To better understand this, we wanted to explore what LBG looks like when combined with mobile learning and how it could be used in a university setting. Hence, the objective of our research was to understand how we could design an LBG to help students learn about various specimens. To achieve this, we have developed a game, CIRCLE-Geocaching (CG), as part of a Classification, Identification, and Retrieval-based Collaborative Learning Environment (CIRCLE) (Borchert et al. 2015).

2.3. Classification, Identification, and Retrieval-based Collaborative Learning Environments (CIRCLE)

The Classification, Identification, and Retrieval-based Collaborative Learning Environment (CIRCLE) is an application that utilizes mobile technology to gather user-generated content into an application for classifying and identifying real world objects. In CIRCLE, students work together on group projects to identify objects and place them in classification trees.

CIRCLE players start the game by finding interesting objects that can be any type, for example, trees, birds, or rocks. When the players are students, they find the objects, which are generally described as specimens, and upload picture of them using their mobile devices. Once, the specimens are gathered, possible experiments are performed on the specimens and then questions are answered, such as what colors or shapes are the specimens. All these results are stored in the game for future tests that can help in further figuring out the structure of the data. After a number of experiments are performed, the students can make classification structures based on this experiment data. A classification tree will be created by utilizing a click and drag interface. Students will perform all these steps for all the assigned specimens. Once classification is completed, students will identify individual specimens. For each specimen classified, the student will create a hypothesis. After all tasks are completed, students can open their game environment to play games in the view of the information they have gathered: experiments, observations, classification structures, and results. Instead of basically endeavoring to memorize their specimen data, they have to effectively retrieve their knowledge from memory that helps students to solidify their knowledge through retrieval learning (Karpicke et al. 2012).

3. IMPLEMENTATION

Model-View-Template (MVT) architecture was used to create the CIRCLE-Geocaching game. Specifically, the Django Framework MVT was used. Django is a free python-based web framework that is an open source. Models store the game state information. Templates are JavaScript enabled HTML web pages. Views take a request from a URL, fetch data from a database and route it to templates, which are the user interface and thus the view acts as the controller to coordinate between models and templates.

3.1. Models

CG uses models to create and maintain its database. Each model maps to a separate database table. It has the essential fields and behavior of the data stored. The API Database-abstraction will take care of creating, retrieving, updating, and deleting objects in the database. Each model created is a python class that subclasses to Django.db.models.Model ("Models", 2018).

3.2. Views

Views are functions that accept requests through the web and return a web response. All the views for CG are available in views.py. The View in Model-View-Template (MVT) pattern acts as a controller, all the code to get responses from the database (Models.py) is put here. Views contain the URL pattern that the user can request. Responses can be HTML, a redirect, a 404 error, an XML report, or an image ("Writing Views", 2018). Ideally, the view will make a request to the created models and return the data to the template.

3.3. Templates

Templates are one of the fundamental parts of the Django framework in this Model-View-Template (MVT) pattern. These contain the desired form of output that a user wants to see. They contain static HTML files with JavaScript enabled. In CG, most of the templates are created using Bootstrap (HTML, CSS, and JS library), a front end framework. Bootstrap was chosen for its usability, responsive nature, and browser compatibility.

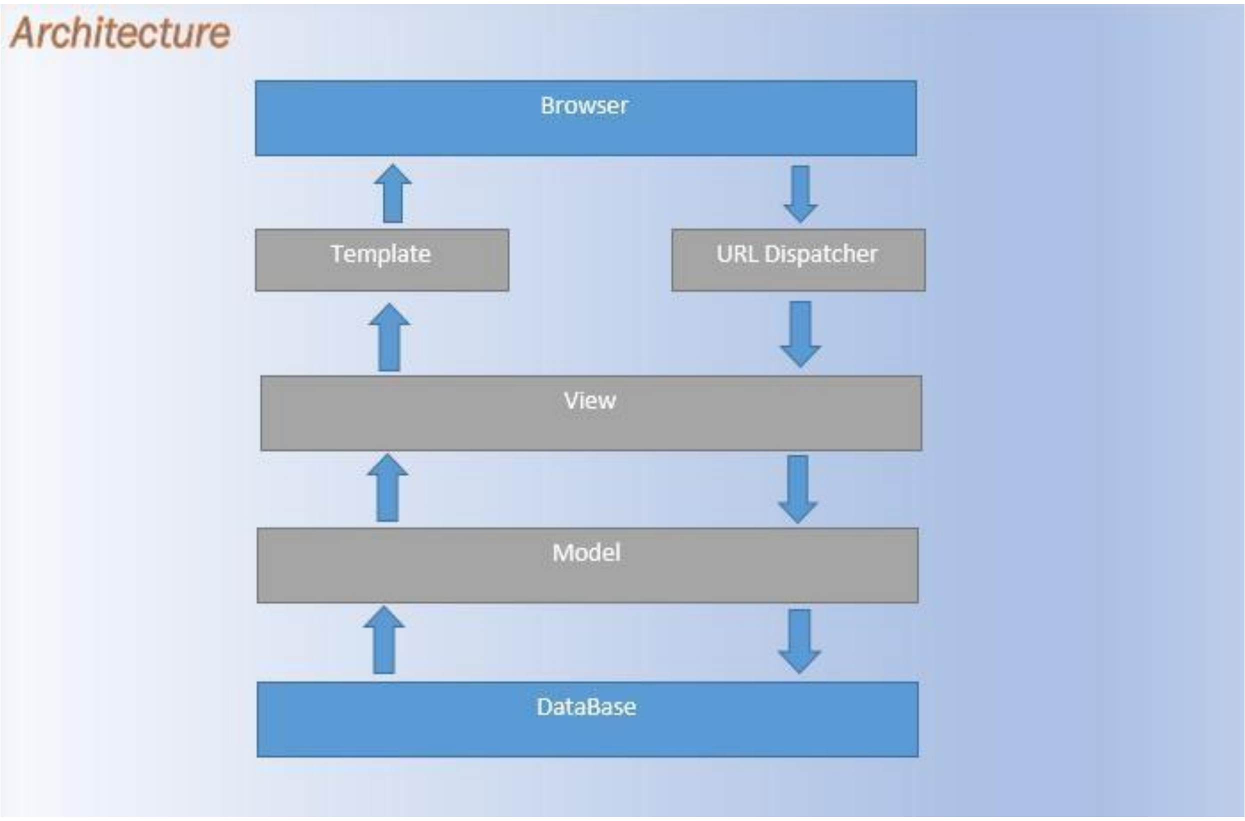
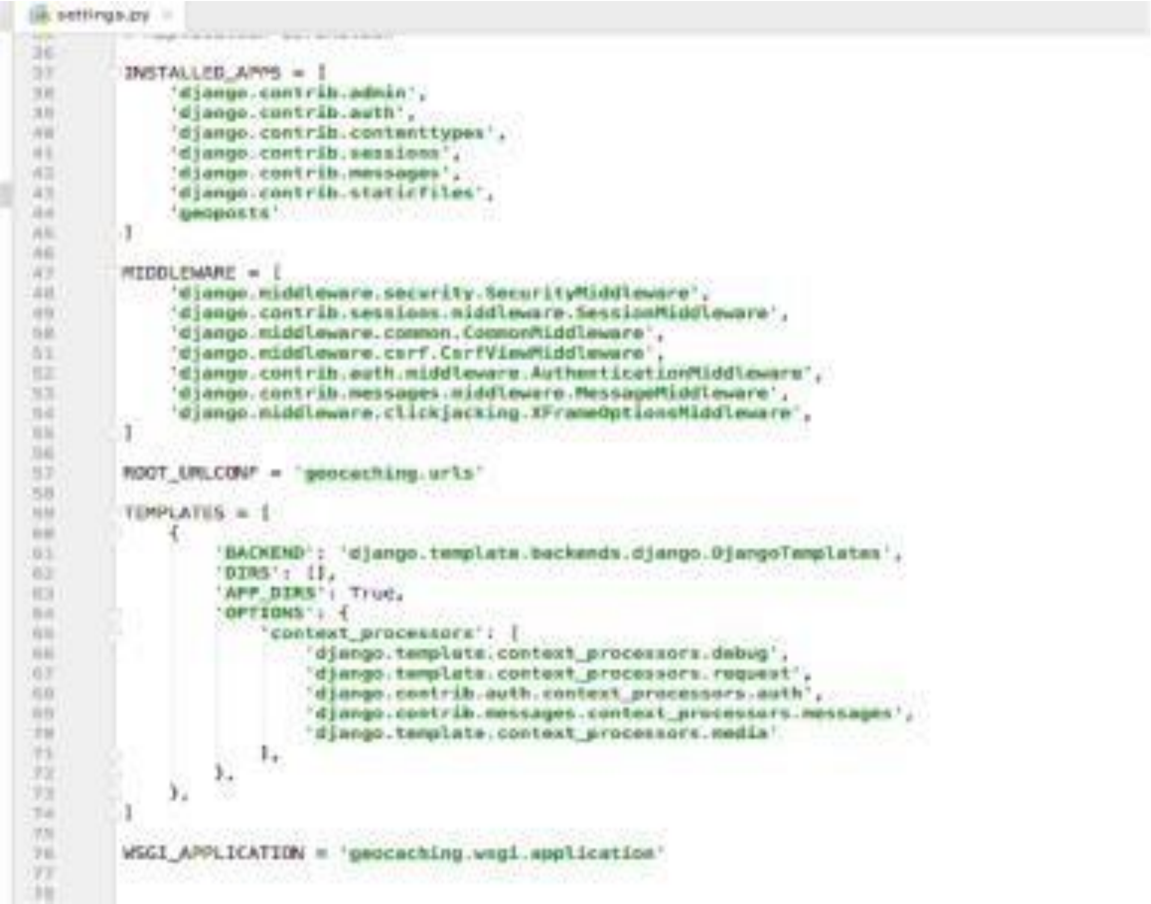


Figure 1. The Architecture of the CIRCLE-Geocaching Application

3.4. CIRCLE-Geocaching architecture

The CG follows the Model View Template (MVT) architecture pattern typically used by Django framework. The user accesses the CG URL using the browser, which is already defined in views. Views accepts the web request, contacts models for the data, and displays web responses to the user as either an HTML page, an image redirect, or as a 404 error through templates. Figure 1 below shows the architecture of the CIRCLE-Geocaching application.

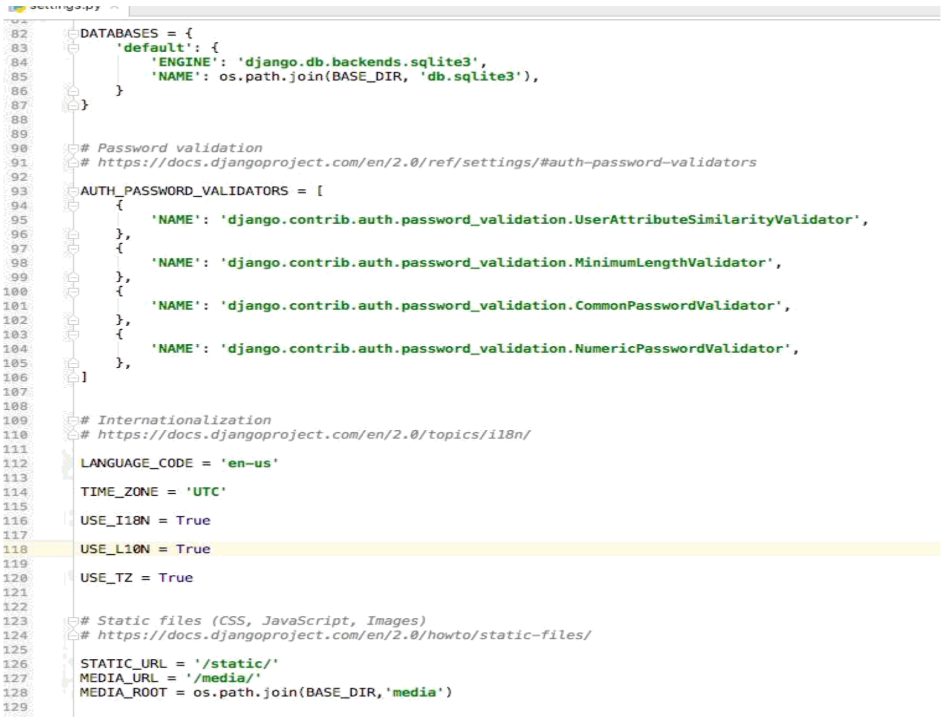


```python
INSTALLED_APPS = [
    'django.contrib.admin',
    'django.contrib.auth',
    'django.contrib.contenttypes',
    'django.contrib.sessions',
    'django.contrib.messages',
    'django.contrib.staticfiles',
    'geoposts'
]

MIDDLEWARE = [
    'django.middleware.security.SecurityMiddleware',
    'django.contrib.sessions.middleware.SessionMiddleware',
    'django.middleware.common.CommonMiddleware',
    'django.middleware.csrf.CsrfViewMiddleware',
    'django.contrib.auth.middleware.AuthenticationMiddleware',
    'django.contrib.messages.middleware.MessageMiddleware',
    'django.middleware.clickjacking.XFrameOptionsMiddleware',
]

ROOT_URLCONF = 'geocaching.urls'

TEMPLATES = [
    {
        'BACKEND': 'django.template.backends.django.DjangoTemplates',
        'DIRS': [],
        'APP_DIRS': True,
        'OPTIONS': {
            'context_processors': [
                'django.template.context_processors.debug',
                'django.template.context_processors.request',
                'django.contrib.auth.context_processors.auth',
                'django.contrib.messages.context_processors.messages',
                'django.template.context_processors.media'
            ],
        },
    },
]

WSGI_APPLICATION = 'geocaching.wsgi.application'
```

Figure 2 Configuring Installed App and Templates

3.4.1. Application configuration

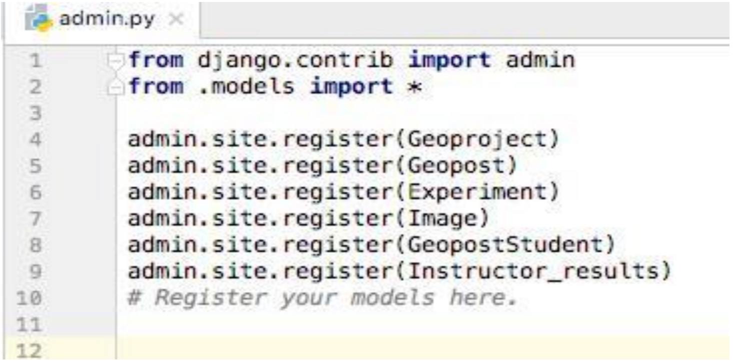
CG utilizes the Django administrator site to create its admin/instructor interface. This interface peruses metadata from the models created for this application, and provides a model-centric interface. The instructor page is basically an administrator page, which employs Django admin features by customizing them. All the configurations of the CG application will be configured in the settings.py file. Below are screenshots (Fig 2. & Fig 3) that show how the geoposts app(where all our models are created that are explained in instructor portal), templates, database, media, and URL are configured in installed apps, templates, database, media_url, and root_url conf, respectively.



```
DATABASES = {
    'default': {
        'ENGINE': 'django.db.backends.sqlite3',
        'NAME': os.path.join(BASE_DIR, 'db.sqlite3'),
    }
}


# Password validation
# https://docs.djangoproject.com/en/2.0/ref/settings/#auth-password-validators

AUTH_PASSWORD_VALIDATORS = [
    {
        'NAME': 'django.contrib.auth.password_validation.UserAttributeSimilarityValidator',
    },
    {
        'NAME': 'django.contrib.auth.password_validation.MinimumLengthValidator',
    },
    {
        'NAME': 'django.contrib.auth.password_validation.CommonPasswordValidator',
    },
    {
        'NAME': 'django.contrib.auth.password_validation.NumericPasswordValidator',
    },
]


# Internationalization
# https://docs.djangoproject.com/en/2.0/topics/i18n/

LANGUAGE_CODE = 'en-us'

TIME_ZONE = 'UTC'

USE_I18N = True

USE_L10N = True

USE_TZ = True


# Static files (CSS, JavaScript, Images)
# https://docs.djangoproject.com/en/2.0/howto/static-files/

STATIC_URL = '/static/'
MEDIA_URL = '/media/'
MEDIA_ROOT = os.path.join(BASE_DIR,'media')
```

Figure 3. Configuring Static Media and Database

The CG application is added as the geoposts app and it uses a Modeladmin class to create its users. All the models are registered to the admin site in the admin.py file to use the admin interface features as shown below.



```
from django.contrib import admin
from .models import *

admin.site.register(Geoproject)
admin.site.register(Geopost)
admin.site.register(Experiment)
admin.site.register(Image)
admin.site.register(GeopostStudent)
admin.site.register(Instructor_results)
# Register your models here.
```

Figure 4. Admin Class Configuration

Geoposts is added and configured in the settings.py configuration of the application. In models.py, all the models related to geocaching are registered to the admin site to use the Django admin features by each and every model. Upon registering to the admin site, all the models will be equipped with CRUD (Create, Read, Update and Delete) operations, which can be seen in the CG model interface.

3.5. Overview of CIRCLE-Geocaching application

There are two CG portals. One is an instructor portal and the other is a student portal.

The **Instructor portal** characterizes all models or components to develop a CG web application and it is not accessible to students and Django framework is used to develop the instructor portal. Instructors log into this portal to create models and configure model interactions.

The **Student portal** is the interface used to play the CG game. It uses all the components defined in the instructor portal to build a game. Bootstrap, HTML, JQuery, JavaScript, and CSS are utilized to develop the student portal. All the JavaScript enabled HTML files are defined in the templates folder of Django. Students login to view all GPS enabled specimen data and perform experiments that are created by their instructor. A block diagram of the CIRCLE-Geocaching application is shown in figure 5.

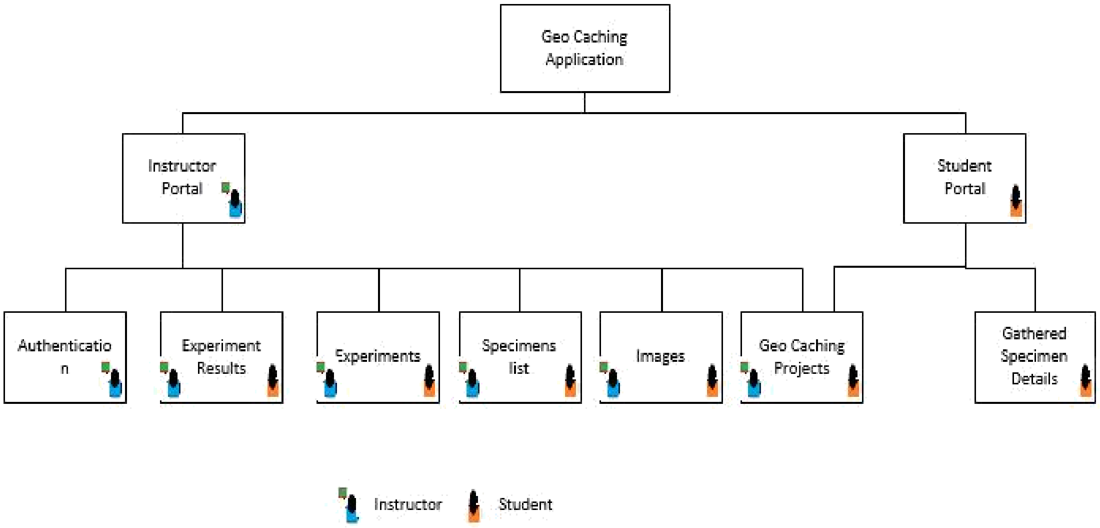


Figure 5. Block Diagram for CIRCLE-Geocaching Application

3.5.1. Instructor portal implementation

Here the instructor accumulates specimens, their GPS coordinates (latitude and longitude), images, and adds experiments that students must perform. A business diagram of the instructor portal representing different transitions is shown in Figure 6. This diagram presents distinctive states the instructor will go through. All the states are communicated using dictionary JSON in the Model-View-Template pattern. A description of each of the states is elucidated in later sections.

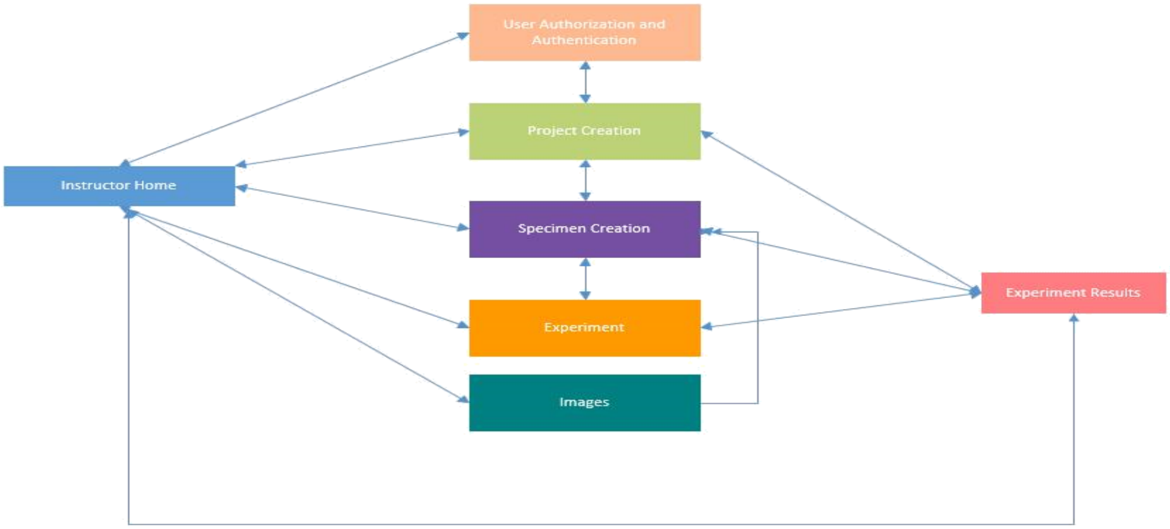
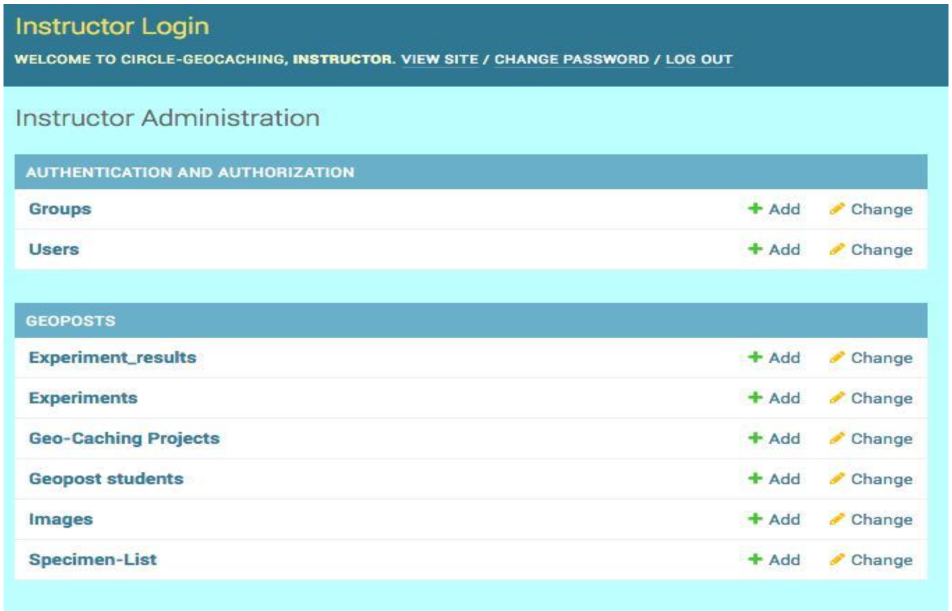


Figure 6. Business Diagram for the Instructor Portal.

3.5.2. Instructor home page

After the instructor connects to the portal, their home page will be displayed. The Instructors home page contains all the models required to build the CG application. This home page consists of both the default and customized applications. Of which, the users and groups are predefined by the Django authorization models and are inherited into the project. All the customized models are present under the Geoposts section. Geoposts is a customized application configured in installed apps of settings.py, where all the models such as CG projects, experiments, specimen list, images, and experiment results are registered. Created models integrate with each other to build the CG application. The instructor home page displays all the models that are present in the CG application (see figure 7). The instructor can logout anytime from the instructor portal. All the models or entities are explained in detail in the coming sections.

CG models developed in the instructor portal use Django object relation mapping (ORM). Each model created in models.py will create a table in the database. Each object for a model is represented by a record in the database and each field corresponds to a column in the database.



Instructor Login

WELCOME TO CIRCLE-GEOCACHING, **INSTRUCTOR**. VIEW SITE / CHANGE PASSWORD / LOG OUT

Instructor Administration

AUTHENTICATION AND AUTHORIZATION		
Groups	+ Add	Change
Users	+ Add	Change

GEOPOSTS		
Experiment_results	+ Add	Change
Experiments	+ Add	Change
Geo-Caching Projects	+ Add	Change
Geopost students	+ Add	Change
Images	+ Add	Change
Specimen-List	+ Add	Change

Figure 7. Instructor Home Page

3.5.3. User authorization and authentication

CG basically has two user accounts one is the instructor or admin and the other is student accounts. The instructor creates templates for this game by collecting specimens, GPS coordinates, uploading specimen images and adding experiments to perform on a specific specimen. Student portal logins are explained in the student web application, where they can login to view specimens and perform experiments.

The account creation feature of the CG instructor web application utilizes the Django admin site with a predefined user creation template. The Administrator can create a super user account in the Django console by using the command “python manage.py createsuperuser”. A Console allows to give the username manually. The administrator can also be the instructor or admin could assign roles to users while creating them like staff, students, etc.

The instructor login screenshot is shown in Figure 7 and the instructor can login to their account as admin in the login page, with all the super user access. In the diagram below screenshot shows the user creation for CG. Instructors can create users as students and add it in groups for the particular project of a course to play with CIRCLE-Geocaching. The Django admin template is provided to create admin users for its web application.

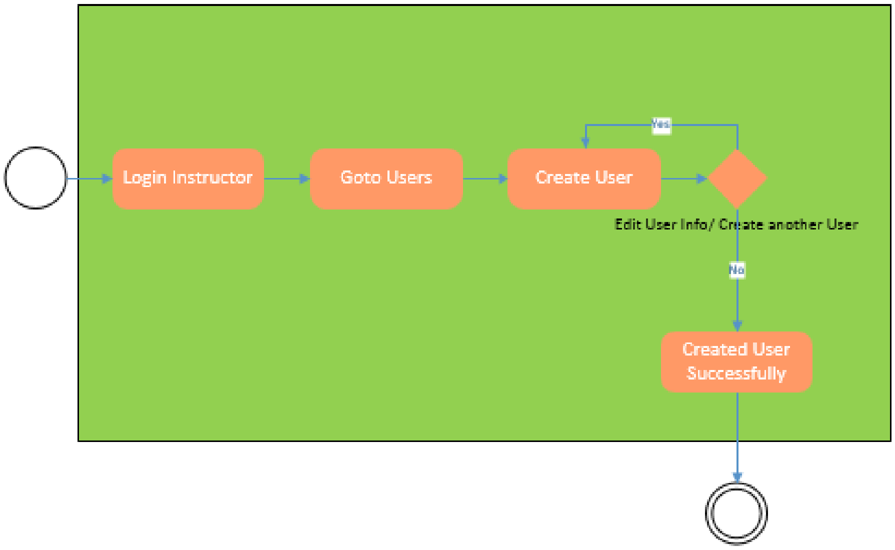

Login Instructor
Goto Users
Create User
Yes
Edit User Info/ Create another User
No
Created User Successfully

Figure 8. Activity Diagram for Account Creation and Authorization.

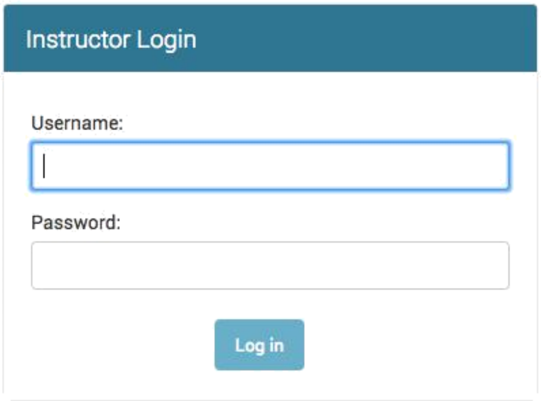


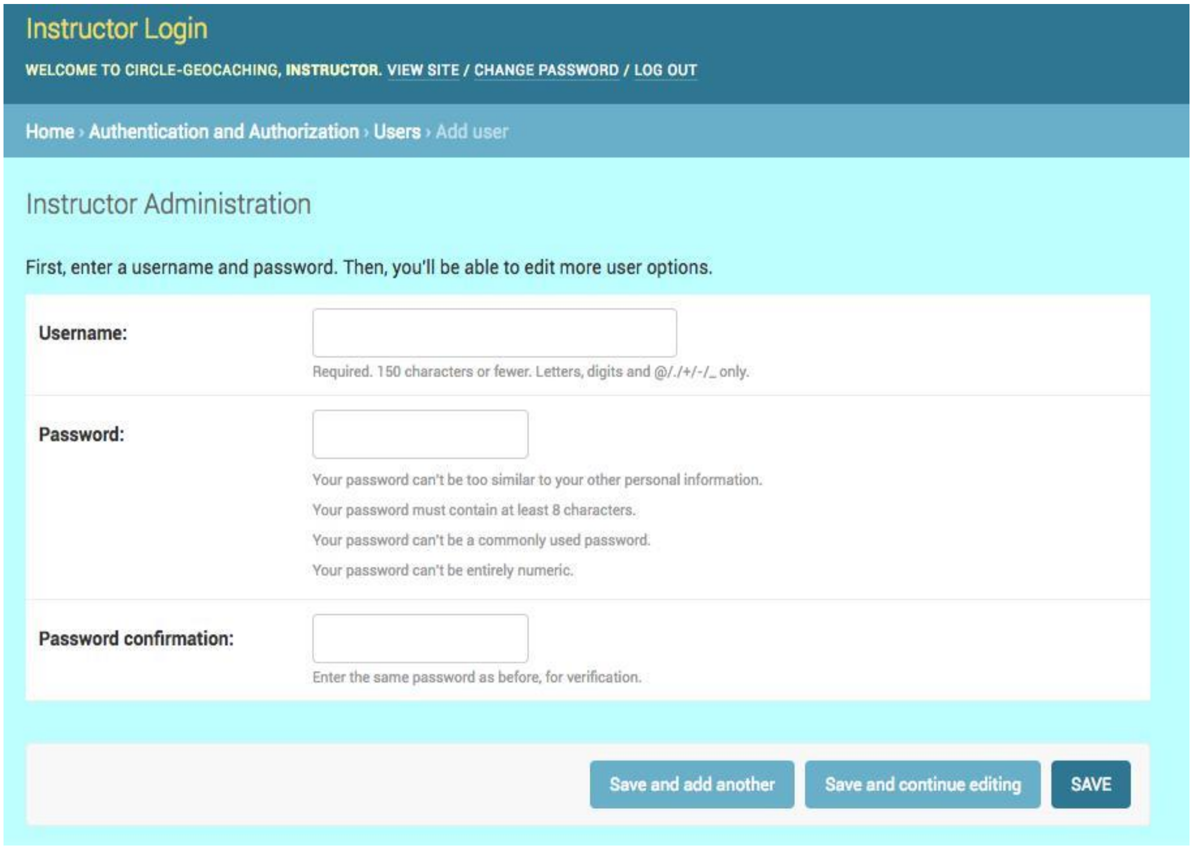
Figure 9. Login Page for Instructor

3.5.4. User Account creation

After the instructor logins to their home page, access is given to add the users and assign roles to the users. Users often will be students and the permission to set them would be Active Status. On the off chance that the instructor needs to offer access to another staff they can log into the instructor page and with the help of Django user admin template, can assign the group of users to certain roles. In the event that role of super user status is check marked for a user, at that point the instructor has all the authorization of super user. Students cannot login using the instructor portal but if they are assigned with a role staff (super user is check marked), then they could take an instructor role and login using those credentials. The primary job of the instructor would be creating projects, specimens, experiments, specimen images and GPS coordinates. Along with those, assigning users for projects is also part of his job, so that they have access to play the CG.

Another major responsibility of the instructor is to include avoidance of redundancy. For this, duplicate user creation is checked every time as a user should be new unfailingly. Some of the criteria's that are followed while creating a Username include containing letters, digits and some special characters which includes (@, +, _,-). The password creation has several 15 restrictions, for an example, the password can't be similar to personal information. It must contain

8 characters and the password can’t be a commonly used password. Also, the password can't be entirely numeric.. These are basic validations for username and password that are pre built by Django framework for user creation on admin panel. Once the users are created, then they are stored in the database which in turn gets stored in the server. The instructor has access to remove all the users or just delete the selected users. Editing the user information is also provided. Users that are saved create a record in the user Django user database. Figure 10 and 11 show how the users can be created and assign the roles. In user assignment, Figure 11 we can observe the checkboxes where we could assign different roles for a single user.



Instructor Login
WELCOME TO CIRCLE-GEOCACHING, INSTRUCTOR. VIEW SITE / CHANGE PASSWORD / LOG OUT
Home › Authentication and Authorization › Users › Add user

Instructor Administration

First, enter a username and password. Then, you'll be able to edit more user options.

Username:

Required. 150 characters or fewer. Letters, digits and @/./+/-/_ only.

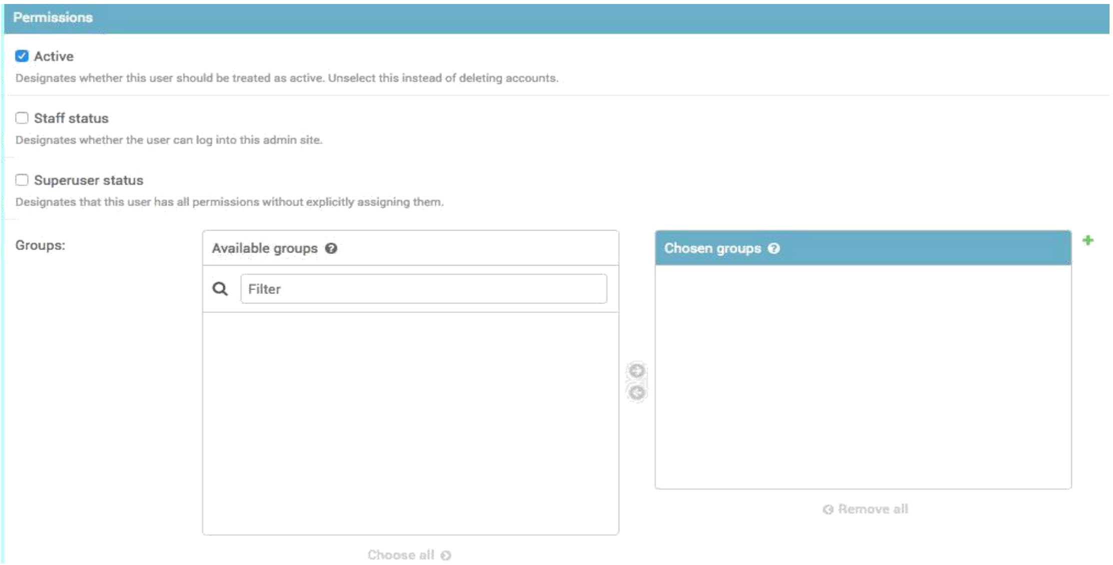
Password:

Your password can't be too similar to your other personal information.
Your password must contain at least 8 characters.
Your password can't be a commonly used password.
Your password can't be entirely numeric.

Password confirmation:

Enter the same password as before, for verification.

Figure 10. User Account Creation



Permissions

☑ Active

Designates whether this user should be treated as active. Unselect this instead of deleting accounts.

☐ Staff status

Designates whether the user can log into this admin site.

☐ Superuser status

Designates that this user has all permissions without explicitly assigning them.

Groups:

Available groups

Filter

Choose all

Chosen groups

Remove all

Figure 11. User Role Assignment

3.5.5. Project creation and access

The instructor creates a new project by selecting add geo-caching project from the instructor page, (Figure 13) and gives access to the users. Each project is assigned with a set of users to play the CG game on the project in the student portal. The instructor can add multiple projects and assign different users based on the project. In the process of assigning a user, the instructor has the option to create new users if any user is missed on the go, by clicking on the user label. Once the instructor saves the project by assigning the users to the project, an event is created and sent to the server to store the project data in the database. The entire process of creating this project is shown in the diagram, Figure 12. The Geocaching model is designed to create a new table for projects. The Geoproject model created adds projects and rows in a table whenever a new project is created. The Model has two fields, project name and users. All the users will have many to many relation with the projects, as each project can be assigned to multiple users and each user can work on multiple projects.

A Project is successfully created when the instructor enters the project name and assign users to the project. Project creation is a simple process. This project will be associated to specimen and experiments gathered by the instructor.

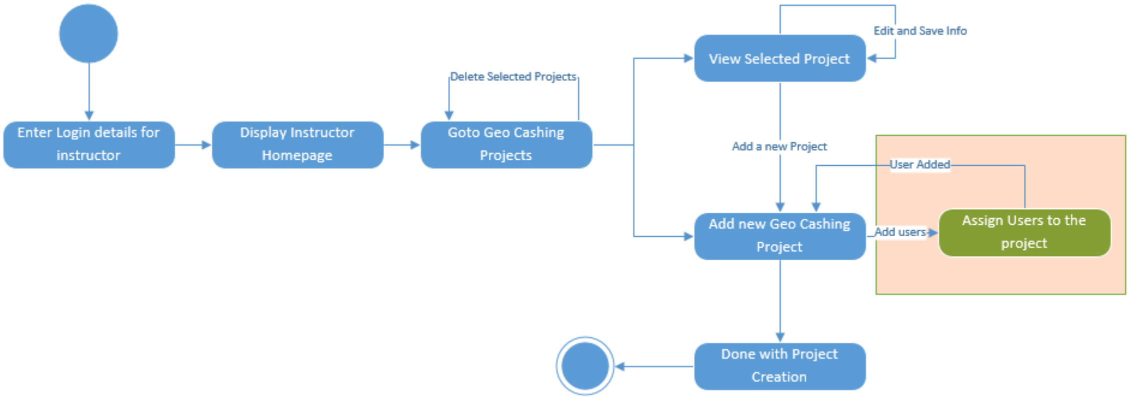
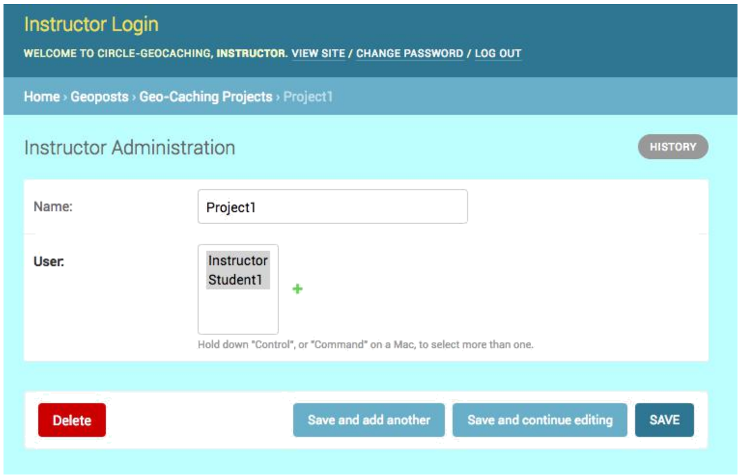

Enter Login details for instructor
Display Instructor Homepage
Delete Selected Projects
Goto Geo Cashing Projects
Edit and Save Info
View Selected Project
Add a new Project
User Added
Add new Geo Cashing Project
Add users
Assign Users to the project
Done with Project Creation

Figure 12. Activity Diagram for Project Creation and Access.


Instructor Login
WELCOME TO CIRCLE-GEOCACHING, INSTRUCTOR. VIEW SITE / CHANGE PASSWORD / LOG OUT
Home › Geoposts › Geo-Caching Projects › Project1
HISTORY
+
Delete
Save and add another
Save and continue editing
SAVE

Instructor Administration

Name: Project1

User: Instructor
Student1

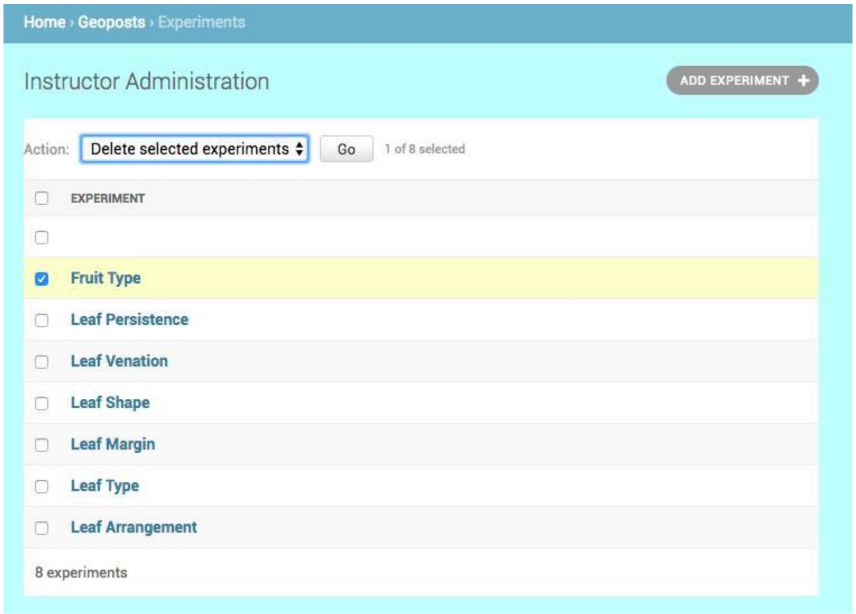
Hold down "Control", or "Command" on a Mac, to select more than one.

Figure 13. Project Creation and Access Screen

3.5.6. Experiments

After successful creation of the project, the next task of the instructor is to add experiments. Instructor adds experiments as separate entity as experiments in the instructor home. Experiments entity consists of experiment name along the possible results for that project specimens. The idea of adding experiments to the project is mainly to distinguish between the specimens collected. Implementation of experiments includes creating a class, or model for experiments in models.py, and adding a list of fields to it to enter the possible options for that experiment. Django ORM maps these model to table experiments and fields to respective column in tables.

The Instructor logins to the portal and selects experiments entity (model), this will prompt the instructor to see available experiments in the portal and allows adding new experiments. Also, the instructor will have the authority to delete or add specimens. Deleting the experiments can be done by selecting the experiments and choosing the action delete and go, which is shown in Figure 14. When the instructor chooses to delete selected experiments, an event to the server is sent to delete the experiments, which automatically deletes experiments from the database. All of the experiments created here, will be reflected in student portal. To play the CG game perform the experiments on each of the specimens.



Home › Geoposts › Experiments

Instructor Administration

ADD EXPERIMENT +

Action: Delete selected experiments ⬍ Go 1 of 8 selected

☐ EXPERIMENT

☐

☑ Fruit Type

☐ Leaf Persistence

☐ Leaf Venation

☐ Leaf Shape

☐ Leaf Margin

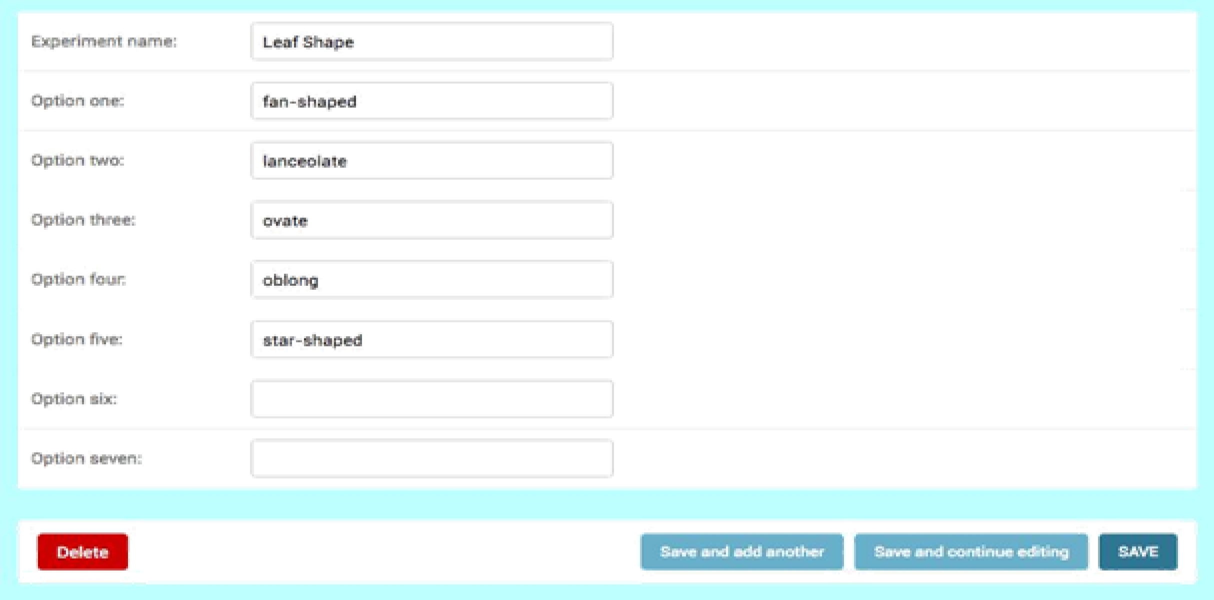
☐ Leaf Type

☐ Leaf Arrangement

8 experiments

Figure 14. Add Experiments and Delete Experiments

The flow of steps for the instructor to create experiments from the portal is explained in detail as follows. The instructor has to choose the Add experiments tab, upon clicking the add experiments, this will prompt to add new experiment with the possible results of the project specimens. The experiment name and options for the results are added in the options field, where name of an experiment and all the possible values of that experiments for project are added here. Experiments will be saved when clicked on save and can be continued to add another experiment. Deletion of a single experiment can also be done by choosing the delete option. The experiment screen, Figure 15 illustrates an addition of new experiments to the project.



Experiment name: Leaf Shape

Option one: fan-shaped

Option two: lanceolate

Option three: ovate

Option four: oblong

Option five: star-shaped

Option six:

Option seven:

Figure 15. Add Experiment Screen

In the database, adding an object of experiment in the experiment model adds a row in experiments tables. Delete an experiment also deletes an object of experiment from the experiments table. A complete flow of adding experiments and deleting experiments is represented in the diagram, Figure 16.

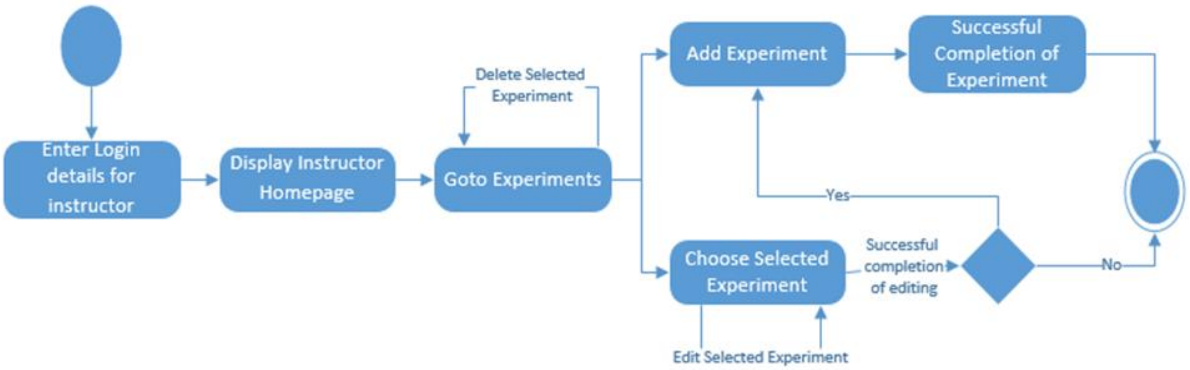

Enter Login details for instructor
Display Instructor Homepage
Goto Experiments
Delete Selected Experiment
Add Experiment
Successful Completion of Experiment
Yes
Choose Selected Experiment
Successful completion of editing
No
Edit Selected Experiment

Figure 16. Activity Diagram of Experiment Model

3.5.7. Specimen images

The instructor uploads specimen images gathered from the location by selecting image entity in home page. When selecting the image model, the screen will be redirected to image screen created by model image. Specimen images can be uploaded by clicking add image button. The instructor will then upload all specimen images necessary for the project. Similar to all other models, images can be uploaded by clicking the save button or deleted by selecting the images to delete and choosing action delete on the image screen. When clicking the add image option, specimen image can be uploaded which can be seen in Figure 18. The specimen entity pulls all the uploaded images. The instructor can also add multiple images for a specimen and assign them to specimens.

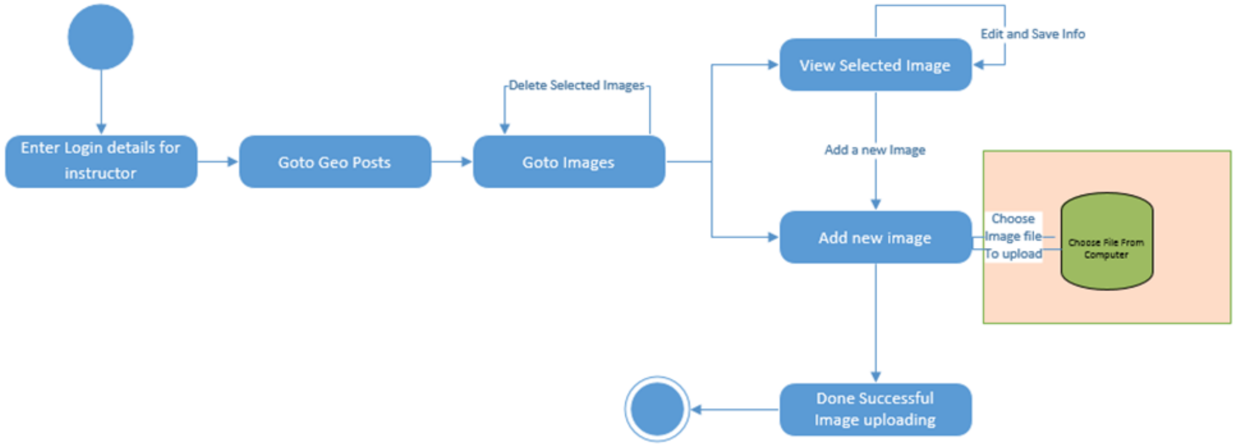
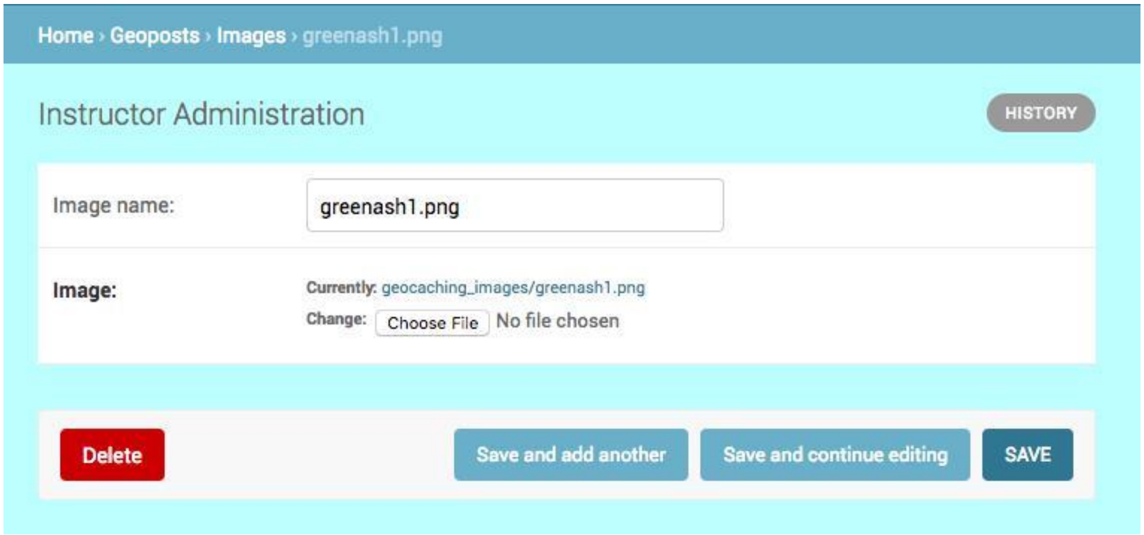

Enter Login details for instructor
Goto Geo Posts
Goto Images
Delete Selected Images
View Selected Image
Edit and Save Info
Add a new Image
Add new image
Choose Image file To upload
Choose File From Computer
Done Successful Image uploading

Figure 17. Activity Diagram for Specimen Images



Home › Geoposts › Images › greenash1.png

Instructor Administration

Image name: greenash1.png

Image:

Currently: geocaching_images/greenash1.png

Change: Choose File No file chosen

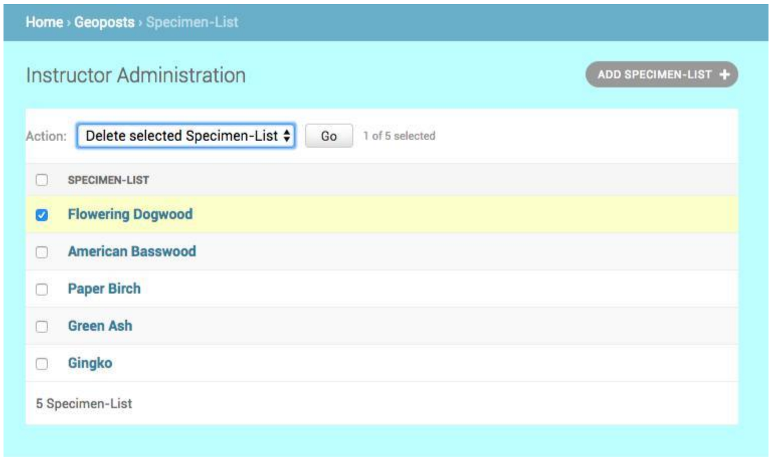
Figure 18. Specimen Image Upload

The Specimen images created are stored in a static media/Geocaching images folder. Image models are created and CRUD (create, read, update and delete) operations are allowed similar to that of other models by registering in admin panel. Python pillow package is used for image processing. When image is chosen and saved, an event will occur to save the image and store in the database. All the images related to each specimen will be displayed in student portal. All the states in specimen images are shown in Figure 17.

3.5.8. Specimens

Each project created by the instructor will contain list of specimens associated to it. Initially, as an outdoor activity the instructor visit the places and collect specimens, its GPS coordinates (latitude, longitude), and location, takes images of specimen, performs experiments and adds it in the portal under experiments entity section. The instructor will then update specimens with these details, so that students have access to it in their portal to play the CG game.

The specimen has a separate entity similar to experiment. The instructor on home screen clicks on specimen-list entity to view available specimens, Figure 19. Specimen-list is a model which uses ORM has its own table in database. Any specimen object created adds an object in the specimen-list model which in turn creates a record in its table. Creating a new specimen and deletion of specimens listed is done by selecting add-specimen-list and delete selected specimen list respectively.



Home › Geoposts › Specimen-List

Instructor Administration

Action: Delete selected Specimen-List Go 1 of 5 selected

☐ SPECIMEN-LIST
☑ Flowering Dogwood
☐ American Basswood
☐ Paper Birch
☐ Green Ash
☐ Gingko

5 Specimen-List

Figure 19. List of Specimens

Creating a new specimen involves specifying the name of the specimen, its GPS coordinates, its location, description of the location and uploading or selecting the specimen images from the image model. It also requires to select project from project model, experiment from the experiment model, right experiments and specimen images added to it. Like other models or entities, specimen added can be deleted or a new specimen can be created. All the states in the specimen creation is shown in the specimen Activity diagram, Figure 20.

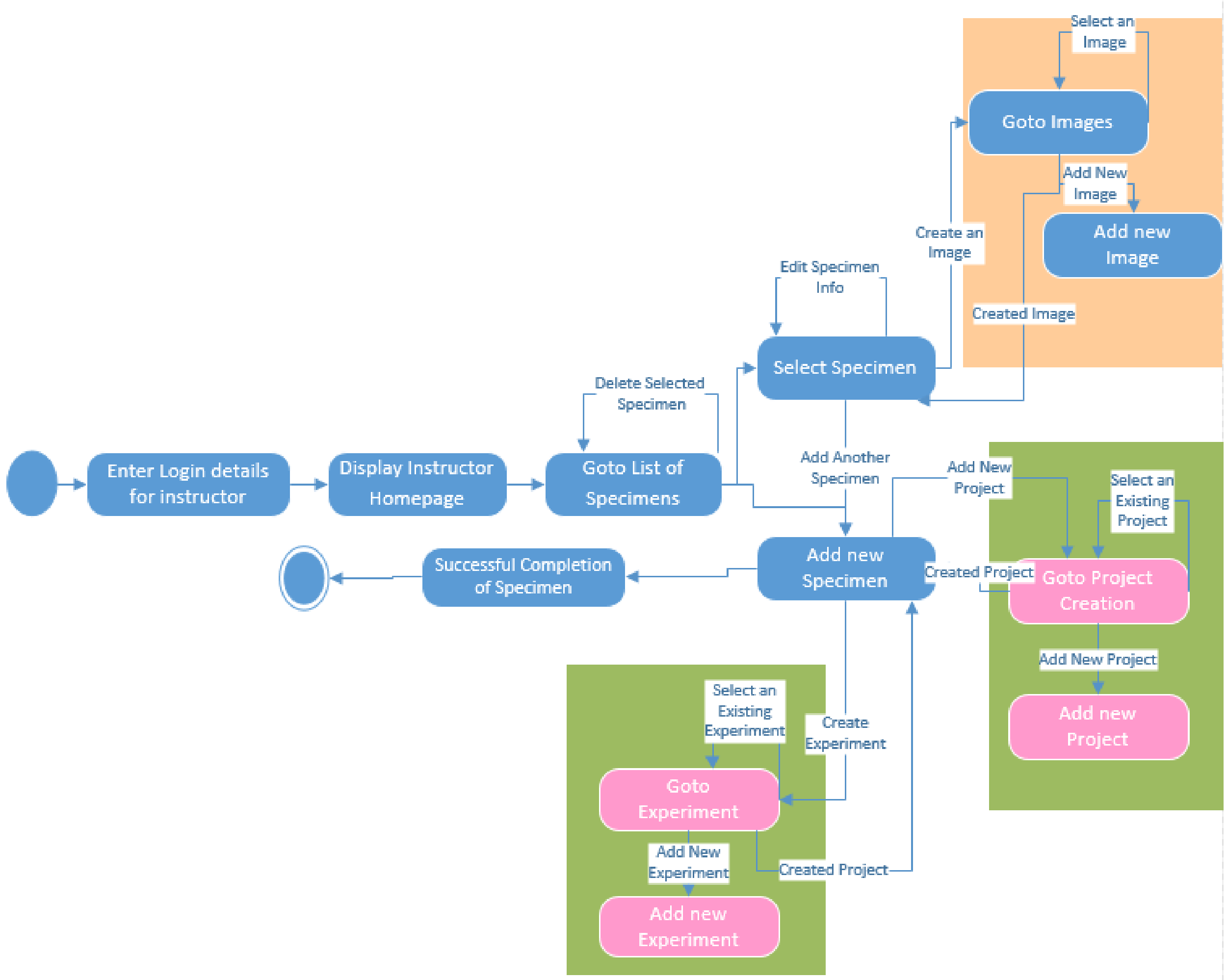
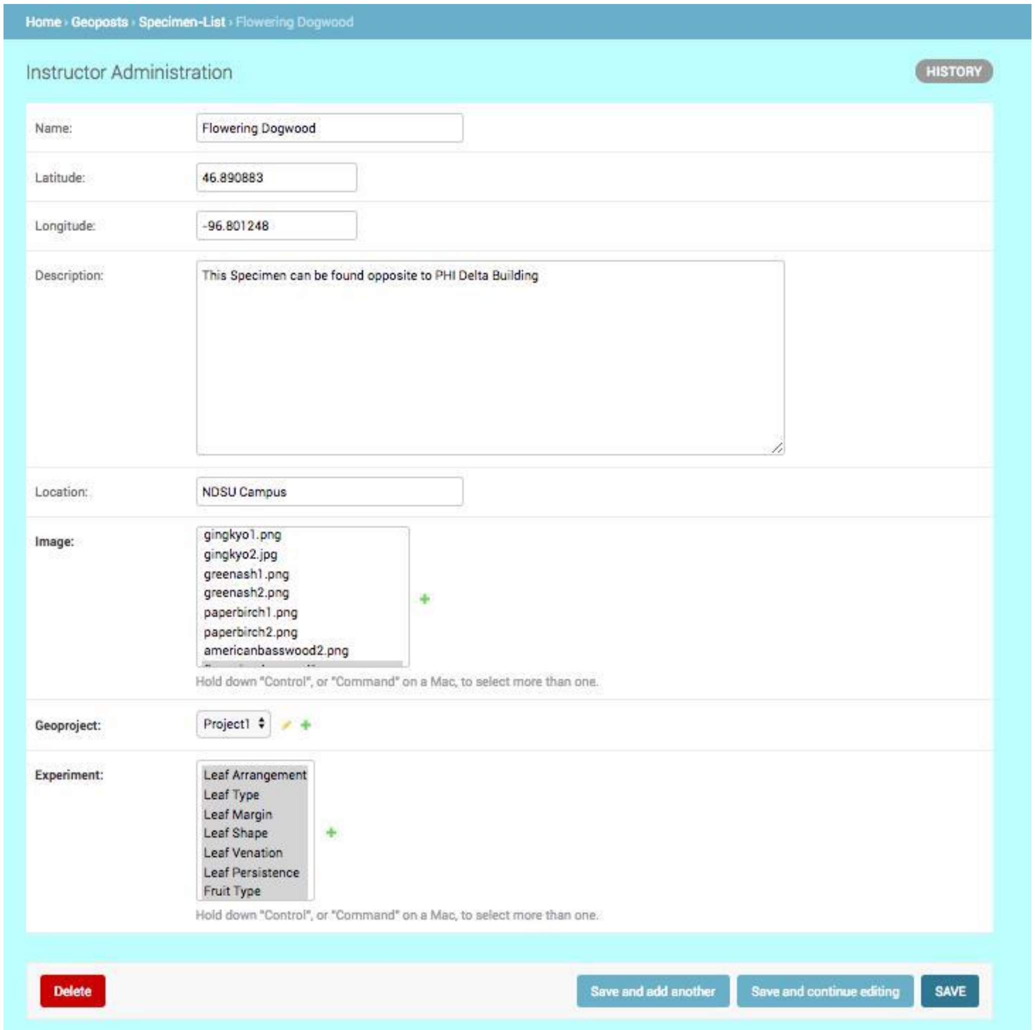


Figure 20. Activity Diagram for Specimen Creation

Uploading and adding specimen images is allowed, this uses models.imagefield for uploading images, where images can be saved or on clicking the + mark we can go to image entity to add a new image. Project selection for the specimen should be chosen here and a dropdown list of available projects will pop up or a new project can be created. Selecting the project will have specimens in that project. Experiments created in the experiments model will be displayed here. Selecting the available experiments for the specimen is made handy by selecting them and new experiments can be created from the specimen screen by clicking on + symbol right next to experiment. Creation of new specimen can be seen in Figure 21.


Home › Geoposts › Specimen-List › Flowering Dogwood
Instructor Administration
HISTORY
Delete
Save and add another
Save and continue editing
SAVE

Name: Flowering Dogwood

Latitude: 46.890883

Longitude: -96.801248

Description: This Specimen can be found opposite to PHI Delta Building

Location: NDSU Campus

Image:
gingkyo1.png
gingkyo2.jpg
greenash1.png
greenash2.png
paperbirch1.png
paperbirch2.png
americanbasswood2.png

Hold down "Control", or "Command" on a Mac, to select more than one.

Geoproject: Project1

Experiment:
Leaf Arrangement
Leaf Type
Leaf Margin
Leaf Shape
Leaf Venation
Leaf Persistence
Fruit Type

Hold down "Control", or "Command" on a Mac, to select more than one.

Figure 21. Specimen Creation Screen

Any new specimen created will have a new object of specimen-list model, in turn creating a new row in table specimen-list. Creation of a new specimen can also lead to creation of a new project and uploading a new image. If the image related to a specimen is not available and also if experiments related to specimens are not available, then a new experiment with possible results can be added.

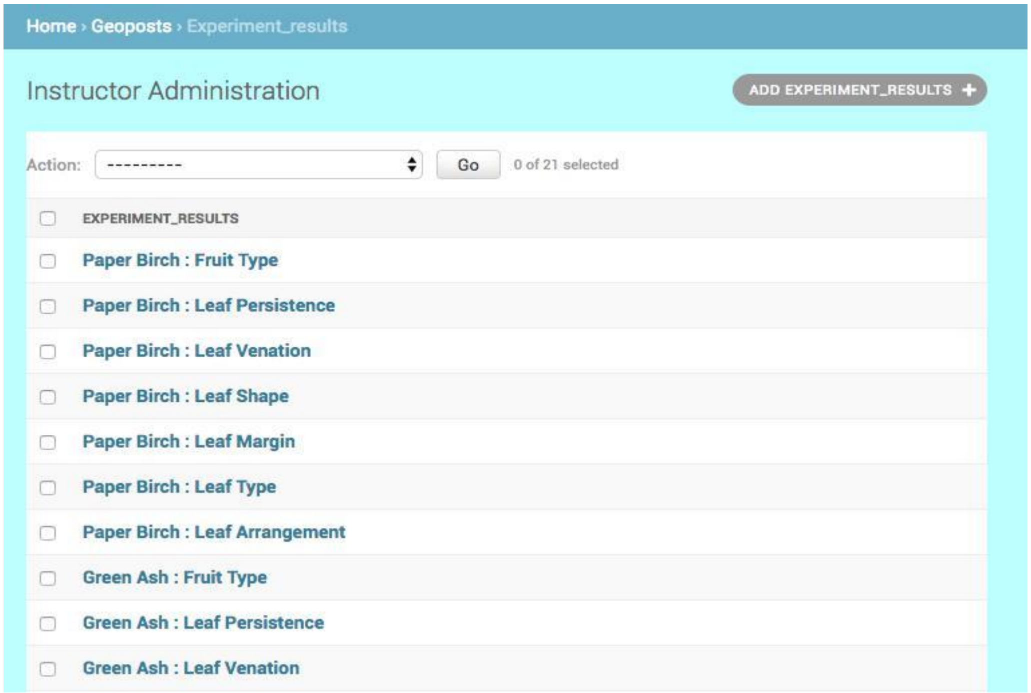
CG portal allows students to view specimens added here and play the game by performing experiments. All the fields provided by the instructor can be seen in instructor portal like specimen name, latitude, longitude, location, description, images uploaded and experiments to perform. This will also be discussed later in the student portal.

3.5.9. Experiment results

Each experiment created for a specimen will have a result (ex. like leaf venation, is pinnate). Experiments created in experiments section will have all possible results as options. This entity is created to validate the results for the experiments chosen by a student while playing the game. The Instructor will map the experiment results to the experiment and specimen in the project. The result is the right experiment answer.

Experiment results is a model created in the instructor home. When the instructor clicks on experiments results entity it will prompt list of experiment results, seen in Figure 22. Experiment results can be added by clicking select experiments results and similarly deletion of experiment results can also be implemented by selecting the experiment results and choosing the action delete on selected experiment results. The list of specimen's screen shows the entry as specimen name/ experiment name. The entries of all specimen with experiment will give an idea about each entry.

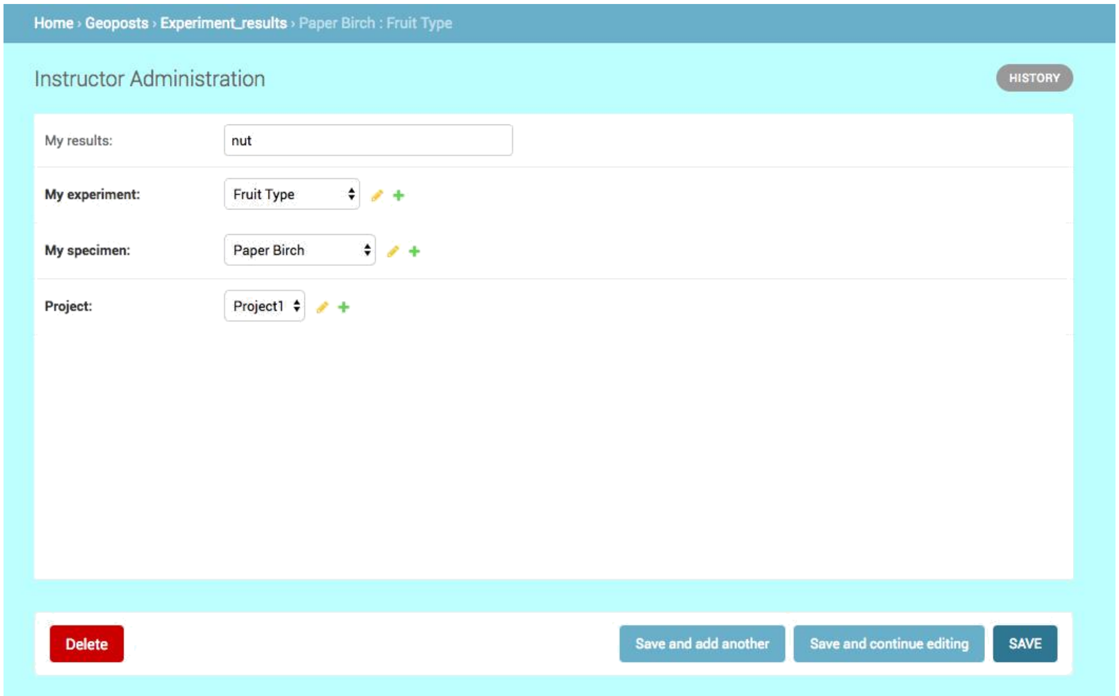
Any experiment result created here will result in an object creation at class or model level and at database level it is a creation of record at the experiment results table.


Home › Geoposts › Experiment_results
Instructor Administration
ADD EXPERIMENT_RESULTS +
Action:
Go
0 of 21 selected

Action: ---------

	EXPERIMENT_RESULTS
□	Paper Birch : Fruit Type
□	Paper Birch : Leaf Persistence
□	Paper Birch : Leaf Venation
□	Paper Birch : Leaf Shape
□	Paper Birch : Leaf Margin
□	Paper Birch : Leaf Type
□	Paper Birch : Leaf Arrangement
□	Green Ash : Fruit Type
□	Green Ash : Leaf Persistence
□	Green Ash : Leaf Venation

Figure 22. List of Experiment Results


Home › Geoposts › Experiment_results › Paper Birch : Fruit Type
Instructor Administration
HISTORY
Delete
Save and add another
Save and continue editing
SAVE

My results: nut

My experiment: Fruit Type

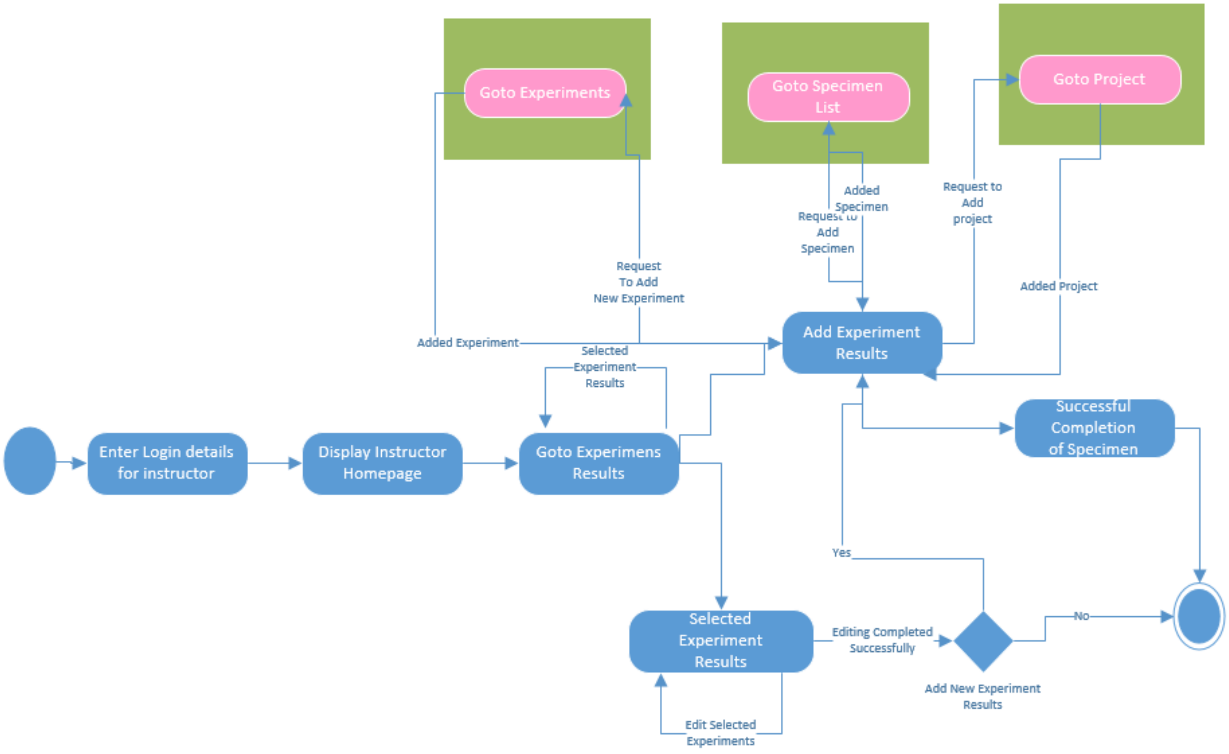
My specimen: Paper Birch

Project: Project1

Figure 23. Experiment Results

When selecting add an experiment the results screen navigate to screen experiment screen as shown in Figure 23. This is where instructor can add result, choose the specimen and experiment to which result is added, and choose the project where this specimen lies and save it. Result Json is automatically filled up when we hit save. It will save experiment name and its outcome which will be compared against the results of the experiments performed by the students on specimen in student portal.

A series of steps are to be followed to create an experiment result explained using an activity diagram, Figure 24. The diagram shows that projects, experiments and specimen list need to be created before creating experiment results.



Goto Experiments
Goto Specimen List
Goto Project
Added Specimen
Request to Add Specimen
Request to Add project
Request To Add New Experiment
Added Project
Added Experiment
Add Experiment Results
Selected Experiment Results
Successful Completion of Specimen
Enter Login details for instructor
Display Instructor Homepage
Goto Experimens Results
Yes
Selected Experiment Results
Editing Completed Successfully
No
Add New Experiment Results
Edit Selected Experiments

Figure 24. Activity Diagram for Experiment Results

3.6. Student portal implementation

The CG game is accessible to both students and instructors; students must login to the student CG portal using their credentials, choose the project and perform experiments. Students are prompted to choose the correct answer until all the experiments have the correct response for the specimen.

The CG student portal is developed using HTML, CSS, JavaScript, and JQuery Library. Front end web framework bootstrap (3.2.0) is used to develop this project for its client implementation.

The open source, front-end framework bootstrap has become more popular in today's trending market to develop web applications because of its ease of use, cross browser compatibility, and responsive nature. It can be effortlessly made to work with mobile devices, tablets, and desktop platforms.

Bootstrap additionally provides pre-designed HTML and CSS templates for forms, navigation bars, and several other custom components of interfaces. The CG client implementation JavaScript enabled HTML files is present in templates of this Django framework. First, templates fetch the data from views, then views using query sets pulls the data from models created in the instructor application. The results are displayed using the templates.

The bootstrap content delivery network (maxcdn) is used to get the access to the bootstrap front-end framework. The CDN for JQuery plugin

(https://cdnjs.cloudflare.com/ajax/libs/jquery.bootstrapvalidator/0.5.0/js/bootstrapValidator.min.js) is used for validating form fields and file uploads, specifically for the gathered images of specimens to be uploaded. This plugin to bootstrap is used to give a more modern, pleasing look to the interface, event handling, animation, and Ajax event calls.

3.6.1. Login page

The CG student login page is created for students to login to the student portal and play the game. Login credentials are created by instructors in the account creation and access module and authorize students to login to the portal. Instructors provide credentials to students so they can login to the portal and play the game. When students login to the portal, they will be redirected to the student home page, where they will be able to view the projects that are assigned by instructor. Below, Figure 25 shows the student login page.

The student login screen was created using bootstrap forms, HTML, CSS, JavaScript, required field validators for username and password. If students enter the wrong password or username other than the instructor provided credentials, they will be requested to enter the correct credentials. This page is placed in the templates folder where all HTML files reside in the Django framework. Media or images are placed in the static/media folder, where static files reside in the Django framework.

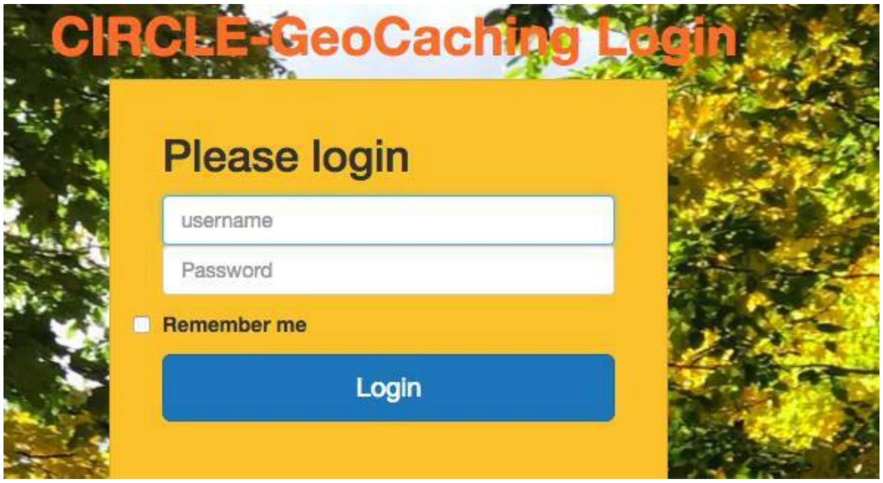
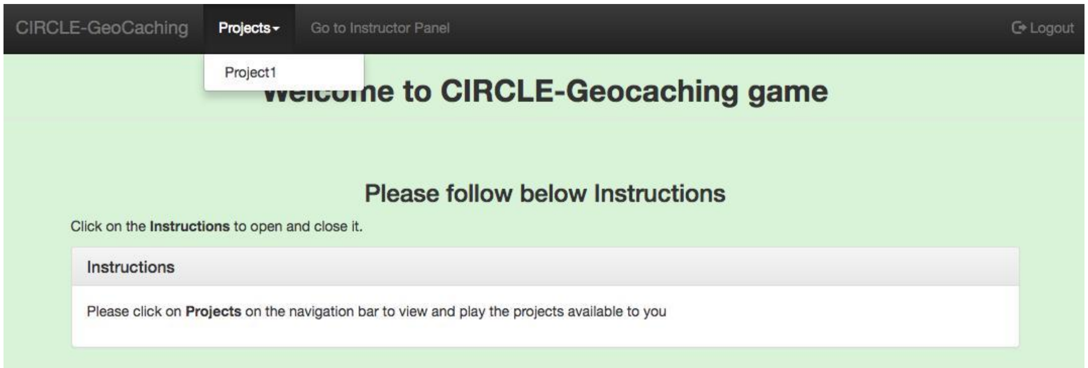


Figure 25. Student Login Page

3.6.2. Student project screen

Once the student's credentials are verified in the login screen they will be moved to the project home page. Students will be able to view the projects assigned to them by an instructor. The student home page consists of a navigation bar that has a projects tab and a logout button on the right. If students log out from this screen, they will be redirected to the login screen. The student home page consists of a welcome screen and instructions to play the game.

The student home page navigation bar is implemented using a bootstrap module navbar, panel group, HTML, CSS, and JavaScript. Project availability is dynamically added to the projects tab whenever the instructor creates a project in the instructor portal. The project list is updated by calling Django injected dictionary JSON in a loop to view all available projects. These projects contain all the specimens' data: name, latitude, longitude, GPS link, images uploaded by instructor, and experiments to perform on the specimen data. Figure 26 shows the student home page.



Welcome to CIRCLE-Geocaching game

Please follow below Instructions

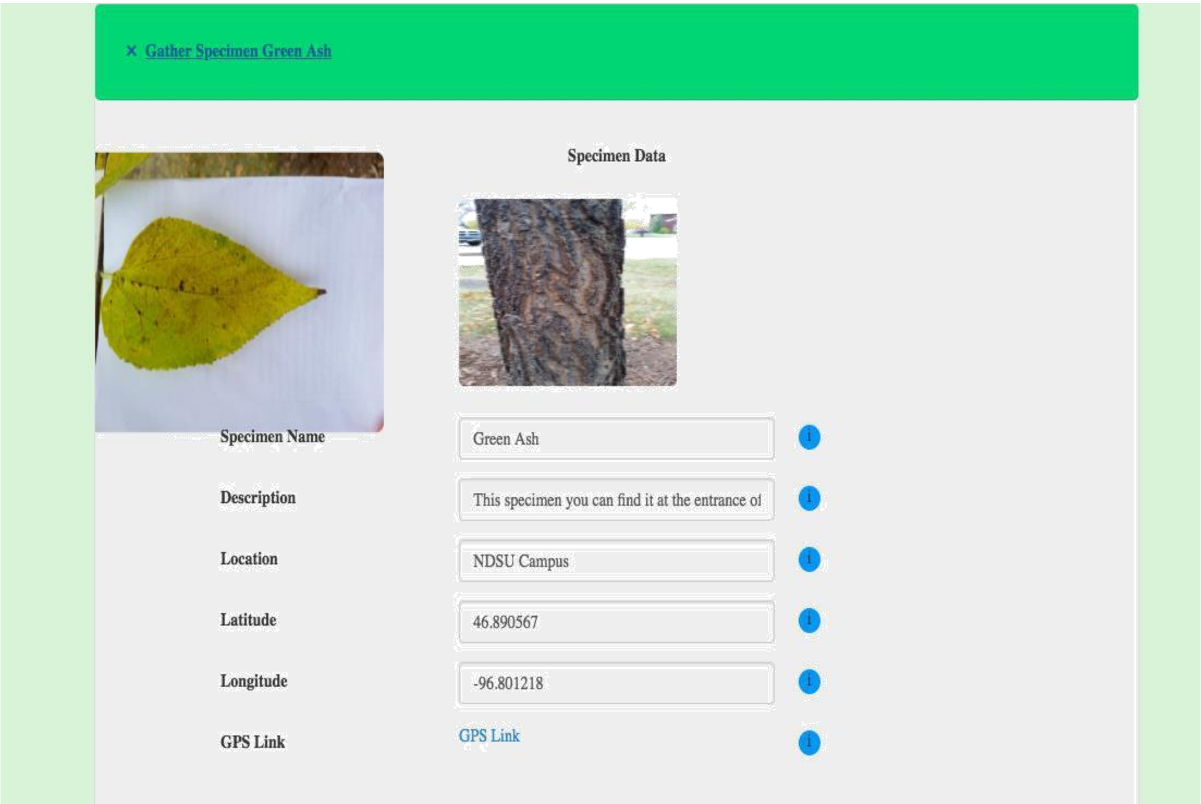
Click on the **Instructions** to open and close it.

Please click on **Projects** on the navigation bar to view and play the projects available to you

Figure 26. Student Home Page

3.6.3. Specimen list

After the student chooses the project to play, a list of specimens with individual specimen data, along with experiments to perform related to that project, will be available. Specimen data includes specimen images, specimen name, specimen description, specimen location, latitude, longitude, and location of GPS link seen in Figure 27. All the fields are available to students as read only because they don’t have permission to edit them. Specimen images are uploaded by the instructor in the instructor portal using an image model; all other specimen data available in student portal are fetched from the instructor’s models.



× Gather Specimen Green Ash

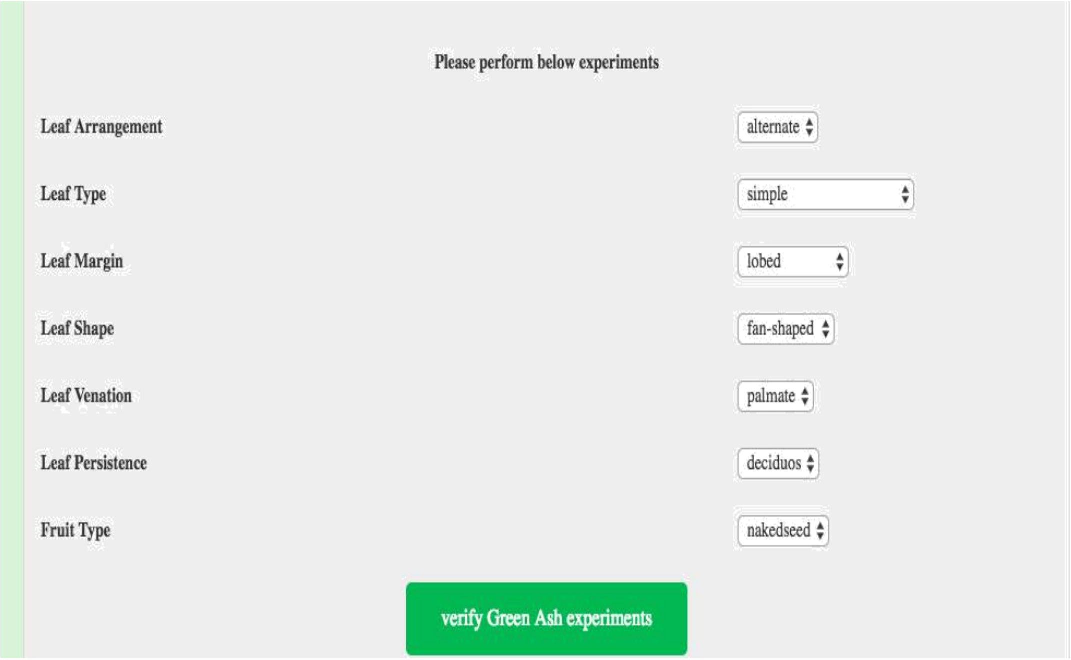
Specimen Data

Specimen Name	Green Ash
Description	This specimen you can find it at the entrance of
Location	NDSU Campus
Latitude	46.890567
Longitude	-96.801218
GPS Link	GPS Link

Figure 27. Specimen Data

Students must perform experiments as a part of CG; the list of experiments to perform will be provided by the instructor, as seen in Figure 28. The instructor adds experiments in the experiment model of the instructor portal; the experiments related to that project will be available to students. The students will choose the answer from the dropdown for each experiment.

The experiment result for each experiment is then verified against the correct answer. If the student chooses the correct answers to all the experiments, then the student will be redirected to the next specimen. The experiment result model implemented by the instructor will store experiment results and verify the student results.



Please perform below experiments

Leaf Arrangement	alternate
Leaf Type	simple
Leaf Margin	lobed
Leaf Shape	fan-shaped
Leaf Venation	palmate
Leaf Persistence	deciduos
Fruit Type	nakedseed

Figure 28. Experiments

The student specimen list screen is implemented using Bootstrap Accordion, Bootstrap Forms, HTML, CSS, JavaScript, JQuery, and Ajax. The specimen data in this student screen is dynamically populated and retrieved from the instructor portal and organized to play the CG. Django models specimen lists experiments, projects, images, and experiment results are the main components. Using these components, data is fetched through query sets for each model. This specimen list page is in the templates folder. Ajax functionality is implemented when the student chooses the experiment results and submits them. The submitted experiment results are verified from the experiment results model. Ajax functionality is used to verify against the correct answers for the experiments; the correct answers will be displayed in green and wrong answers will be displayed in red on the student screen. The GPS link is implemented using google maps, API and appending the latitude and longitude to the endpoint. Thus the location is opened in google maps. The activity diagram below, Figure 29 represents students playing the CG game.

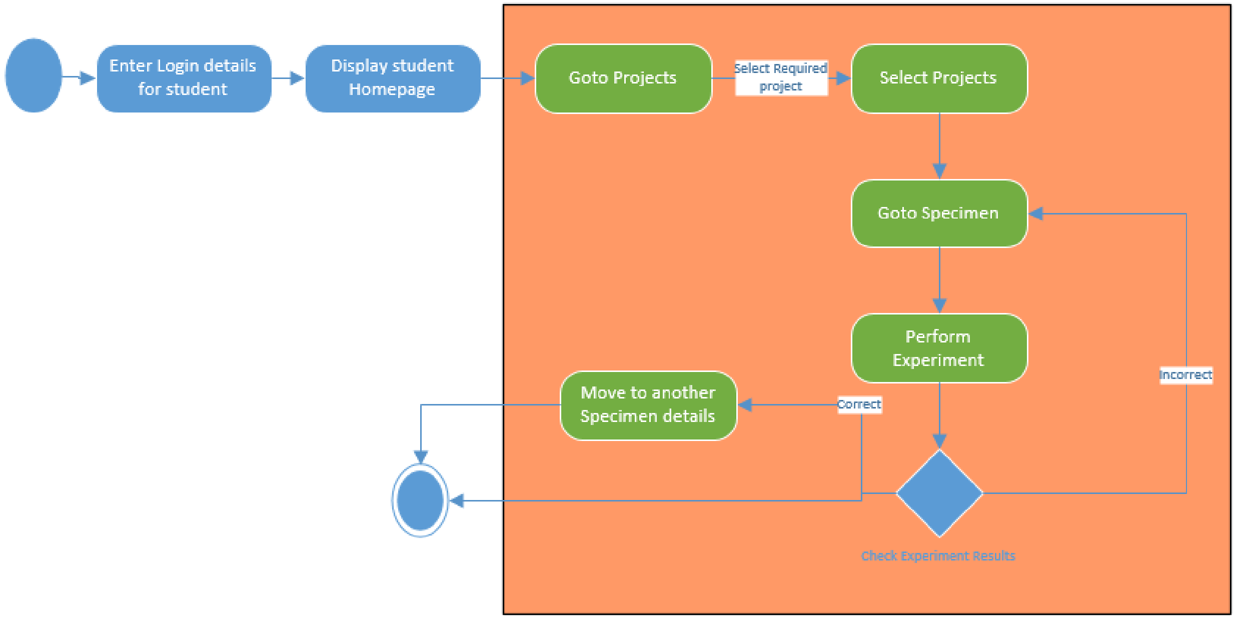


Figure 29. Activity Diagram for Student CIRCLE-Geocaching

3.6.4. Game play and results

The CG game is played in the student portal, where the student logs in to this site with the credentials given by the instructor. Once the student logs into the portal, the student needs to select the projects from the list of projects available. Once the student chooses the project, then the specimen data is displayed with the experiment list to perform on that specimen, as shown in Figures 27 and 28. The student gets the specimen data, takes down the GPS coordinates, images, location description, and the experiments to perform, with possible results provided in the dropdown in handheld devices. The student then goes to the location and there the student will explore the location for the specimen, using the coordinates and the images to find the specimen cache. The student then chooses the experiment result from the given possible results.

To illustrate an example, Binder1 (CIRCLE) provides a specimen list along with experiments and results. These are used to create a CG project. Let us perform experiments for a green ash specimen as shown in Figure 27. The green ash specimen has the following specimen data the specimen name, location description, GPS coordinates, and GPS link.

The green ash specimen is on the NDSU campus at the entrance of Ceres Hall. Clicking on the GPS link will open the location in Google Maps, which can be viewed in Figure 30.

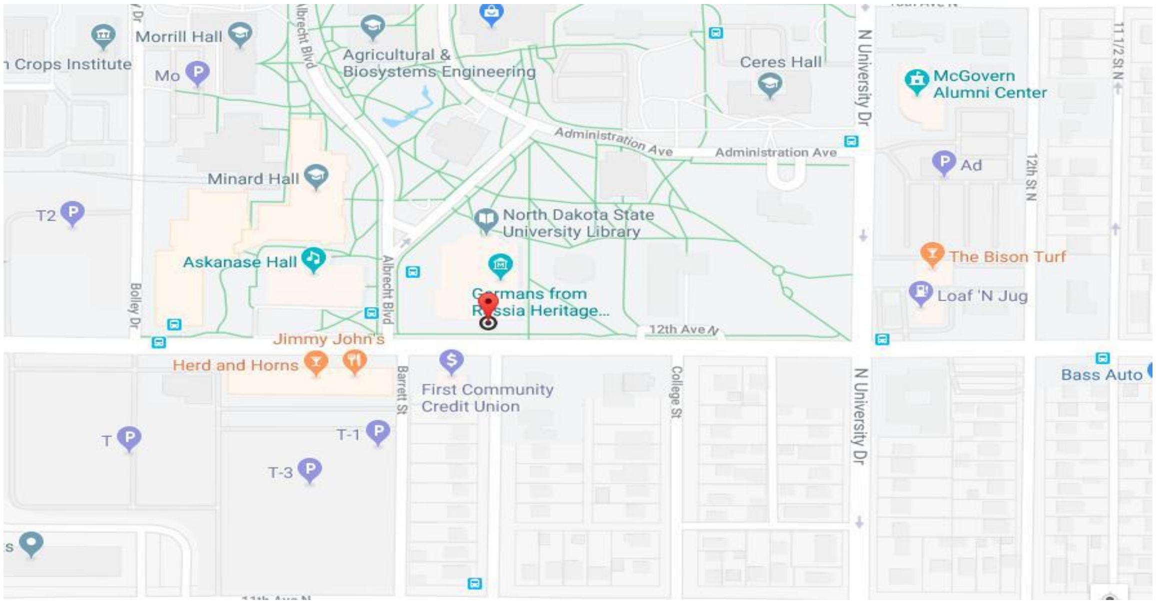
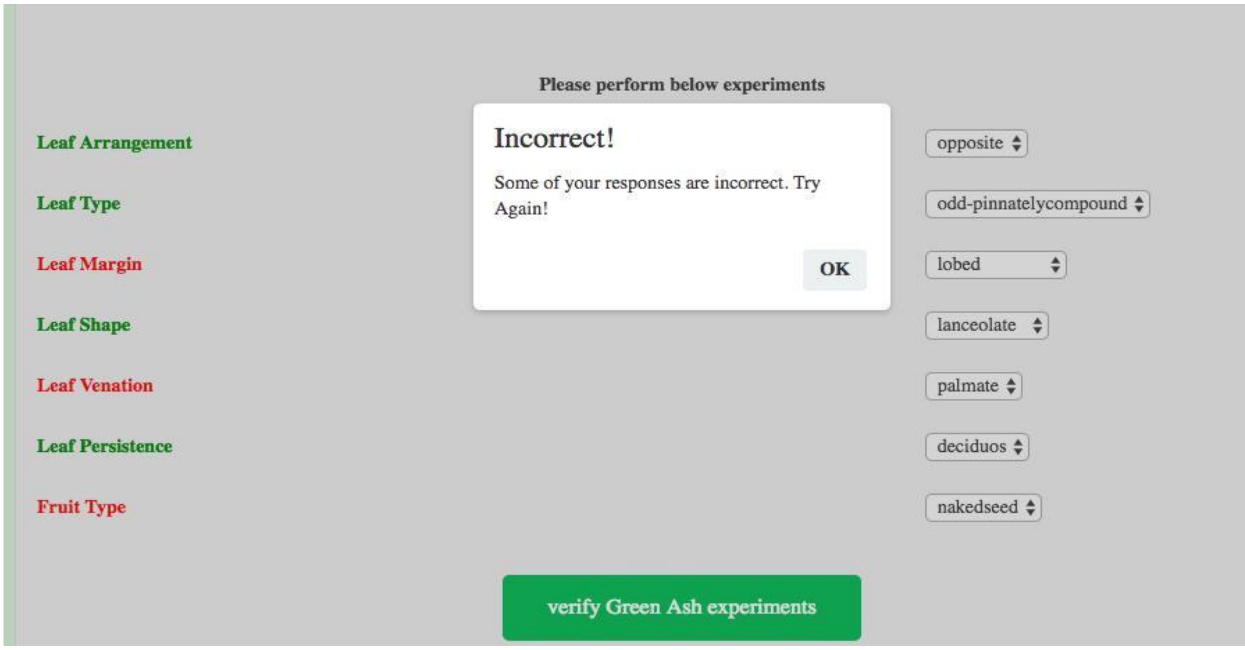


Figure 30. Green Ash Specimen Location in Google Maps

Once the student reaches the location using the GPS link or GPS coordinates, finding the specimen will be the next task. After finding the specimen, the student will note down the results for the experiments. The experiments list for the specimen are as shown in Figure 28. Experiments to perform for specimen green ash are leaf arrangement, leaf type, leaf margin, leaf shape, leaf venation, leaf persistence, and fruit type. Possible results for these experiments are: opposite, odd pinnately compound, serrate, lanceolate, pinnate, deciduous, and samaras respectively.

Students noted experiments results are verified on clicking the button verify the green ash experiments. Students choose from experiment results against each experiment and click verify the Green Ash experiments. If the student experiment results are wrong then a window pops up saying that some of the responses are wrong. Experiments with the wrong result chosen will be displayed in red color and experiment results that are correct will be displayed in green color. This can be seen in Figure 31. (See Figure 31)



Please perform below experiments

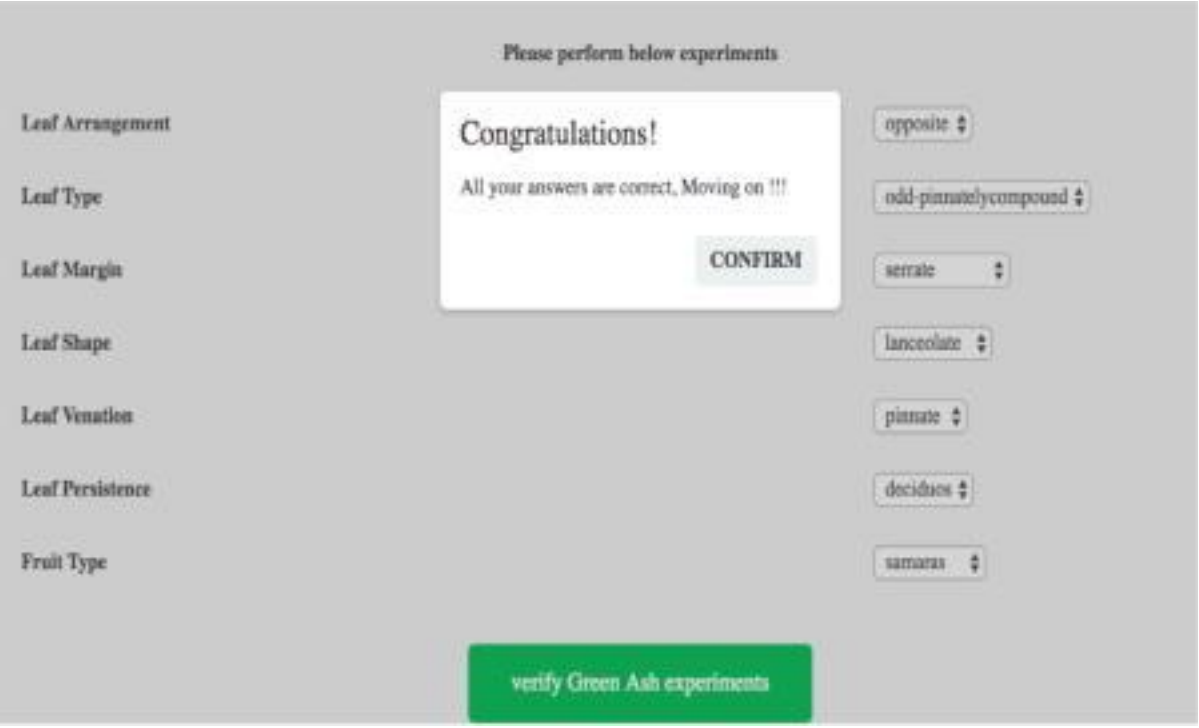
Leaf Arrangement	opposite
Leaf Type	odd-pinnatelycompound
Leaf Margin	lobed
Leaf Shape	lanceolate
Leaf Venation	palmate
Leaf Persistence	deciduos
Fruit Type	nakedseed

Incorrect!

Some of your responses are incorrect. Try Again!

Figure 31. Experiments with Wrong and Correct Answers

Green font for the experiments show that your results are correct and red color font indicates that right answers have to be chosen. Until the student indicates the correct answer to all the experiments, pop ups will keep being displayed. Students who get the correct results for all experiments get a congratulatory message saying Congratulations all your answers are correct! When clicking confirm it will move to the next specimen which is shown in Figure 32.



Please perform below experiments

Leaf Arrangement	opposite
Leaf Type	odd-pinnatelycompound
Leaf Margin	serrate
Leaf Shape	lanceolate
Leaf Venation	pinnate
Leaf Persistence	deciduos
Fruit Type	samaras

Congratulations!

All your answers are correct, Moving on !!!

Figure 32. Experiments with All Right Results

4. CONCLUSION AND FUTURE WORK

The CG game holds a good promise for students to learn about specimens through retrieval learning. Binder1 specimen data (from CIRCLE) of the experiments is used to create the CG game. Students use the GPS coordinates given in the student portal to visit the location, find the specimen, and perform experiments. This game is made exciting and interesting by incorporating fresh air, walking, and exploring along while learning about the specimens.

CG can be included in the coursework by providing classification and identification of specimens. Students, either in a group or as an individual, explore the location given, like the NDSU Campus and other accessible places. CG increases knowledge of the specimens as they perform experiments repetitively until the results are correct. Students spend time exploring and this form of retrieval-based learning strengthens memory on specimens. Therefore, students will be less likely to forget. CG might act as a powerful tool for improvement of knowledge without much reading and memorizing.

Future work will revolve around making the game more scalable and flexible. Altering the CG architecture by using REST to optimize for scalability and maintenance, and developing a mobile application. By evaluating student's feedback new features can be added. One potential new feature can be a points-based geocaching game that awards points to students for the accuracy of their results. Students that find the correct result for an experiment the first time will receive full points and for each iteration of incorrect answers there will be deductions in their points. REST architecture can be used to alter the current CG architecture. REST can also be implemented for the CG application by using HTTP modules to integrate and perform CRUD operations on CIRCLE data. A mobile app, both in Google play and App store, for CG can be developed, which will be handy for students visiting the location and performing experiments on the specimens.

Further improvements can be made to the interface to add motivation and learning about the specimens.

5. REFERENCES

L. Barkhuus, M. Chalmers, P. Tennent, M. Hall, M. Bell, S. Sherwood, and B. Brown, Picking Pockets on the Lawn: The Development of Tactics and Strategies in a Mobile Game, *In the Proceedings of Ubicomp* 2005, Springer. September 11—14, 2005.

S. Benford, A. Crabtree, S. Reeves, M. Flintham, A. Drozd, J. Sheridan, and A. Dix. The Frame of the Game: Blurring the Boundary between Fiction and Reality, *In the Proceedings CHI, ACM Press*, 427–436. April 22-27, 2006.

O. Borchert, G. Hokanson, A. Peruri, B. M. Slator, (2015). Here a Game, There a Game: classification, gamification, and retrieval learning. *Proceedings of the 1st International Conference on Higher Education Advances (HEAd'15).* Valencia, Spain. Pg. 96-101. June 24-26, 2015.

M. Capra, M. Radenkovic, S. Benford, L. Oppermann, A. Drozd, and M. Flintham, (2005) The Multimedia Challenges Raised by Pervasive Games, *In the Proceedings of Multimedia*, ACM Press, 89-95. November 6-11, 2005.

G. Clough, A. Jones, P. McAndrew, & E. Scanlon, Informal Learning Evidence in Online Communities of Mobile Device Enthusiasts. *In the Proceedings of Empowering Learners and Educators in Mobile Learning*. (Ed) Ally, M. Athabasca University Press. November 24, 2009.

S. Deterding, S. Björk, L. E. Nacke, D. Dixon, & E. Lawley. Designing gamification: Creating gameful and playful experiences. *In the Proceedings of the CHI 2013 Conference on Human Factors in Computer Systems*. New York, NY: ACM Press. 27 April- 2 May 2013.

J. D. Karpicke, Retrieval-Based Learning: Active Retrieval Promotes Meaningful Learning. Current Directions in Psychological Science, 21(3), 157-163.

doi: 10.1177/0963721412443552, 2012.

Models., Retrieved June 17, 2018, from https://docs.djangoproject.com/en/2.0/topics/db/models/, June 17, 2018

K. O’Hara, Understanding Geocaching Practices and Motivations, *In the Proceedings of CHI*, ACM Press (2008).Geocaching, http://geocaching.com, April 5-10, 2008.

Retrieval-based learning: Active retrieval promotes meaningful learning JD Karpicke - Current Directions in Psychological Science, 2012.

Writing Views., Retrieved June 17, 2018, from https://docs.djangoproject.com/en/2.0/topics/http/views/, June 17, 2018