

# IDEALS

## Final Project Report

### CSCE 606 - Software Engineering

## Introduction

The IDEALS project aims to bridge the gap in educational theory training and implementation of high-impact practices by creating an interactive, user-friendly online tool. This tool is designed to simplify the understanding of the relationship between influential learning theories and practical teaching methods. The project's main customer need is to facilitate educators' understanding of why certain practices are more effective than others, justify their use of particular practices, and design learning activities that align with desired outcomes and competencies. To meet this need, the project team has transformed a complex, visually overwhelming Miro concept map into a more accessible, visually appealing interactive website.

This web-based platform serves a dual-stakeholder group of educators and researchers. For educators, the tool provides a guided, user-friendly interface that allows them to traverse the concept map, starting from a chosen theory, through its associated assumptions, and ending with connected learning activities. This unique feature empowers educators to design more effective learning experiences and understand the theoretical underpinnings of their teaching practices. The tool offers a comprehensive view of the complex interconnections between various learning theories, assumptions, and practices for researchers. It supports them in identifying relevant theories for strengthening their teaching and learning research. This approach not only aids in developing more robust educational theories but also ensures that the tool remains a valuable resource in the evolving educational theory and practice field.

## User Stories

We successfully **completed all user stories** outlined in our backlog, effectively addressing customer and developer requirements. Most of these tasks were identified during the project's initial phase and thus served as the foundation of our development work. As the project progressed and customer needs evolved, we demonstrated adaptability by incorporating and completing additional tasks. This iterative and responsive approach ensured that our output remained aligned with the dynamic demands of our client.

1. **Feature/Points:** Application deployment/3  
As a user,  
So that I can build, analyze and share concept maps  
I want to open the platform on my browser

**Iteration: 1**

**Justification:** The implementation of this user story is crucial for the efficient deployment and maintenance of the application. Using Docker images ensures the application runs uniformly across environments, increasing portability. Deployment on the cloud enhances scalability and availability while reducing costs. Finally, a CI/CD pipeline automates integration and deployment, accelerating development and improving software quality by quickly identifying and fixing bugs. This user story streamlines the deployment process and maintains high software quality. We will further discuss this in the next section.

2. **Feature/Points:** Database setup and structure/3  
As developer

I want to have an SQL-structured database and seed it with initial data  
So that I can manipulate data easily

#### Iteration: 1

**Justification:** Adopting an SQL-structured database is pivotal for organized data storage, retrieval, and manipulation. Seeding the database with initial data aids in testing the functionality of the database and the application's data operations, ensuring optimal performance. This step aligns with best practices for robust and reliable application development, enhancing efficiency, security, and scalability. Figure 1

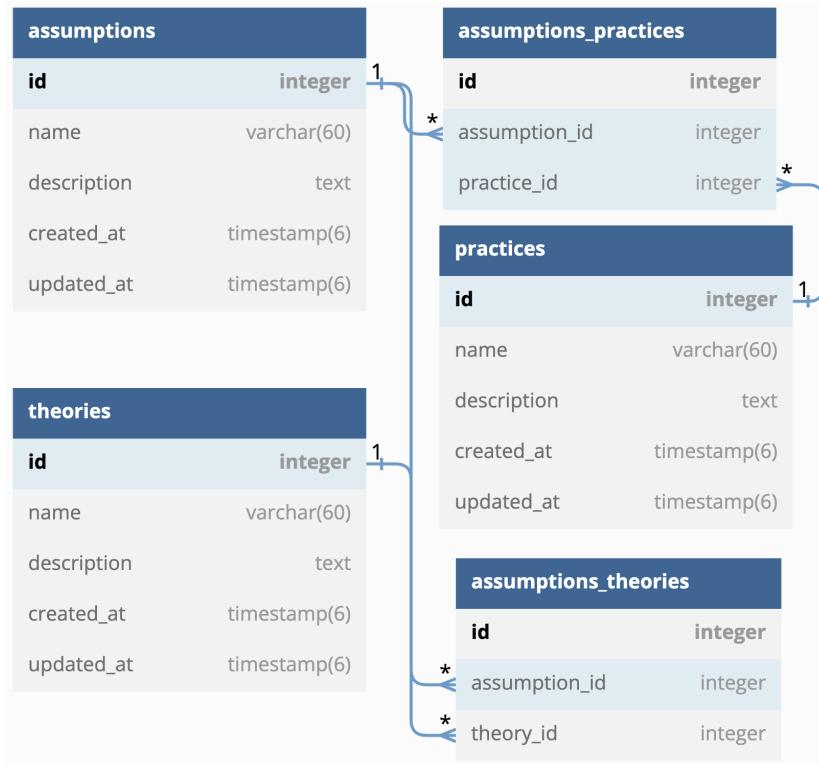


Figure 1: SQL Schema Diagram

#### 3. Feature/Points: Add Theory/1

As a site owner

So that I can help build, setup and expand the database

I want to be able to add a theory and its details

#### Iteration: 2

**Justification:** This includes the functionality that lets researchers add learning theories (Figure 2) with their information to the database. This helps educators and third parties analyze the learning theory's relationship to other concepts, such as assumptions and practices.

#### 4. Feature/Points: Add Assumption/1

As a site owner

So that I can help build, setup and expand the database

I want to be able to add an assumption and its details

#### Iteration: 2

**Justification:** This includes the functionality that lets researchers add assumptions with their details to the database. This helps educators and third parties analyze the learning theory's relationship to assumptions.

#### 5. Feature/Points: Add Practice/1

As a site owner

So that I can help build, setup and expand the database

## IDEALS

New theory

Name

Description

B I S O T " < > :=

Select Assumptions

learning occurs within a zone of proximal development (ZPD)

learning requires cognitive dissonance

Figure 2: Adding a Theory

I want to be able to add practice and its details

**Iteration:** 2

**Justification:** This includes the functionality that lets researchers add practices with their information to the database. This helps educators and third parties analyze the learning theory's relationship to practices.

6. **Feature/Points:** Update Practice/1

As a site owner

So that I can improve the knowledge content of the database

I want to be able to edit the name and description for a practice

**Iteration:** 2

**Justification:** This includes the functionality that lets researchers update practices along with their name, description and connections.

7. **Feature/Points:** Update Assumption/1

As a site owner

So that I can improve the knowledge content of the database

I want to be able to edit the name and description for an assumption

**Iteration:** 2

**Justification:** This includes the functionality that lets researchers update assumptions along with their name, description and connections.

8. **Feature/Points:** Update Theory/1

As a site owner

So that I can improve the knowledge content of the database

I want to be able to edit the name and description for a theory

**Iteration:** 2

**Justification:** This includes the functionality that lets researchers update theories along with their name, description and connections.

9. **Feature/Points:** Initial Object Selection/2

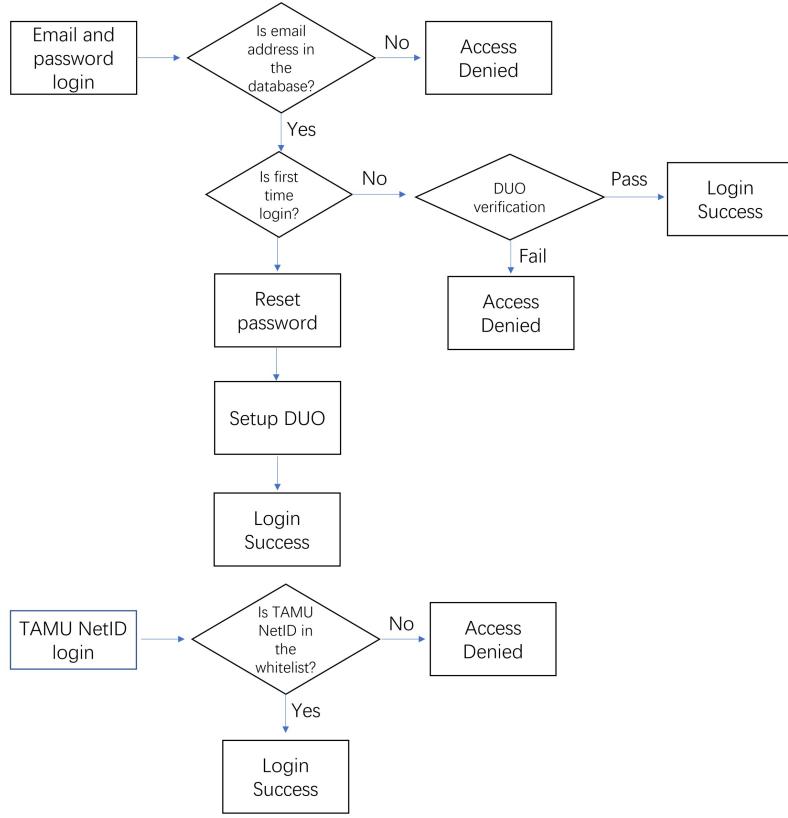


Figure 3: Auth Flow. **Note:** Because TAMU NetID login already required DUO, when the user login with TAMU NetID, it will not be required to setup DUO again.

As an end user

So that I can see all of the connections to a particular object

I want to choose an object from the home page and get a connections page

#### Iteration: 2

**Justification:** In the user interface design of our platform, we have incorporated a feature that allows a user to access specific concepts within a chosen category, namely theory, assumption, or practice. Upon selecting a concept category, the user is redirected to a page displaying a comprehensive list of concepts falling under that particular category. The user can click on a specific concept for a more detailed examination. This clicks action triggers the display of the individual concept, as illustrated in Figure 4. The sequence diagram, delineating the flow of this interaction, is depicted in Figure 5. It is crucial to note that this feature constitutes part of our platform's 'open flow'. This means authorized and unauthorized users can view and interact with learning theories and their associated assumptions/practices. This open-access approach underscores our commitment to fostering an inclusive and interactive learning environment.

#### 10. Feature/Points: Database Relationships/2

As a developer

I want to access the relations between objects

So that I can retrieve links

#### Iteration: 2

**Justification:** This includes the functionality that will establish the association for theory, assumption, and practice, which theories could link with assumptions, and assumptions could link with theories and practice.

#### 11. Feature/Points: Remove Sidekiq from production deployment/1

As a developer,

So that I can execute the app within memory limits,

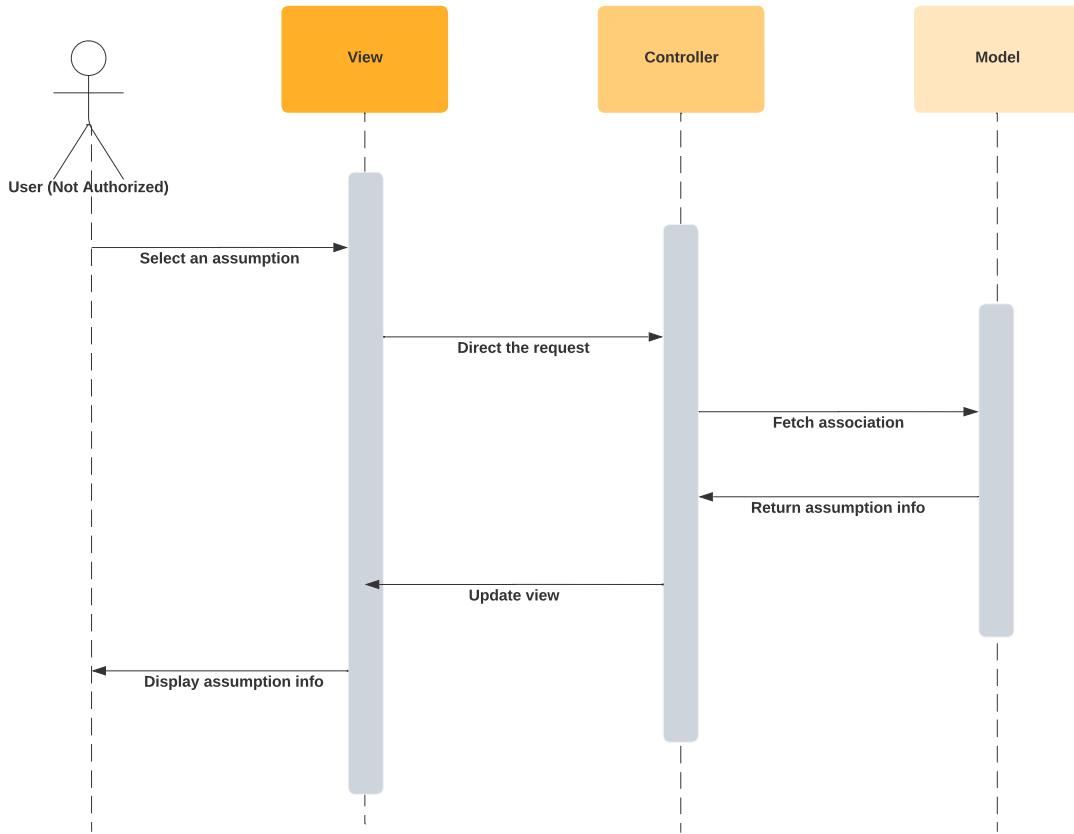


Figure 4: Initial Concept Selection Flow

I want to remove Sidekiq and multiple workers.

**Iteration: 2**

**Justification:** Removing Sidekiq and multiple workers is essential for optimizing application performance by reducing resource consumption on servers with limited resources such as RAM. This step ensures efficient use of server capacity while maintaining optimal response times for users' requests in production environments.

#### 12. Feature/Points: User registration/3

As a new user

So that the system can remember me and my data

I want to register by creating a username and password

**Iteration: 3**

**Justification:** This includes the functionality that Gives a new user to sign up by entering a username and password and clicking sign up. The user successfully registers and can log in with the chosen credentials. However, we disabled this feature later as the client requested not to allow external users to have update permissions for concepts.

#### 13. Feature/Points: User Login/2

As a registered user

So that the system can authenticate me and I can trust it

I want to log in with my username and password

**Iteration: 3**

**Justification:** This includes the functionality (figure 6) that the user has the credentials can log in to the web page by entering the username and password. Unfortunately, we do not allow self-registration through Auth0, so users are created through invitation only. However, this was

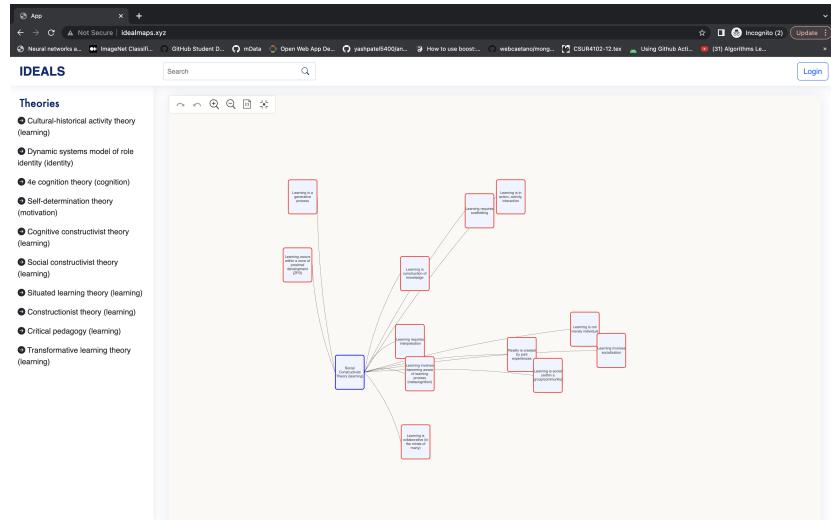


Figure 5: Initial Concept Selection (all theories are listed on the left panel)

requested by the client, and due to the limited number( $< 10$ ) of active users available, this approach is much more efficient. Furthermore, diagram 3 shows the flowchart associated with user authentication and authorization.

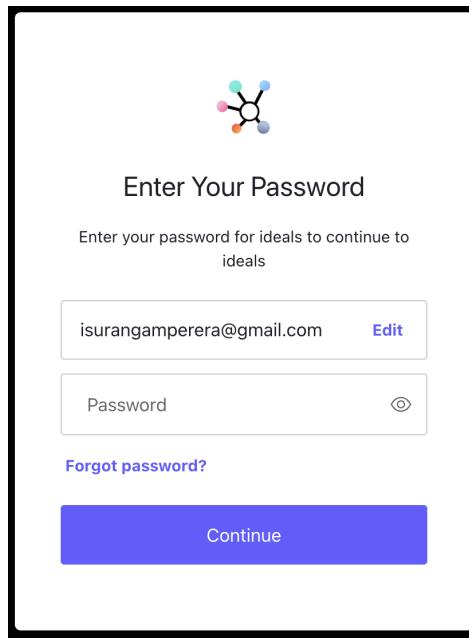


Figure 6: Output of **User Login** User Story

#### 14. Feature/Points: Integrate PostgreSQL for production/1

As a developer

So that I can persist and manage customer data

I want to integrate PostgreSQL

**Iteration:** 3

**Justification:** Using PostgreSQL as the production database will ensure a more dependable and expandable approach to managing customer information. Transactional processing and backup and recovery functionalities are among the more sophisticated data handling features it supports. Data integrity and availability are key factors for maintaining a productive environment.

15. **Feature/Points:** Display Option of Theory and Practice for connection/3

As a site owner

So that I can select theories and practice to connect with assumptions

I want to be able to see a list of valid selectable theories and practice

**Iteration:** 3

**Justification:** The relationship between assumptions and their corresponding learning theories and practices is a critical aspect of understanding the dynamics of the learning process. To address this, the proposed system incorporates a feature that allows users to effectively associate a new assumption with relevant learning theories and practices. As illustrated in Figure ??, this user story facilitates the efficient management of these connections. By enabling users to seamlessly select and link all related theories and practices to a specific assumption, the system promotes a comprehensive understanding of the underlying interdependencies. This functionality not only streamlines the process of curating and organizing learning-related content but also fosters a more in-depth exploration of the complex relationships among assumptions, theories, and practices within the field of learning.

The screenshot shows a user interface titled "IDEALS". A sub-section titled "New assumption" is displayed. It contains a "Name" input field with a placeholder, a "Description" input field with a rich text editor toolbar (containing icons for bold, italic, underline, etc.), and two sections for selecting "Theory" and "Practice". Each section has a title and a list of checkboxes for different models or concepts.

Select Theory
<input type="checkbox"/> Cultural-Historical Activity Theory (learning)
<input type="checkbox"/> Dynamic Systems Model of Role Identity (identity)

Select Practice
<input type="checkbox"/> joint or shared experiences
<input type="checkbox"/> concept mapping

Figure 7: Display Option of Theory and Practice for Connection

16. **Feature/Points:** Display Option of Assumptions for connection/3

As a site owner

So that I can select assumptions to connect with theories

I want to be able to see a list of valid selectable assumptions

**Iteration:** 3

**Justification:** This includes the functionality that there is a list of assumptions with the checkbox in the create and edit of theory. The site owner can select any related assumptions for that theory.

17. **Feature/Points:** Research on JS and CSS libraries/3

As a developer

So that I can create a visually interactive concept map

I want to research various Javascript and CSS libraries

**Iteration:** 3

**Justification:** This involved researching existing JS libraries that can support interactive graph visualization. We decided to use the G6 library as it helps dynamic changes and allows more interactivity and easy integration.

18. **Feature/Points:** Research on various testing frameworks for JS/3

As a developer

So that I can implement test-driven development

I want to research various testing frameworks for JS

**Iteration:** 3

**Justification:** This user story involves researching various testing frameworks for the G6 JS library. After exploring multiple testing frameworks like MochaJS, Jasmine, Jest, Karma, Cypress, and NightwatchJS, we have selected Jest as our testing framework.

19. **Feature/Points:** Creating DB backup/1

As a developer

So that I can recover my data in case of failure

I want to backup the DB

**Iteration:** 3

**Justification:** Database backups are essential for disaster recovery and business continuity planning. In case of any system failures or disasters, such as hardware crashes or cyber-attacks leading to loss or corruption of important information stored in databases, regular backups help ensure quick restoration with minimal downtime.

Regularly backing up the database prevents significant losses and ensures smooth functioning without disruptions due to sudden outages caused by unforeseeable events like power cuts etc., which might lead to corrupted files if not saved correctly.

20. **Feature/Points:** View object relationships/3

As an end user

So that I can explore connections

I want to click a connected object on a connections page and get a new connections page.

**Iteration:** 3

**Justification:** This includes the functionality that after the user selects an option with the checkbox from the create or edit page, the user can view it in that object's details page.

21. **Feature/Points:** Cucumber test case for editing theories, assumptions, and practices/2

As a developer

So that I can make the edit page more reliable

I want to have more cucumber test cases that validate the edit page

**Iteration:** 3

**Justification:** Cucumber is an excellent tool for testing web applications, providing end-to-end tests from user interactions with GUI elements down to database operations. Creating additional cucumber test cases validates edge-case scenarios of users interacting with our application's functionality in different ways while ensuring correct implementation throughout usage periods. Adding these new automated tests will give us confidence when deploying features or making changes; this reduces bugs being introduced into the production system.

Moreover, this feature aligns well with good development practice because maintaining high-quality software needs rigorously tested modules/features both during the initial stages and after deployment phases to maintain stable performance over time. Comprehensive unit/integration/test-driven development strategies and automation tools like Cucumbers reinforce high-performance standards within teams working towards building robust enterprise-level solutions.

22. **Feature/Points:** Cucumber test cases for the view page/2

As a developer

So that I can have a robust view page

I want to have cucumber tests to ensure validation of data

**Iteration:** 3

**Justification:** Automated Testing with tools such as Cucumber has become an integral part of modern-day Agile Software Development methodologies due to their ability to improve code quality by identifying bugs early on, ultimately leading to better product satisfaction among users/customers. Incorporating these features ensures high-quality products resulting in reduced maintenance costs over its lifetime.

23. **Feature/Points:** Login with GitHub account/1

As a user

So that I can easily access the platform

I want to log in to my GitHub account using my GitHub credentials

**Iteration:** 3

**Justification:** Given that I am on the login page, When I select the "Log in with Github" option, Then the system should redirect me to Github's website to authenticate my identity. Given that I have been granted access to Github, When I am redirected back to the system, the system should create a new account or log me in with my existing one.

24. **Feature/Points:** Create the production environment/1

As a developer

So that I can allow customers to work with the platform

I want to enable and support the production environment

**Iteration:** 4

**Justification:** Enabling and supporting a robust production environment is essential for delivering high-quality services efficiently while meeting customer needs in real-time. This feature ensures seamless integration of application components within an optimized infrastructure designed for scalability, availability, reliability & security under load conditions- all critical factors towards achieving excellent user experience (UX). Deploying appropriate industry standard tools such as Kubernetes or Docker Swarm significantly enhances performance by automating scaling up/down web containers based on traffic demands while providing fault tolerance through replication rules.

25. **Feature/Points:** Create a new concept map/1

As a teacher/professor

So that I can create relationships between theories and activities

I want to create a new concept map

**Iteration:** 4

**Justification:** The ability of teachers or professors to quickly build visual representations of concepts is an essential component of the project. Creating the functionality for users to generate their own maps allows them greater flexibility when displaying complex ideas through graphic representation rather than just text. This feature will provide users with a valuable tool they interactively use to analyze theories and how they are created. The concept map is an integral part of the project, and the final output of the story is shown in figure 8.

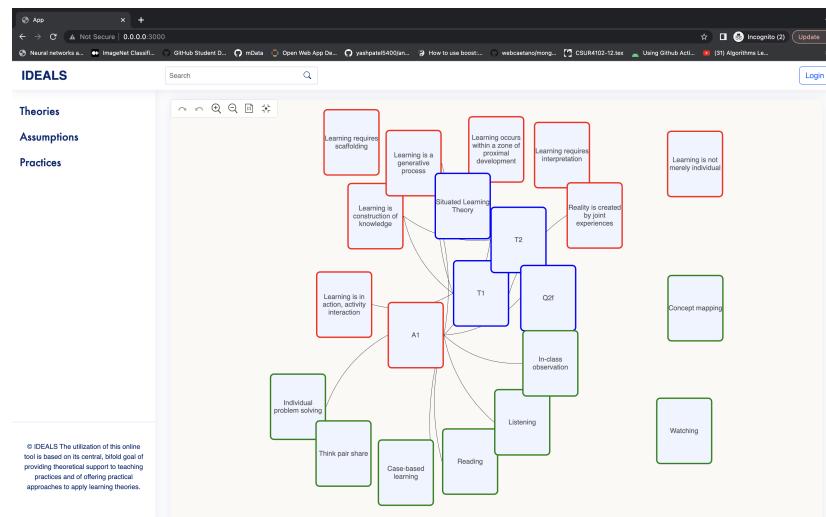


Figure 8: Output of **Create a new concept map** User Story

26. **Feature/Points:** Bring node to the attention/1

As a user

So that I can isolate all its neighbours  
 I want to highlight a node by clicking on it

#### Iteration: 4

**Justification:** Highlighting nodes is an essential feature of data visualization software as it helps users focus their analysis and understand complex relationships between data points quickly. In addition, this feature enhances interactivity within the application by allowing users to select a specific concept and observe all relationships that theory has with other practices and assumptions. Figure 9 shows the story's outcome.

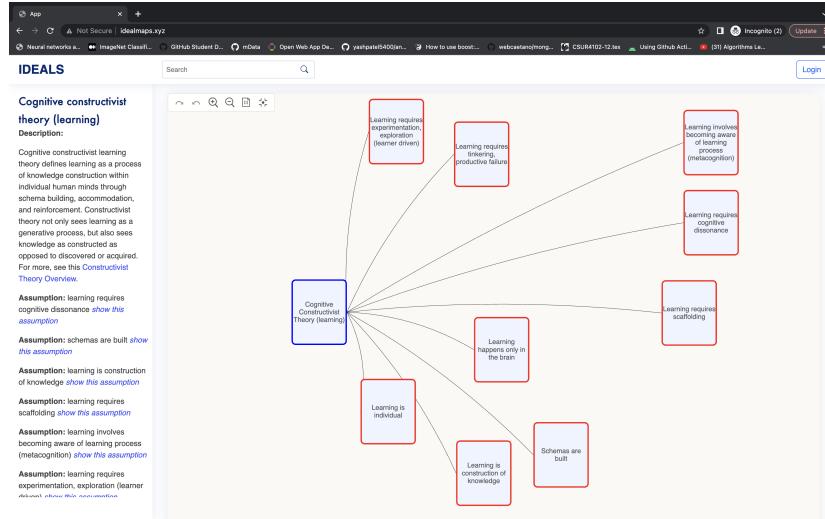


Figure 9: Output of Bring node to the attention User Story

#### 27. Feature/Points: Add support for rich text for the description/3

As a researcher  
 So that I can highlight/format different parts of the description  
 I want to use rich text for the description

#### Iteration: 4

**Justification:** This includes the functionality that the description text box can support more format and highlight of text.

#### 28. Feature/Points: Implement user authorization for creating, updating, and destroying/3

As an authenticated user  
 So that users didn't have permission that they cannot create and update  
 I want to be the author who can create or update theory, assumption, and practice

#### Iteration: 4

**Justification:** This includes the functionality that only the user has the credential that can log into the web page. And then, the user can create, edit, and destroy.

#### 29. Feature/Points: Duo Two Factor Authentication/1

As a registered user  
 So that my account is more secure  
 I want to use DUO as a two-factor authentication method when logging in

#### Iteration: 4

**Justification:** Given that I am a registered user and on the log-in page: When I enter my username and password correctly and click login, the system should prompt me to enter a code generated by DUO on my registered device. Given that I am a registered user and on the log-in page: When I enter my username and password correctly but fail to enter the correct DUO code, the system should display an error message that the code is invalid. Given that I am a registered user and on the log-in page, the system should provide an alternate way to authenticate my identity when I cannot access my registered DUO device.

30. **Feature/Points:** Search concepts/1

As a Researcher

So that I can search for theories, assumptions and practices and analyze them

I need to have a search method

**Iteration:** 5

**Justification:** In the proposed system, a user-centric functionality has been developed to facilitate seamless searching of learning theories, assumptions, or practices. This feature employs a predictive text algorithm that provides users relevant suggestions based on the entered substrings. As depicted in Figure 10, the visual representation of the search interface is both user-friendly and intuitive. A caching mechanism has been incorporated into the system to enhance the efficiency of the search process. This approach allows storing and retrieving the suggestions from a cached list, eliminating the need for repetitive API calls. Optimizing this feature reduces latency and improves the overall user experience while searching for learning-related concepts within the platform.

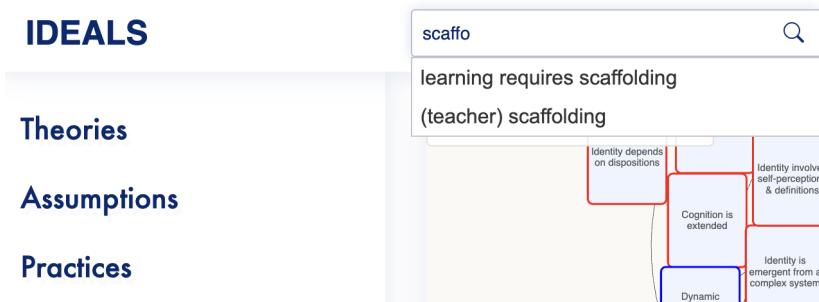


Figure 10: Search Theory/Assumption/Practice

31. **Feature/Points:** Login with TAMU account/2

As a user

So that I can easily access the platform

I want to log in to TAMU account using TAMU credentials

As a developer

So that only specific users can log in by using TAMU account

I want to write some rules for the specific user

**Iteration:** 5

**Justification:** The finalized platform now incorporates a secure and streamlined login functionality (11), utilizing Texas A&M University (TAMU) credentials. This decision was strategically made to leverage the federated authentication system available through TAMU, simplifying the process for both the development team and the client, who are all TAMU account holders. To ensure the integrity and security of the system, a 'whitelist' mechanism has been put into effect. This mechanism limits access to the platform's core functionalities, such as creating, editing, and destroying, to only a specified group of users. By doing so, we have effectively mitigated the risk of unauthorized access and potential misuse while providing ease of access to the designated users. This well-calibrated balance between accessibility and security underscores our commitment to creating user-centric, secure software solutions.

32. **Feature/Points:** Hide add,edit, and destroy link/1

As a user

So that I can hide add/edit/destroy button if the user doesn't login

I want to the user to log in first, and they can do the following actions like add/edit/destroy

**Iteration:** 5

**Justification:** This includes the functionality that the authorized user should log into the web page. Otherwise, the authorized user cannot view and use the path for creating, editing, and destroying the path.

33. **Feature/Points:** Cucumber test for covering missing paths in basic operations/2

As a developer

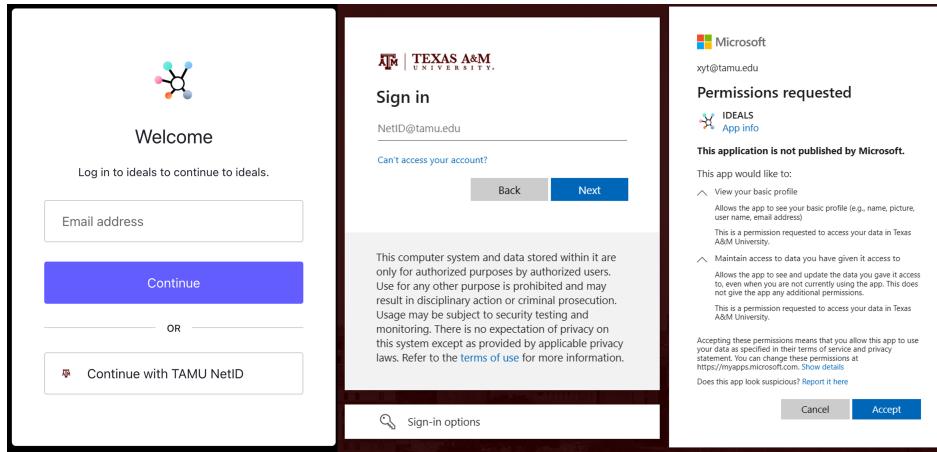


Figure 11: Output of **Login with TAMU account** User Story

So that the application can be reliable

I need to have more cucumber test cases to cover the basic operations completely

**Iteration:** 5

**Justification:** The addition of cucumber tests is essential in ensuring comprehensive and effective testing of all features and functionalities within an application. By adding more cucumber tests for covering missing paths in basic operations, developers ensure greater reliability by detecting any bugs or errors early on, preventing them from being deployed into production mode.

#### 34. **Feature/Points:** Cucumber Test with Authorization/1

As a developer

So that I can ensure proper authorization

I want to have more cucumber test cases that validate the authorization process

**Iteration:** 5

**Justification:** Authorization affects most of the functionalities because only users log in to the web page to which they will have access. Therefore, it will lead most of the functionalities to fail in the cucumber. The team uses selenium techniques for authorization to generate the video to see how the cucumber test fails.

#### 35. **Feature/Points:** Presentation slides/2

As a student,

So that I can present the features and workflow of the website,

I want to prepare slides for proper documentation for future reference.

**Iteration:** 5

#### 36. **Feature/Points:** Final report/3

As a student,

So that I can report all processes associated with the project

I want to prepare the final report

**Iteration:** 5

#### 37. **Feature/Points:** Demonstration video/3

As a student,

So that I can explain the team project to the professor,

I want to record a demonstration video for the project

**Iteration:** 5

#### 38. **Feature/Points:** Presentation video and Final Talk/3

As a student,

So that I can explain the team project to the professor,  
I want to record the presentation video and give a final talk on final exam day.  
**Iteration:** 5

## Team Roles

**James Camp** consistently played the Product Owner role throughout the project. The Scrum Master role, however, was rotated among team members for each iteration to foster a better understanding of the project management process. **Sidharth Anil** spearheaded the initial phase, followed by **Ritika Nigam** for iteration 1, **Chonglin Zhang** for iteration 2, **Yuntao Xie** for iteration 3, **Isuranga Perera** for iteration 4, and **Sidharth Anil** reprised the role for the final iteration 5.

Our team instituted structured sprint planning meetings at the onset of each iteration. These sessions were instrumental in determining the backlog, assigning story points to each story, and fostering a collaborative decision-making process. We emphasize pair programming significantly to ensure a thorough review of each task before merging and delivering it, thereby maintaining high-quality output. At the culmination of each sprint, we conducted a retrospective meeting, reflecting on our teamwork, evaluating our performance, and finalizing the stories' completion. This iterative process, punctuated by planning and review, strengthened our collaboration and increased our work's efficacy.

## Scrum Summary

### Iteration 00: Project Design

#### Points Completed: 0

The primary objective of the initial iteration was to engage in discourse with the client to identify critical specifications and delineate the architectural dimensions of the project. This entailed conceptualising the fundamental project trajectory (figure 12) in conjunction with developing user interface (UI) prototypes (Figure 13). Most of these UI mockups remained unaltered throughout the project's lifespan. However, it should be emphasized that the development of specific features was not undertaken during this phase.

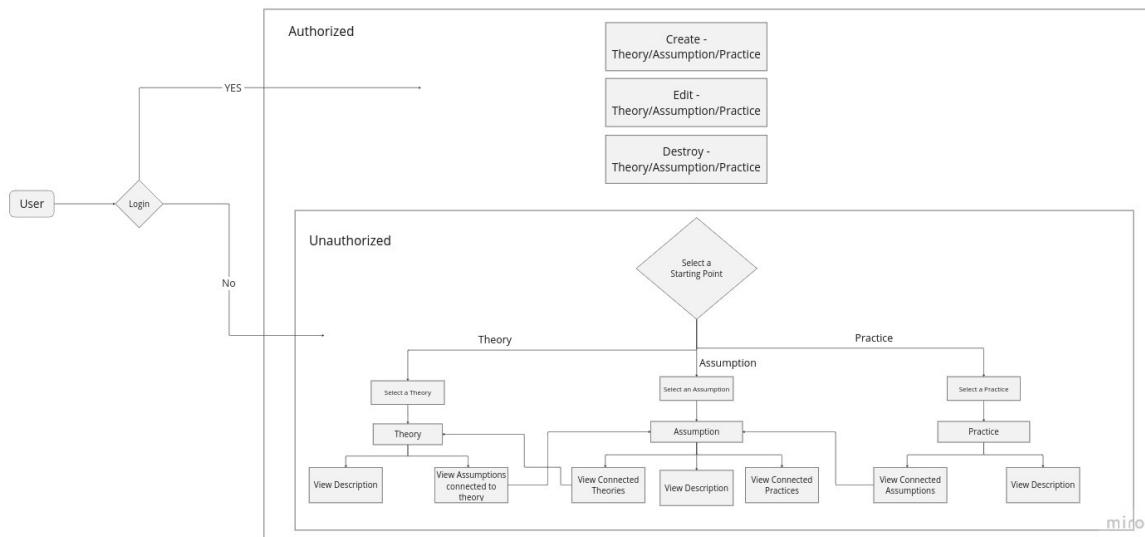


Figure 12: Application Workflow

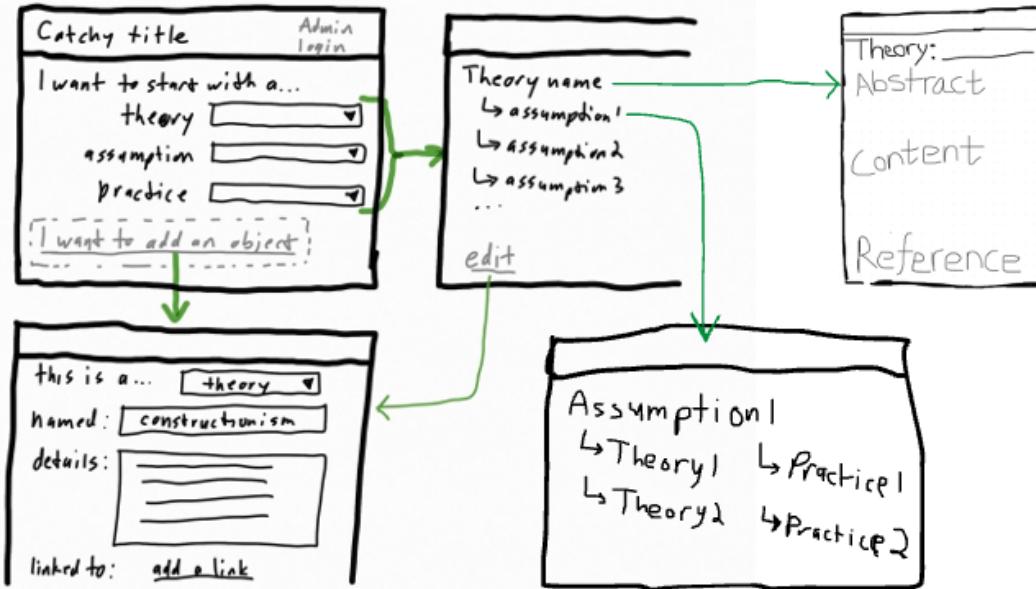


Figure 13: Lo Fi Wireframes

## Iteration 01: Initial Design & CI/CD Pipeline Configuration

### Points Completed: 6

Given this project's novelty, the initial iteration's primary objective was to establish the foundational project structure, configure the Continuous Integration/Continuous Delivery (CI/CD) pipeline, and deploy the preliminary template onto the AWS cloud platform. Given the project's emphasis on graph manipulation and visualization, we prioritized selecting a suitable database and schema design, acknowledging their critical role in the project's success.

By the conclusion of this iteration, we successfully deployed the application on the AWS cloud with the CI/CD pipeline fully configured, laying the groundwork for efficient development and deployment cycles in future iterations. Additionally, substantial progress was made in setting up the database and designing the schema, paving the way for the project's subsequent phases. This solid foundation ensures we can tackle the subsequent development tasks with a reliable, robust infrastructure.

## Iteration 02: Database and Base Functionalities for Theories, Assumptions, and Practices

### Points Completed: 11

In this iteration, the team tried to set up the base functionalities and the database. And then, we successfully designed and developed the add and update functionalities for theory, assumption, and practice, setting up the database correctly and initial object selection.

To add theory, assumption, and practice, the site owner clicks the link "Create a new theory". It should show the name field and description field. After the site owner finished filling in these details and clicked the bottom "Create Theory", this theory would save to the database.

The site owner could modify their details to update theory, assumption, and practice. The site owner could click the link "Edit this theory". The site owner would be on the edit page. The site owner could change and modify the object's name and description, and these changes would be saved in the database when the site owner clicks the "save" button.

For the database part, our team established the association for theory, assumption, and practice, which theories could link with assumptions, and assumptions could link with theories and practice.

For the initial object (theory, assumption, and practice) selection, our team created the homepage displaying the links of three categories: theory, assumption, and practice. When the site owner clicks

the theory link, it will display the list of theories. The site owner could click any link from that list. It will display its name and description.

## Iteration 03: Integrating User Login, PostgreSQL, Testing, and Object Relationships

### Points Completed: 27

In this iteration, one of the highlights is that we have successfully integrated some vital aspects like the user login system for both clients(using the traditional email and password login) and developers (using a third-party Github account with OAuth), making it easy for them to navigate through secured access, using PostgreSQL(Replaced the SQLite used in our development stage) as our database solution has allowed us to create a robust and reliable system for managing data within our production environment. We implement data loss prevention by setting up the database backup process. To implement test-driven development(TDD) with JavaScript coding, our team researched different testing frameworks and various JS/CSS libraries required for creating interactive concept maps.

Also, in this iteration, we implemented a feature that allows users to view object relationships and explore connections between connected objects to enhance the user experience. To ensure data validation and reliability when editing theories, assumptions, and practices or viewing pages, we added Cucumber test cases. The introduction of logging in with GitHub credentials coincided with creating a database backup system for data recovery purposes in case of failure to ensure that data would not be lost and to ensure data integrity.

Last but not least, additional user stories have been included for user authentication that only allows authenticated users to generate new theories, practices and assumptions while updating or deleting existing ones. We edited the user stories to show options for assumptions and practices in connections.

The key objective of this iteration was to enhance user experience, improve data management and ensure that users have a secure and reliable platform to explore and interact with concept maps.

## Iteration 04: Authorization & Concept Map

### Points Completed: 13

In this iteration, we successfully designed and developed the concept map, a cornerstone feature of the project. The initial implementation equips users to inspect various concepts and their interconnections, including but not limited to learning theories, practices, and assumptions. We further enhanced the user experience by implementing a feature to streamline the visualization process, allowing users to focus solely on concepts directly associated with the selected item by hiding unrelated concepts.

In response to client feedback, we extended our services to incorporate rich text support in concept descriptions. This advancement empowers users to create descriptions with formatted text and hyperlinks, adding depth and flexibility to the information presented.

In addition, we accomplished a critical milestone by setting up the production deployment within this iteration. This task encompassed the design of a robust backup method and configuring precompiled assets, thereby mitigating latency and ensuring a smoother, more responsive user experience.

Lastly, we integrated an authorization mechanism supplemented by two-factor authentication. This addition fortifies the application's security, preventing unauthorized alterations to customer data.

## Iteration 05: Project Wrap-up

### Points Completed: 9

During this iteration, we achieved substantial progress by implementing a range of functionalities and making strategic optimizations. We incorporated a search feature that enables users to pinpoint specific theories, assumptions, or practices and observe their relationships with other concepts, enhancing the application's usability. Moreover, we expanded the graph visualization capacity by supporting node expansion, contraction, and deletion, providing users with a more interactive and intuitive interface for their analysis tasks.

Addressing a critical bottleneck in our CI/CD pipeline, we transitioned the process of building Docker images from the AWS EC2 container to Github actions. This strategic shift alleviated memory

consumption issues that occasionally rendered the EC2 instance unresponsive and leveraged the cost-effectiveness of Github actions for public repositories.

In response to specific client requests, we prioritized the integration of federated authentication using TAMU NetID. This addition streamlines the login process, further enhancing the user experience.

Finally, as part of our commitment to delivering high-quality and reliable software, we intensified our efforts to improve cucumber test coverage, successfully increasing it from 91% to 98%. This improvement underscores our dedication to thorough testing and quality assurance.

## Customer Meeting Summary

### Meeting 01: Project Goal & Description

**Date:** 7<sup>th</sup>, February 2023

**Time:** 9:00 - 9:30 AM

**Minutes of the meeting**

1. A productive discussion was held with the client wherein the expectations and limitations of the current solution were thoroughly explored.
2. The client furnished a working draft of the academic paper pertinent to the project and other resources instrumental to its execution.
3. The project timeline was deliberated upon, and clear expectations for deliverables in each iteration were established.

### Meeting 02: Deployment Options Available

**Date:** 21<sup>st</sup>, February 2023

**Time:** 9:00 - 9:30 AM

**Minutes of the meeting**

1. Potential final deployment options were thoroughly discussed, and the client assumed responsibility for inquiring about the specific requirements necessary to host the application on Texas A&M University (TAMU) servers.
2. It was mutually agreed upon that these considerations pertain to the latter stages of the project and will be conclusively decided upon as the project approaches completion. Moreover, the client supported our decision to initiate the application deployment on Amazon Web Services (AWS) in the initial stages of the project.

### Meeting 03: Deployment Options Available

**Date:** 7<sup>th</sup>, March 2023

**Time:** 9:00 - 9:30 AM

**Minutes of the meeting**

1. The client engaged in a detailed discussion with the team regarding the webpage structure. The webpage comprises several pages, including the home page, theory page, assumption page, and practice page. The home page is a gateway, offering links to the theory, assumption, and practice pages. These three pages provide users with the capability to create objects.
2. The client expressed satisfaction with the current iteration of the project.
3. The team also deliberated with the client about the conceptual structure, focusing on the [link to](#) feature. The client highlighted that theories are connected to multiple assumptions, and assumptions, in turn, are linked to practices. It was, however, made clear that theories should not directly link to practices.
4. The client further discussed the user interface with the team. Initially, the client wanted to see the user interface's ability to connect to objects. Once this functionality is confirmed, the client aims to start incorporating data into the user interface. This sequence of operations underscores the iterative and interactive nature of the project's development process.

## **Meeting 04: Feature Requests & Enhancements**

**Date:** 28<sup>th</sup>, March 2023

**Time:** 8:00 - 8:30 AM

**Minutes of the meeting**

1. A demonstration of our project was presented to the client, who expressed that its current state aptly aligned with their objectives.
2. The client proposed specific enhancements to the interface, primarily integrating a larger text box and providing a more comprehensive array of formats for the description field.
3. User authentication was another critical feature requested by the client. The client emphasized that only authorized users should be allowed to create, update, and destroy theory, assumption, and practice objects.
4. Additionally, the client expressed an interest in knowing when they would be able to begin entering data into the system.

## **Meeting 05: Project Feedback**

**Date:** 4<sup>th</sup>, April 2023

**Time:** 9:00 - 9:30 AM

**Minutes of the meeting**

1. A demonstration of the project's progress was conducted, and the client expressed satisfaction with the project's current state.
2. The meeting also facilitated a comprehensive discussion about the prerequisites to be met before the first production version of the application can be delivered. This discussion enhanced the team's understanding of the client's expectations and priorities, which will steer future development.
3. The client also provided constructive feedback on the rich text module, previously requested in an earlier meeting.

## **Meeting 06: Interim Demonstration**

**Date:** 18<sup>th</sup>, April 2023

**Time:** 9:00 - 9:30 AM

**Minutes of the meeting**

1. A meeting was conducted with the client to demonstrate the project's progress and gather the client's insights and feedback. The key highlight of the meeting was the developed visual map, which was met with client satisfaction. In addition, feedback regarding the application's visual elements, such as the color scheme, was provided by the client.
2. The authentication process was demonstrated to the client, supplemented by instructions on how to log into the application.
3. Finally, after implementing security measures, the application was handed over to the client for data addition. Over the week, the client actively engaged with the portal and contributed significantly to the initial mind map data.
4. The client communicated that the decision on the server options for application deployment is still under consideration, with a promise to provide an update on this matter in due course.

## Meeting 07: Final Demonstration & Client Feedback

**Date:** 2<sup>nd</sup>, May 2023

**Time:** 11:00 - 11:30 AM

### Minutes of the meeting

1. In a recent engagement, we had the opportunity to present the final version of the project to the client, which was met with positive feedback. The demonstration also served as a platform to discuss potential enhancements in the UI/UX, which will further refine the application.
2. The client provided an update on procuring a server from TAMU to deploy the project. In addition, he requested comprehensive instructions to assist in this deployment process, highlighting the importance of a smooth transition.
3. Notably, the client expressed high satisfaction with the final project and expressed interest in acknowledging our contribution to the research paper involving the platform we developed by offering to include us as co-authors.

## BDD/TDD Process

Our development team followed a comprehensive Behavioral-Driven Development (BDD) and Test-Driven Development (TDD) approach to ensure our platform's successful and efficient development. This method emphasizes early and consistent collaboration with the customer, rigorous testing procedures, and iterative development to ensure that the final product aligns perfectly with the customer's expectations. Our approach employs a range of tools, including Cucumber for BDD, RSpec and Mocha for TDD, and Ruby and JavaScript for the development of the application. In the following plan, we detail the steps of our BDD/TDD approach, illustrating our commitment to delivering robust, high-quality software that meets the precise needs of our clients.

### 1. Collaboration with the Customer

Our development cycle begins with in-depth discussions with the customer to understand their requirements. This ensured that we were aligned with their vision and understood their needs accurately.

### 2. Feature Analysis and Scenarios

Following the discussions with the customer, we analyzed and outlined the features that need to be developed. Each feature was broken down into user stories and scenarios, forming our BDD approach's basis. We used Cucumber for this stage, leveraging its Gherkin syntax to write precise, understandable specifications for each scenario.

### 3. Creating Test Cases

With the scenarios clearly outlined, we created test cases for each one. These test cases were written in a 'given-when-then' format to ensure they were clearly defined and could be understood by all team members and the client.

### 4. Developing Tests

Once the test cases were ready, we started developing the tests using RSpec for Ruby-based components and Mocha for JavaScript components. These tests initially failed because we followed a TDD approach where tests are written before the code.

### 5. Development & Refactoring

After the tests had been written, we started developing the actual code to make these tests pass. This ensured that our code aligned with the customer's requirements and that all scenarios were covered. After the tests passed, we refactored the code to ensure it was clean, maintainable, and efficient.

### 6. Repeat

This cycle of discussing requirements, outlining scenarios, creating test cases, developing tests, and writing code was repeated for each feature. This ensured that we aligned with the customer's requirements and that our code was thoroughly tested and maintainable.

## 7. Continuous Integration

Throughout this process, we used a continuous integration system. Each code commit will trigger the test suite to run, ensuring no changes haven't broken existing functionality. This allowed us to catch and fix any issues early in the development cycle.

## 8. Review & Feedback

After each iteration, we reviewed our process, seeking feedback from the customer and learning from our experiences. This allowed us to continuously improve our practices, ensuring we deliver high-quality, well-tested software that meets the customer's requirements.

This BDD/TDD plan provides a structured approach to software development that prioritizes collaboration, customer input, and thorough testing, ensuring we deliver high-quality, reliable software that aligns with the customer's vision.

## Challenges

While implementing our BDD process, we encountered several challenges that demanded complex solutions. One of the most notable was the development of tests for endpoints necessitating authorization. The complexity of this task was further exacerbated by utilizing an external Identity provider to manage access. In addition, the presence of this external component introduced a layer of complexity in the creation of mock objects during the design of our tests.

In addition, another challenge arose in the form of using Mocha for the design of JavaScript function tests. Including certain JavaScript libraries in our project via Rails Webpacker complicated the test-writing process. Specifically, we needed to adjust the configuration of the web packer to support library transpilation during the testing phase. This intricate aspect demanded a more nuanced approach to our usual testing methodology.

## Test Coverage

Through the diligent implementation of our testing methodology, we attained substantial test coverage across multiple facets of our project, as shown in figure 14. Cucumber tests, instrumental in our BDD process, achieved an impressive coverage of 98.36%. These comprehensive results are publicly accessible for review<sup>1</sup>.

All Files ( 98.36% covered at 3.57 hits/line )							
File	% covered	Lines	Relevant Lines	Lines covered	Lines missed	Avg. Hits / Line	Search:
app/controllers/application_controller.rb	75.00 %	23	8	6	2	6.25	
app/controllers/auth0_controller.rb	95.00 %	47	20	19	1	3.95	
app/controllers/assumptions_controller.rb	100.00 %	77	36	36	0	2.31	
app/controllers/concerns/securer.rb	100.00 %	15	7	7	0	1.29	
app/controllers/main_controller.rb	100.00 %	4	2	2	0	1.00	
app/controllers/map_controller.rb	100.00 %	26	10	10	0	24.80	
app/controllers/practices_controller.rb	100.00 %	72	35	35	0	2.03	
app/controllers/theories_controller.rb	100.00 %	75	36	36	0	2.28	
app/controllers/user_controller.rb	100.00 %	15	8	8	0	1.00	
app/helpers/application_helper.rb	100.00 %	4	1	1	0	1.00	
app/helpers/assumptions_helper.rb	100.00 %	4	1	1	0	1.00	
app/helpers/map_helper.rb	100.00 %	4	1	1	0	1.00	
app/helpers/newobjects_helper.rb	100.00 %	4	1	1	0	1.00	
app/helpers/practices_helper.rb	100.00 %	4	1	1	0	1.00	
app/helpers/theories_helper.rb	100.00 %	4	1	1	0	1.00	
app/models/application_record.rb	100.00 %	5	2	2	0	1.00	
app/models/assumption.rb	100.00 %	8	5	5	0	1.00	
app/models/practice.rb	100.00 %	7	4	4	0	1.00	
app/models/theory.rb	100.00 %	8	4	4	0	1.00	

Figure 14: BDD Test Coverage

<sup>1</sup><https://reports.cucumber.io/reports/5eb1371d-343e-4795-a897-e0c5f1bcd08e>

In addition to this, our implementation of RSpec, key in our TDD strategy, also reached a commendable coverage of 97.19% (figure 15). We are particularly proud to report that our JavaScript tests, driven by the Mocha framework, yielded an impeccable coverage of 100%.

All Files ( 97.19% covered at 2.01 hits/line )							
File	% covered	Lines	Relevant Lines	Lines covered	Lines missed	Avg. Hits / Line	Search: <input type="text"/>
app/controllers/main_controller.rb	0.00 %	4	3	0	3	0.00	
app/controllers/auth0_controller.rb	90.00 %	47	20	18	2	1.05	
app/controllers/application_controller.rb	100.00 %	23	8	8	0	11.00	
app/controllers/assumptions_controller.rb	100.00 %	77	36	36	0	1.97	
app/controllers/concerns/secured.rb	100.00 %	15	7	7	0	1.43	
app/controllers/map_controller.rb	100.00 %	26	10	10	0	1.00	
app/controllers/practices_controller.rb	100.00 %	72	35	35	0	1.89	
app/controllers/theories_controller.rb	100.00 %	75	36	36	0	1.92	
app/controllers/user_controller.rb	100.00 %	15	8	8	0	1.00	
app/models/application_record.rb	100.00 %	5	2	2	0	1.00	
app/models/assumption.rb	100.00 %	8	5	5	0	1.00	
app/models/practice.rb	100.00 %	7	4	4	0	1.00	
app/models/theory.rb	100.00 %	8	4	4	0	1.00	

Figure 15: TDD Test Coverage

## Configuration & Release Management

### CI/CD Pipeline

Our project's initial deployment strategy was predicated on using Heroku to support application development. However, upon extensive client consultation, we discovered that our client strongly preferred hosting the application on a TAMU server.

This presented a unique challenge, as securing a TAMU server for our project was expected to be time-consuming. As such, we required an interim solution that could closely emulate the environment of the TAMU server, allowing us to continue our development process effectively.

Another constraint we grappled with was the limited memory offered by the free tier of Heroku, which caps at 512MB. For our application, which is both data and resource-intensive, this posed a potential limitation on its performance and scalability.

In pursuing a solution, we evaluated several cloud providers, including Amazon Web Services (AWS), Google Cloud Platform (GCP), Oracle Cloud Infrastructure (OCI), Microsoft Azure and Alibaba Cloud. These providers offered superior resource provisions compared to Heroku, thus making them attractive alternatives. Furthermore, the generic nature of these cloud providers allowed us to evade vendor lock-in, a scenario where reliance on a specific platform makes transitioning to another service exceedingly difficult. This was an essential consideration as it would allow us to easily switch providers, ensuring our project remained adaptable to changing circumstances.

In our updated Continuous Integration/Continuous Deployment (CI/CD) pipeline (figure 16), we leveraged GitHub Workflows and AWS EC2. This approach offered greater flexibility and ensured our readiness to transition to the TAMU servers. By simply updating the computing instance's SSH key in our current configurations, we could easily move from AWS to TAMU servers, thus further underscoring the adaptability of our revised deployment strategy.

### Development Pipeline

Upon the completion of work on a specific feature or bug on a new branch, the responsible developer would initiate a pull request (PR) from the feature branch to the main branch. This action triggers our development pipeline, ensuring the proposed changes undergo rigorous testing before merging into the main codebase.

GitHub Actions underpin the pipeline, and upon initiating a pull request, a GitHub Action<sup>2</sup> is triggered to create a container, merge the PR into the main branch, and execute a suite of tests.

<sup>2</sup><https://github.com/Proj-IDEALS/ideals/blob/main/.github/workflows/development-pipeline.yml>

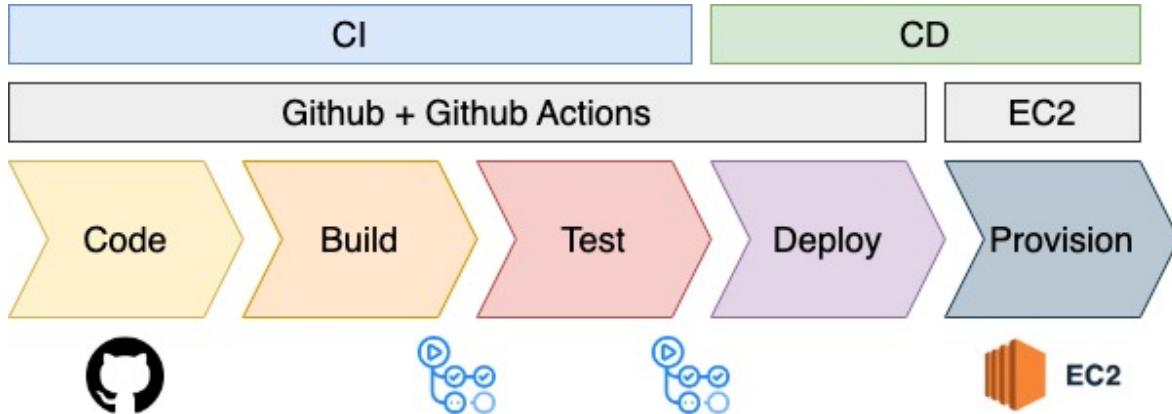


Figure 16: CI/CD Stack for Development and Release

These tests verify that the changes proposed in the PR do not introduce any breaking changes or disrupt existing functionalities.

After the successful completion of automated testing, the PR is reviewed by another member of the development team. This additional layer of review provides an opportunity for knowledge sharing and promotes a shared understanding of the codebase across the team. Upon approval, the PR is merged into the main branch, signifying that the feature or bug fix has been successfully integrated into the project.

### Release Pipeline

In our commitment to maintaining a streamlined and efficient development process, we have automated our release process. Typically, a release is generated at the end of each iteration, representing a stable version of our application that incorporates the changes and enhancements made during the given iteration.

The release process is initiated by tagging a release, which triggers a GitHub Action to commence the release workflow<sup>3</sup>. This workflow performs a comprehensive suite of tests on the code in the repository and conducts a trial build. This critical phase ensures the release is thoroughly validated and no inconsistencies or errors have been introduced.

Provided the tests and build process is successful with no failures, the workflow proceeds to the next step, which involves containerizing the source code. First, the application is packaged into a Docker container, providing an encapsulated and consistent runtime environment. This container is then published to a public DockerHub repository, making it readily accessible for deployment.

Following the successful creation and publication of the Docker container, the workflow establishes a secure shell (SSH) connection to the computing instance earmarked for deployment. Finally, the Docker container is pulled from the DockerHub repository and deployed to this instance, marking the successful completion of the release process.

### Secret Management

Currently, our GitHub actions rely on the following credentials, which are stored as GitHub secrets.

1. **Dockerhub:** Publish application container to Dockerhub
  - DOCKERHUB\_USERNAME - Username for the dockerhub
  - DOCKERHUB\_TOKEN - Password for the dockerhub
2. **AWS EC2** - Container which we host the application
  - AWS\_SSH\_KEY - SSH key to access the EC2 container
  - HOSTNAME - Hostname/IP of the EC2 container
  - USER\_NAME - Username of the EC2 user with minimally required privileges

<sup>3</sup><https://github.com/Proj-IDEALS/ideals/blob/main/.github/workflows/release-pipeline.yml>

## Auth0 Login Configuration

Our project has chosen to use Auth0 as our user authentication and authorization solution. Since, Auth0 provides a secure and reliable platform for user authentication, which is essential for any application that handles sensitive user data. And, Auth0 offers a variety of authentication methods, including social logins and multi-factor authentication, making it easy for users to access our application conveniently and securely. The configuration steps of Auth0 Login are the following.

**Step 1:** Create an Auth0 Account First, you must create an account on the Auth0 website (<https://auth0.com/>). Once you've done that, you can create a new application and retrieve the client ID and client secret you'll need to integrate with your Ruby application.

**Step 2:** Create a new Auth0 application After creating an Auth0 account, you need to create a new application. Go to the Auth0 Dashboard and click the "Create Application" button.

**Step 3:** Configure your application After creating a new application, you need to configure it. In the "Settings" tab, you can set the necessary parameters for your application, such as the allowed callback URLs and the allowed origins. In the application settings page, you can get the following information:

- Domain
- Client ID
- Client Secret

In the "Settings" tab, there are also some important parameters that need to be set:

### Configure Callback URLs

A callback URL is a URL in your application where Auth0 redirects the user after being authenticated. The callback URL for your app must be added to the Allowed Callback URLs field in your Application Settings. If this field is not set, users cannot log in to the application and get an error.

### Configure Logout URLs

A logout URL is a URL in your application that Auth0 can return to after the user has been logged out of the authorization server. This is specified in the returnTo query parameter. The logout URL for your app must be added to the Allowed Logout URLs field in your Application Settings. If this field is not set, users cannot log out from the application and will get an error.

**Step 4:** Edit Auth0 Configuration in IDEALS App Open the Auth0 config file `./config/auth0.yml`

---

```
production:
  auth0_domain: {AUTH0 DOMAIN}
  auth0_client_id: {AUTH0 CLIENT ID}
  auth0_client_secret: {AUTH0 CLIENT SECRET}
```

---

## Deployment & Testing

Please refer to [README](#) for deployment instructions and testing.

## Tools & Gems Used

In our project, we utilized several tools and libraries to enhance the efficiency and effectiveness of our development process.

1. **SimpleCov:** The integration of SimpleCov with Cucumber and RSpec was seamless, providing an efficient solution for continuous coverage assessment. In addition, upon a particular configuration, SimpleCov automatically updated coverage reports each time tests were executed.

The screenshot shows the 'Basic Information' section of the Auth0 'Settings' tab. It includes fields for Name, Domain, Client ID, and Client Secret. The Client Secret field contains redacted text. A note at the bottom states 'The Client Secret is not base64 encoded.'

Figure 17: Auth0 application "Settings" tab

2. **RuboCop:** RuboCop played a pivotal role in maintaining the quality of our Ruby code. RuboCop helped us adhere to the Ruby style guide and other best practices, providing an automated way to ensure our code was clean, efficient, and readable.
3. **Auth0:** Auth0 facilitated secure login and signup processes, and its adoption allowed us to devote more time to core application features. It further offered a variety of identity providers, such as TAMU NetID, thereby ensuring a versatile and user-friendly authentication process.
4. **G6<sup>4</sup>:** G6 provided robust and customizable tools for creating interactive graph visualizations, significantly developing the concept map feature in our application. This allowed us to deliver a visually engaging and intuitive user interface, enhancing the overall user experience.
5. **Nginx:** Nginx provided a critical layer of control and security to our application, managing client connections and forwarding requests to our application servers. This practice increased our application's ability to handle larger traffic loads and enhanced security, provided load balancing, and allowed for more flexibility in our server's configuration.
6. **Selenium:** By employing Selenium for end-to-end testing procedures, we confirmed that our application was functioning properly as viewed by the users, and automating critical user flow tests in a real web browser environment with full JavaScript support was permitted, which led to reduced risk for human error as well as faster test cycle times. Furthermore, Selenium's integration capacities with diverse web browsers allow us to carry out testing procedures for our application across varied platforms resulting in consistent performance when used by the users.

## Production Issues

1. During our project, we confronted a series of challenges pertaining to the deployment of the production environment. One notable obstacle was our usage of Rails webpacker for asset management. Additionally, as the deployment on the production environment necessitated the pre-

<sup>4</sup><https://g6.antv.antgroup.com>

compilation of our assets, we had to navigate this process through trial and error, given the absence of prior experience within the team in this specific aspect.

2. We encountered considerable difficulties related to our initial build process. The process had been configured to run on the Amazon Elastic Compute Cloud (EC2) container, which resulted in substantial memory consumption. This, in turn, led to frequent crashes of the container, as our project was operating on the AWS free tier, which offers a memory limit of 1GB. This constraint posed a significant bottleneck for our development and deployment workflow.

To mitigate the excessive memory consumption issue, we shifted our build process to GitHub Actions, a feature that offers free service for public repositories. This strategic move effectively alleviated the memory strain on our EC2 container while maintaining the integrity of our build process.

In conclusion, while initially daunting, these prominent challenges related to production deployment were ultimately addressed through exploratory learning and strategic reconfiguration of our build process.

## Summary

Over the course of the three-month project duration, we successfully accomplished all functional requirements stipulated by the client. Our adaptable and agile methodology allowed us to incorporate and execute additional features that arose mid-project per the client's request. While minor enhancements in the UI/UX were suggested during our final client interaction, it can be concluded that the project has been successfully completed, meeting and exceeding client expectations. Our efforts were corroborated by the client's affirmation of the project's successful outcome.

## Important Links

1. Presentation & Demo Video: <https://www.youtube.com/watch?v=9gU7nBRN1LQ>
2. Pivotal Tracker: <https://www.pivotaltracker.com/n/projects/2628920>
3. Github: <https://github.com/Proj-IDEALS/ideals>
4. Deployment: <http://idealmaps.xyz>
5. Cucumber Tests: <https://reports.cucumber.io/reports/5eb1371d-343e-4795-a897-e0c5f1bcd08e>