Developing Quality of Life Features for

the E-TRIALS Platform

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Submitted to:

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Abstract

Following the COVID-19 pandemic, the ASSISTments Foundation launched E-TRIALS (EdTech Research Infrastructure to Advance Learning Science) as a tool for researchers to understand different teaching tools and methods, with the goal of understanding how best to provide feedback and assistance to students. In this project, students worked alongside full-time employees in an Agile environment to improve the current E-TRIALS platform. Additions were made to the previous release of the platform, adding in new functionality and improving the overall user experience.

Acknowledgements

I would like to thank everyone who helped me with this MQP. Thank you to Professor Neil Heffernan for providing me with the opportunity to work with The ASSISTments Foundation. Thank you to Angela Kao, for your endless support with all of the logistics surrounding my MQP (and to Oscar for being the most welcome distraction.) Thank you to Hannah Pandolph, for welcoming me into her team. Thank you to Ryan Emberling, for providing guidance and insight. Thank you to Brian Rojas and Kanita Bojagic, for their encouragement and support whenever I was struggling with tasks. Thank you to Aaron Haim and Ethan Prihar Ph.D., for welcoming me into the lab and answering my miscellaneous questions. Thank you to Patrick Spillane, Jin Ryoul Kim, and May Dong, even though our projects were independent, the collaboration and teamwork was invaluable. Thank you to my family, who have supported me and encouraged me to pursue Computer Science, I wouldn't be where I am today without you.

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1.0 Introduction

The prevalence of online learning increased immensely from the onset of the COVID-19 pandemic in spring 2020. Teachers adopted a wide variety of online teaching styles to best address their students' educational needs during a time when remote learning was very new to many students (Barbour, 2021). As a result of the new situation that teachers found themselves in, there were many different successes and failures of online learning that became immediately obvious (Dietrich et al., 2020). In order to better understand how to provide the best virtual education to students, research is conducted to determine the best methods that teachers can use to ensure the students learn effectively, even in a remote environment.

To better meet the needs of such research, the ASSISTments Foundation implemented a method to conduct research on learning that utilizes the education content that is already available at ASSISTments. Altogether, the product allows for the curation of student work and problem sets as well as the creation of research studies. The platform and its services are offered free of charge to teachers and researchers to provide quality learning resources to students and make it more viable for researchers to conduct educational studies.

However, by being committed to offering such a wide variety of services as a platform, this led to issues in the design and structure of the platform itself. For example, creating problem sets using the ASSISTments Builder is not intuitive for new users and can be confusing or intimidating. This is partly due to the overall complexity of the tool but is exasperated due to outdated design implementations.

In recognition of such issues, several student projects came about with the goal of developing the ASSISTments research functionality into a viable enterprise platform that would be able to assist educational researchers to conduct efficiently and effectively. In the beginning

of the lifecycle of the research platform for ASSISTments, a student Major Qualifying Project (MQP), E-TRIALS (Krichevsky, Spinelli, 2020), named the product (E-TRIALS) alongside providing basic designs and prototypes that would aim to improve the usability of the E-TRIALS platform. Further student work, Continuing the Development of E-TRIALS (McCarthy, 2021) looked to improve upon the original designs and had the goal of preparing a minimum viable product. The E-TRIALS product was finally launched in February 2022 with the help of another student project, Preparing the E-TRIALS Minimum Viable Product for Release (Philippo, Spofford, 2022).

Much of the groundwork for E-TRIALS was done in former MQP projects allowing the product to be currently available and in use by researchers. The primary focus for E-TRIALS now is to make improvements to what is an already existing product. The objective of this MQP project is to improve the user experience of E-TRIALS by making quality of life improvements through improving designs, usability, and clarity throughout the E-TRIALS product.

2.0 Background

2.1 The ASSISTments Platform

ASSISTments is an online learning platform that provides practice and assessment tools to teachers that helps them make the greatest positive impact on student learning outcomes. ASSISTments provides many different avenues for teachers to take in regard to their students' educational experience, from creating their own learning content in the ASSISTments Builder or pulling content from certified texts or Open Educational Resource (OER) materials. This content can then be assigned to students through systems that are integrated into ASSISTments, such as Google Classroom or Canvas. When students have completed their assigned work, teachers are provided with detailed reports on how the students performed on the assignment. Educators are then able to use the accrued performance data to make informed decisions on how they present lessons and learning material to their students. ASSISTments can also provide support to students on assignments, such as feedback after problem completion, hints that guide the student to the answer progressively, or common wrong answer feedback that provides feedback for specific errors in a student's answer. These supports aim to address a student's understanding of assigned problems while also serving as a guide for similar problems in the future. The way that ASSISTments is structured created an opportunity to allow researchers to conduct educational studies using real student data that is gathered from teachers' assignments. This research functionality was launched using the ASSISTments platform under the name E-TRIALS.

2.2 E-Trials

E-TRIALS (Ed-Tech Research Infrastructure to Advance Learning Science) is the built-in research functionality for the ASSISTments platform, allowing researchers to conduct studies on learning and education at a larger scale for a lower cost. The goal of these studies is to

determine how students learn best and under what circumstances, to allow educators to provide the most effective educational content to their students. Because the ASSISTments platform is an established product with an active user base, researchers can easily find participants for their studies. The increased feasibility of learning science research as a result of the already established ASSISTments platform allows research to focus on the creation of their studies, rather than who will participate and how they will be deployed.

A basic example of an E-TRIALS study is known as the "Support Comparison", where a given problem set serves as the base of the study, and researchers can create two sets of student supports (hints or explanations) that would be randomly assigned to students completing the problem set. Therefore, when two students complete a problem in the set, they might be given different support for that problem. Once the duration of a study is completed, the researchers receive a performance breakdown of how students performed with each support. At a large scale, research could determine that one type of support was more effective than another at guiding the student to the correct answer. E-TRIALS also offers other types of studies such as "Single Support" and "Problem Varied" studies, which look at providing a single support to students, or varying which problem sets students receive rather than varying the supports they receive. New types of studies will also be coming to E-TRIALS in the future, such as the "Common Wrong Answer" study, which looks at how often a certain wrong answer is given and what type of feedback should be given for such answers.

E-TRIALS handles the finding of participants and the deployment of studies at no cost to the researchers in order to ensure that educational research is accessible to the widest pool of potential researchers. By expanding the pool of potential researchers for learning science studies,

ASSISTments aims to bring forth valuable and actionable research results that can make an impact on real students' learning experience.

2.3 The History of E-Trials

The concept for E-TRIALS began its life in the ASSISTments 1.0 Builder, which is the content creation tool that allows teachers to create problems and problem sets which were to be assigned to students. The builder was also simultaneously used as a tool by researchers for creating the basic studies that one might build on the current implementation of E-TRIALS. This multifaceted nature of the builder meant a level of complexity that did not lend itself to ease of use for researchers in creating useful research studies or to teachers who did not require the complexity of the research tools. The multitude of required features to function as both a content creation tool and a study creation tool resulted in a clogged and somewhat overwhelming overall design for users. The basis of the 1.0 builder design visualized studies as a tree structure, which closely matched the underlying structure of the problem set stored in ASSISTments. As a result of this design pattern, researchers who may not be familiar with tree structures would struggle with creating studies in the 1.0 builder. Researchers that requested help needed to meet with ASSISTments team members, which resulted in an inefficient system that wasted the time of both researchers and internal team members. The goal of alleviating these problems spawned the process of developing the E-TRIALS platform with the help of some student work.

2.4 E-Trials Prototyping

The beginnings of the E-TRIALS platform originated in an IQP by Nicholas Krichevsky and Kamryn Spinelli in 2020 with the main goal of redesigning how studies were built in ASSISTments. This was completed by conducting user research and creating prototypes for what building a study might look like in the new E-TRIALS platform. The students began by creating

different prototypes in parallel which aimed to rework how a study was structured in ASSISTments. The parts that the students deemed most important to change were the documentation, visualization, and content selection of the study build. Wireframe models were constructed to illustrate the flow of how a study is constructed, as depicted in *Figure 1*.
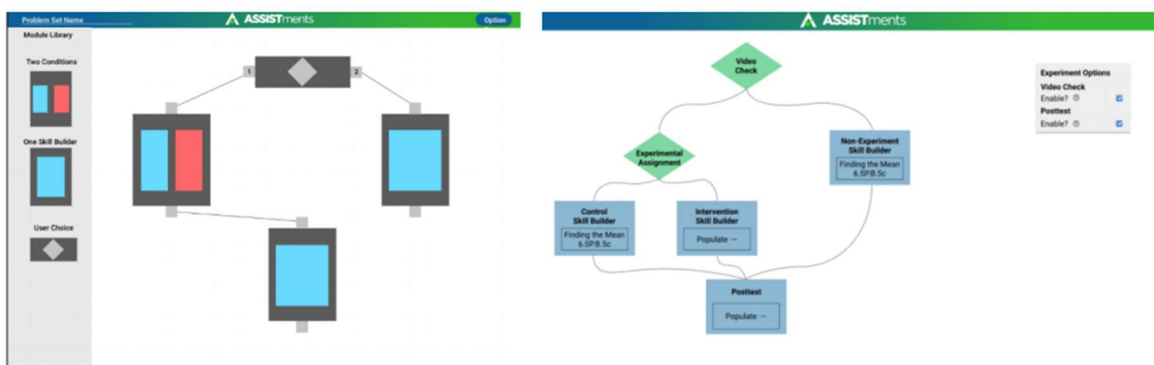
Figure 1: Examples of studies built in Mr. Krichevsky's prototype (left), and Mr. Spinelli's

With prototypes built, the next step was to conduct user testing with ASSISTments team members. The result of such testing found that providing users with too much granular control over the building process was a detriment to the overall study building experience. This informed changes to the final prototype, which represented a unified version of the students' individual prototypes. This final version of the prototype for the E-TRIALS interface (shown in *Figure 2*) was an application built with the Vue.js JavaScript framework and the accompanying Vuetify Material Design framework. At the end of the first IQP project working on E-TRIALS, the basic construction of the user-facing interface was completed, however the project was lacking in functionality that was necessary to make E-TRIALS a reality.
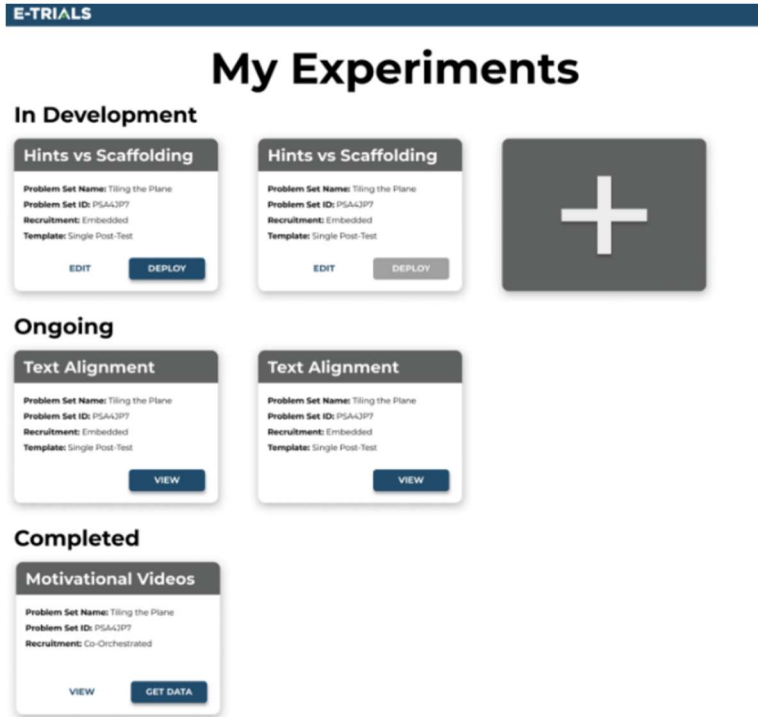
Figure 2: Homepage of the prototype E-TRIALS interface.

2.5 Implementation and Development

Student work on the E-TRIALS project continued in 2021 with an IQP by Timothy McCarthy. Alongside Mr. McCarthy, several software engineers were employed by ASSISTments to continue development of the E-TRIALS platform. The goal of this project was to continue the user-facing work that was done in the 2020 IQP while also constructing the essential backend functionality that was missing from the previous final interface. In accomplishing these goals, the project would move E-TRIALS towards becoming a minimum viable product.

The first step for this project was integrating the frontend with a new backend that was created with the help of the E-TRIALS development team. The purpose of this task was to ensure that the data created using the web browser application of E-TRIALS was stored and could be later retrieved again from an external server. Without the implementation of a backend

for E-TRIALS, any of the studies that researchers may have created in their local browsing session would be lost upon the window being closed. A secondary effect of integrating the frontend with the backend would allow for more extensive testing of the application itself. This allows for thorough end-to-end tests that can simulate how a user would interact with the interface, as well as minimize any unforeseen bugs in the codebase of the project. Alongside end-to-end tests, an integrated platform allows for testing with real users that is more interactive and representative of how the platform might be used.

Aside from integrating the interface designed in the initial stages of E-TRIALS, this project sought to simplify ASSISTments studies such that they were easier to understand, build, and use for researchers. In order to more closely align with how researchers might view a research study, the development team made parts of the study to be toggleable in order to break a study down into modules. Using such modules then allowed researchers to create studies exactly how they wanted while still being guided through the study building process. The process to accomplish this improvement involved taking the study data from the frontend and mapping that information to database tables. This mapping followed the conceptual diagram in *Figure 3*.
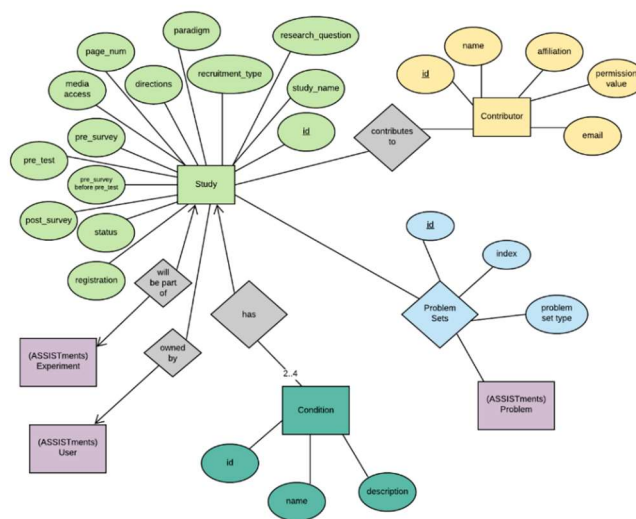

Figure 3: The conceptual diagram for the E-TRIALS tables.

The last major accomplishment of the 2021 IQP project dealt with modifying the content selection process in order to ensure researchers were clear on how education content was being used in their study. In the original design, the content selection process was interrupted by other parts of the study building process, and this would lead to researchers getting sidetracked. This issue was resolved by having researchers immediately associate problem sets with their conditions. This solves the problem of discontinuity in the building process while also familiarizing the researcher with the types of problems in their study, which allows them to better understand how their study should be built. The project also added further functionality to the content selection process by adding filters and metadata about problem sets that would allow researchers to make more informed decisions about what content is included in the study. An example of the project's design for the content selection process is available in *Figure 4*.
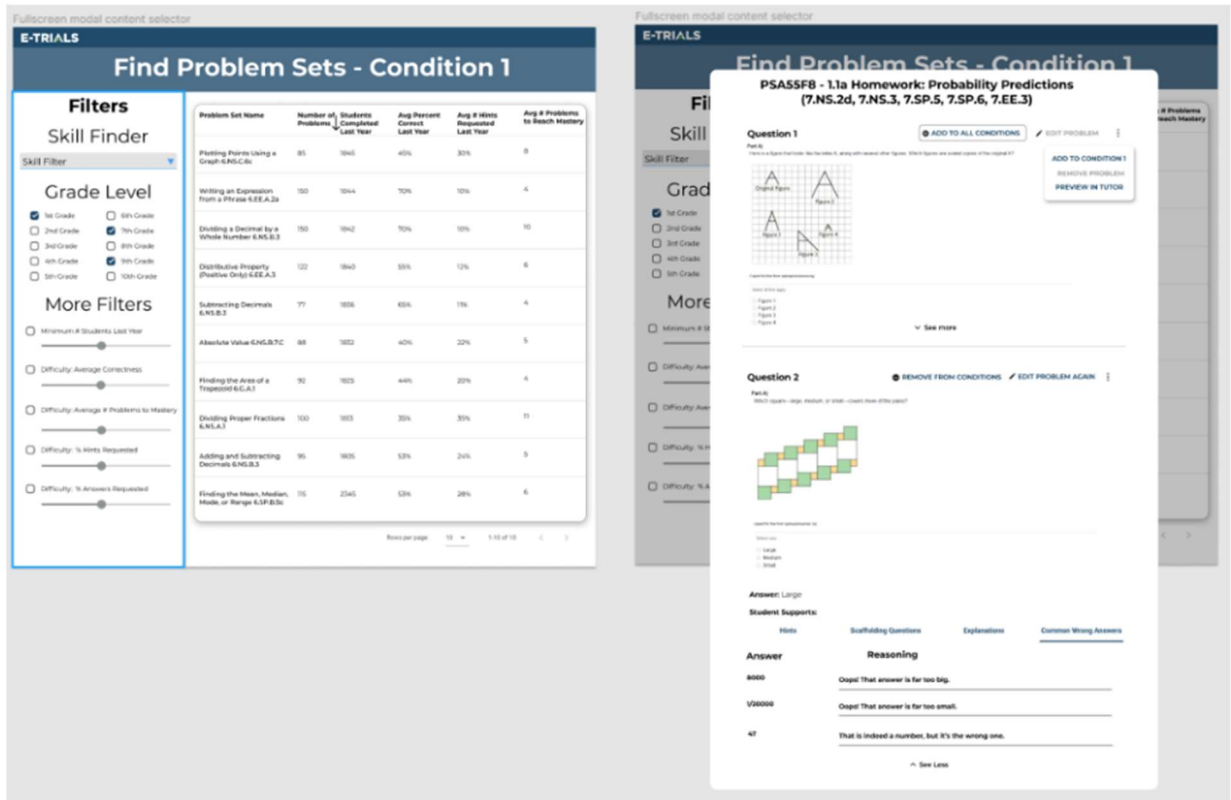

Figure 4: The content selection modals as designed in Figma.

Mr. McCarthy's IQP project took the original design proposed in 2020 and made steps to turn E-TRIALS into a working platform. However, the product was still incomplete, with noticeable gaps for functionality, security, and overall project infrastructure. As a result, more work was required before E-TRIALS could be considered a viable product that could be effectively utilized by educational researchers.

2.6 Platform Launch

In 2022, an MQP project by Edward Philippo and Matthew Spofford continued the work on E-TRIALS with the goal of preparing the platform to be a minimum viable product. The students worked together with the already established E-TRIALS development team to make contributions to the functionality, security, and infrastructure of the product. A successful MQP project would coincide with the launch of the platform in February 2022.

In regard to functionality, the students sought to resolve issues that were hindering researchers in the initial stages of user testing. Many of these functionality changes were related to a platform called the Open Science Frame, or OSF (Center for Open Science, n.d.). The OSF platform allows for sharing research in the scientific community, and E-TRIALS had decided to integrate with OSF using their provided API. The students worked to resolve issues with properly loading study data by validating OSF IDs, as well as ensuring that changes to a study in E-TRIALS were then properly reflected on the OSF platform. In addition to OSF-related issues, the students also contributed to changes in design functionality, such as redesigning the problem set stepper to make it clear to the researcher where they were currently making edits, as well as where they had already made edits. An example of this redesign is shown in *Figure 5*.
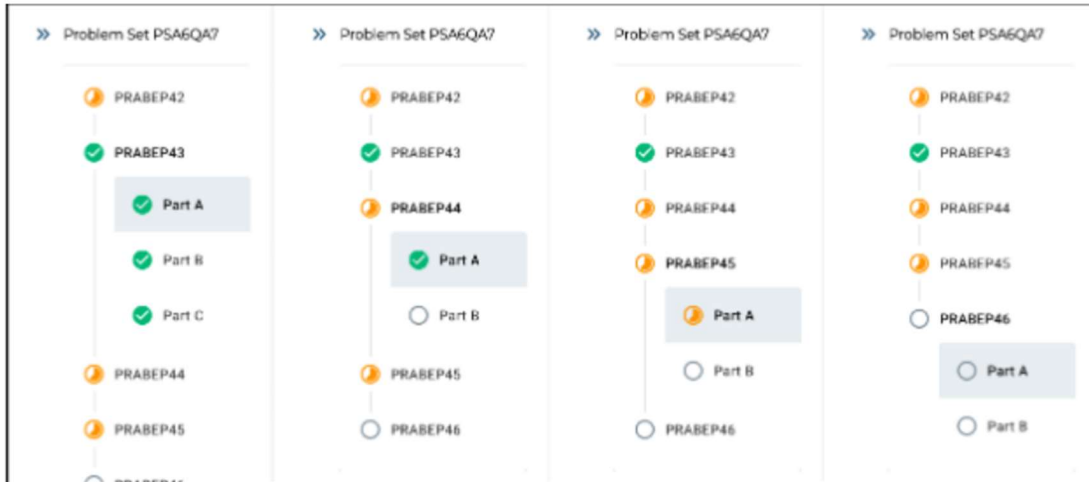
Figure 5: viewing different problems with the problem set stepper.

Another contribution made by this project was ensuring the security of the platform such that researchers could feel confident in the integrity of their studies being published in E-TRIALS. The biggest security issue that the development team had found was that any user could access and make changes to a study if they were in possession of the specific study URL. To address this issue, changes were made to the backend that rejected users from viewing or modifying a study unless they were the owner of the study, and administrators would only be given viewing access. Following this change, it was decided that new role permissions would be put in place that would change how a user or admin could interact with a study depending on the stage of study development. These permissions are shown in *Figure 6*.

Study Phase	Study Owner Actions	Administrator Actions
Development	View, Edit, Remove	View, Edit
Awaiting Approval	View, Edit	View, Edit
Deployment	View	View, Edit
Disseminate	View	View

Figure 6: Authorized actions for study owners and administrators based on the study phase.

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The last major contribution of the students in this project was to make changes to the frontend infrastructure to handle the growing complexity of E-TRIALS as the platform grows larger. This was done by beginning the process of migrating the E-TRIALS frontend codebase to TypeScript, which is a strongly typed programming language that acts as a static type checker for code written in JavaScript (Microsoft Corporation, n.d.). This migration constitutes a significant improvement to the development experience by ensuring strictly defined properties and types that can remove ambiguity in the JavaScript code that makes up much of the E-TRIALS frontend.

By the end of their project in March 2022, both Mr. Philippo and Mr. Sofford had made considerable contributions alongside the E-TRIALS development team which coincided with the launch of the platform earlier in the year. Following this project, the E-TRIALS platform is an up-and-running product that is utilized by researchers to run education studies within ASSISTments. The work going forward will entail making smaller additions and adding features that make sense at this stage in the platform's lifecycle.

3.0 Methodology

3.1 Project Objectives

The E-TRIALS platform is a product that has already been launched and developed over the course of several years and multiple student projects. Moving forward with E-TRIALS, the goal of this project is to make quality of life improvements and changes that are valuable to the researchers that make use of the product every day. This takes the shape of making improvements to the user experience through improving on designs, usability, and clarity through the E-TRIALS platform.

3.1.1 Design

The way that a platform is designed is the most visible part of the overall product and improving on those designs over time is crucial to retaining and growing a user base, thereby facilitating learning science. In E-TRIALS, researchers will spend a significant amount of time at each step of the study building process. This requires that the way each page is designed is updated continuously to reflect how ASSISTments wants researchers to go about creating their study. In this project, several steps of the building process are reworked to better accommodate what a researcher should be thinking about at that time.

3.1.2 Usability

Usability addresses how easily and efficiently a user can accomplish a given task using an interface. Improving upon usability can be done in many ways, from reworking how a task might be done to adding features and information that makes completing the task easier than before. For E-TRIALS, this project looks at making additions with the goal of making a researcher's life easier by giving them greater agency over the study building process and easier access to available information.

3.1.3 Clarity

An important goal for any product should be to ensure that the user completely understands the result of each action they carry out. In this project, improving clarity means making small changes that make it clear to the user exactly what choices they can make at all steps of the study building process as well as providing them with sufficient information to make those choices deliberately.

3.2 Project Workflow

In this MQP project, a small group of students worked loosely together alongside a group of full-time employees to make updates and additions to the currently running E-TRIALS platform. The project development environment was structured using the Agile Scrum methodology, in which tasks were assigned to be completed within two-week periods called "sprints". On the last day of a sprint (typically a Friday), the team would meet to discuss how each member had handled their assigned work for the previous sprint, as well as determining what tasks they could start on in the following sprint. The tasks that are assigned to the development team are given by Ms. Hannah Pandolph (E-TRIALS Product Owner) and Mr. Ryan Emberling (Director of Engineering at ASSISTments). The tasks that are assigned to all team members are organized and visible on Jira, an issue and project tracking software. Using Jira, all the information that is pertinent to any given task is available to all members of the project development team, from who the task is assigned to, the progress of the task, details, comments made, as well as any tasks that are related. As a staple of the Agile methodology, the team met in the mornings several times a week for "standup" meetings, where the team members discussed what they were currently working on as well as providing a place to discuss any questions or issues that they might be having with their assigned work. Team communication

was completed remotely by making use of tools like Zoom and Slack for quick meetings and general correspondence throughout the course of the project. The code that is created by the development team was shared via the ASSISTments Github organization, which contains the collection of repositories that were necessary for developing code alongside the team for E-TRIALS.

As mentioned previously in this report, the structure of E-TRIALS is composed of the frontend and the backend. The frontend constitutes the user-facing side of E-TRIALS, which is the user interface that is built using the Vue.js framework. Using the Vue framework adds additional tools to the standard HTML, CSS, and JavaScript which allows the E-TRIALS team to create an aesthetically pleasing and easy to use user experience. In turn, the content that populates this user-facing component is the backend, which is built using Java and the Spring framework. The backend serves and stores E-TRIALS data in a PostgreSQL database. For the deployment of the E-TRIALS platform, the frontend and backend are hosted using Amazon Web Services (AWS).

4.0 Results

At its current state, E-TRIALS attempts to have consistency across the various elements on a page, and across the various types of studies. By using Vuetify, which takes elements from Material Design to create simple yet elegant interfaces, E-Trials is able to achieve a clean and consistent look. However, because of the nature of rolling out a Minimal Viable Product (MVP) and then returning to make quality of life edits, oversights are made because the priority is functionality. Now that the MVP has been released, there is time to focus on the usability and visual components of E-TRIALS.

4.1 Uniformity and Visibility

On a platform, it is important to have a consistent and uniform layout for users. This makes pattern recognition easier and enables users to easily find what they are looking for. Uniformity can be visible across multiple screens, but it is just as critical for different elements on the same screen. This can be seen on the Overview tab of a new study. The original design had multiple user inputs, but the sizes of each input box were completely unique. Additionally, the paragraphs below had an entirely different breakpoint from either of the input boxes. Following the UI changes to account for the variability in the layout, there is a much cleaner and more consistent look within the application, as seen in *Figures 7 and 8*.
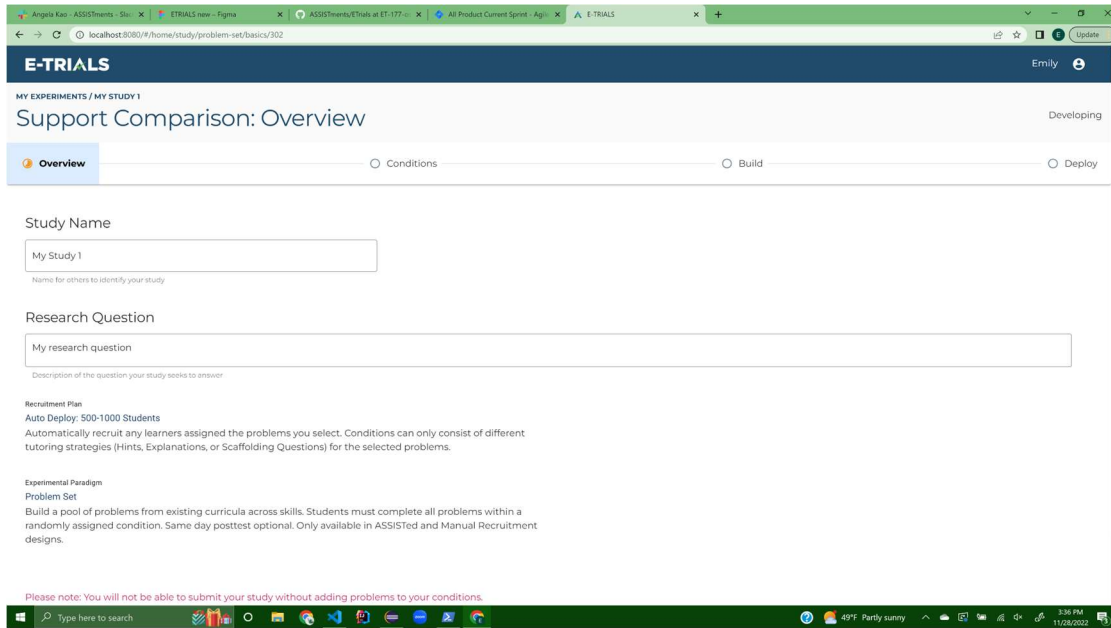
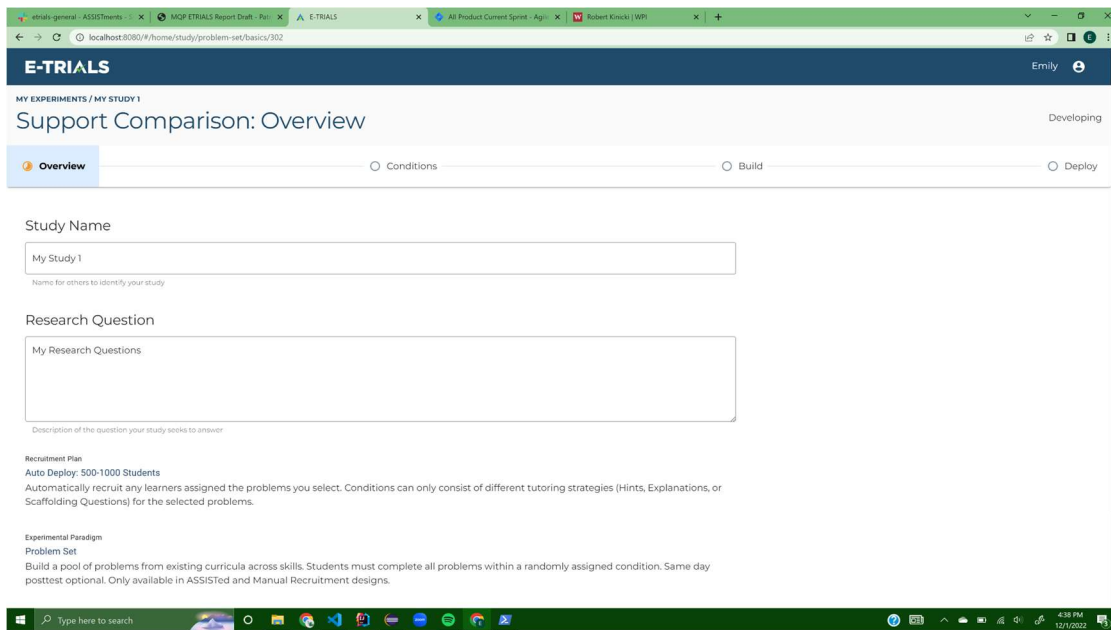*Figure 7: The layout of the Overview page before ET-203*

Figure 8:The layout of the Overview page after ET-203.

Visibility issues can occur when divs are not nested properly, causing unwanted or unexpected reactions. The Buildplace Stepper, which acts as a table of contents for the questions in a set, is expected to be always seen by the user. If a user were to scroll down on the page, the Buildplace Stepper should have been persistent and scroll with the screen. Unfortunately, this

was not accounted for in the initial feature build and needed to be corrected. Following ticket

ET-134, the page operates as expected, and the Buildplace Stepper is always seen, even when the

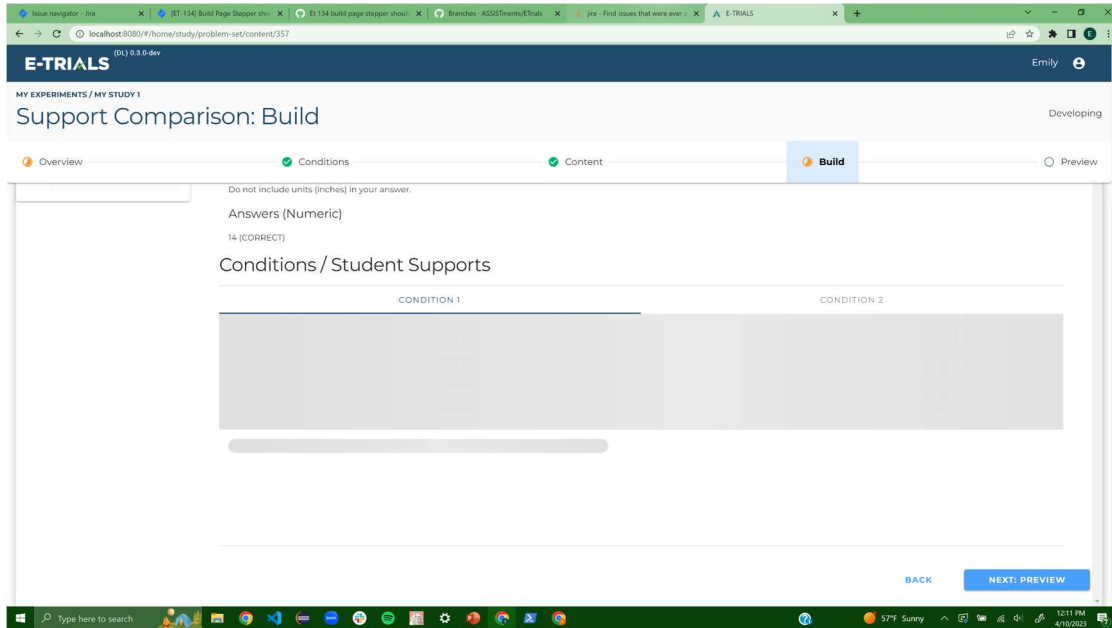user scrolls down. The before and after can be seen below in *Figures 9 and 10*.

Figure 9: The Build page stepper disappearing when scrolling to the bottom of the page.
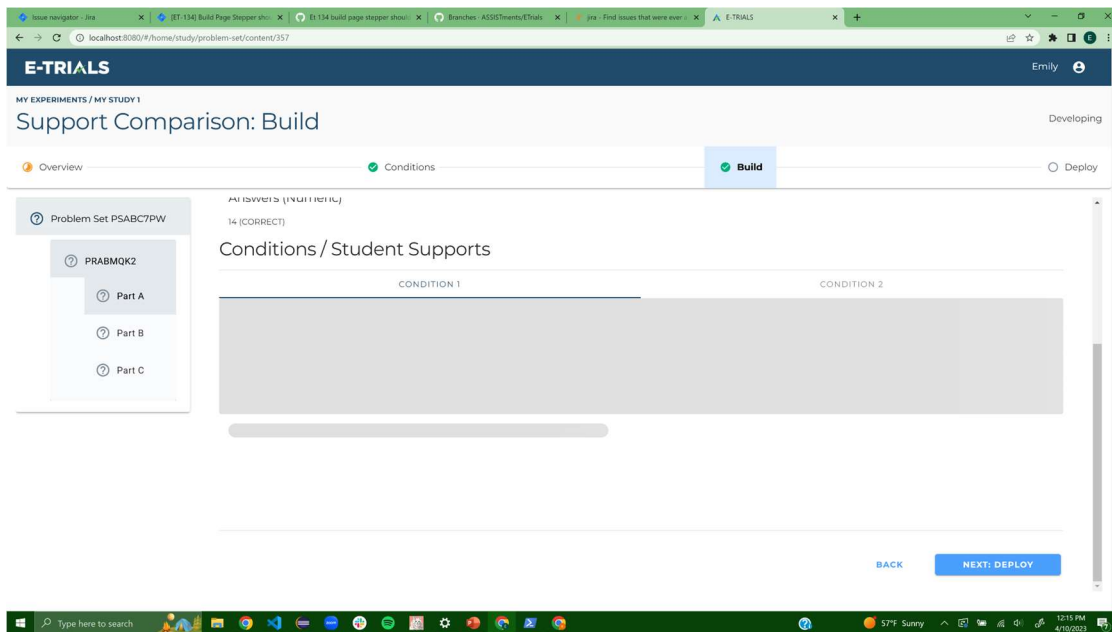

Figure 10: The Build page stepper is now visible when scrolling to the bottom of the page.

4.2 Bugs

Another oversight can occur when forgetting to account for interactions with the elements on the page. These interactions can occur in several ways, including hovering over an element with a mouse, typing in an element, or clicking an element.

One example of this occurred within the hints and explanations messages that appear under questions in a problem set. Before the bugfix, the buttons to edit and delete appeared to be properly sized. However, when a user went to interact with the buttons, it became apparent that the buttons were not properly nested. This caused the ellipse—which indicated that the button was being interacted with—to appear as tall and narrow, rather than uniform and circular around the icon. The bug before and after the fix can be seen below in *Figure 11*.
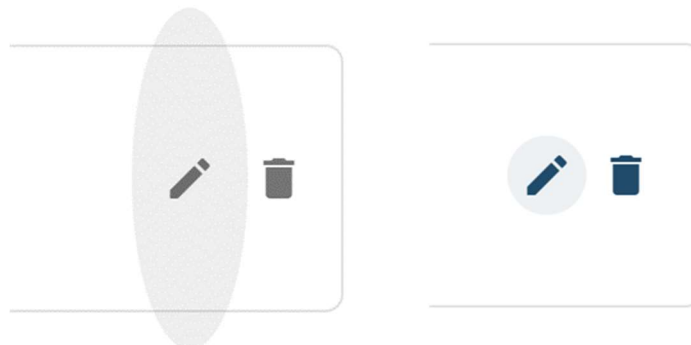
Figure 11: Edit and Delete buttons before and after ET-185

Another issue can occur when certain functionalities are only supposed to be available under specific use cases. It is important to toggle functionality so that features are available where it makes sense, not at all times. For example, a researcher that is currently designing a study should have access to modify or change elements of that study. However, once the study is submitted and under review, changes should no longer be allowed. Before ticket ET-173, there was a bug that did not remove the 'edit' functionality once the state of the study changed. Following the ticket, functionality was as expected.

4.3 New Features and Usability

There are some features that are not thought of initially but instead are thought of by users after beginning to use the product. For example, on the admin end of publishing a study, the initial output was to display a message saying "Confirm Publishing Study" as a warning in the event that the publish button was mis-clicked. However, on this pop-up, there was no way to see the name of the study that was being referred to. This was an oversight when designing the feature, and once users began interacting with this screen, they expressed interest in having the name of the study visible on the screen. Thus, one of the new additions to the submission was including the name of the study on the pop-up confirmation, as seen below in *Figure 12*.
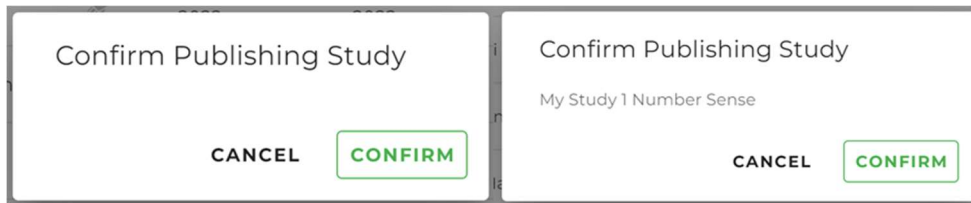
Figure 12: Ticket ET-233 before and after implementation.

Other features to add included having the OSF reference information visible on the page when editing or creating a study. This information was previously visible in the table of all studies but not on the study's page itself. By adding it to the build page, it will be easier for administrators looking through studies to find the corresponding Study ID, as well as the researcher who designed it. The OSF Reference Information display, created in ticket ET-177, is seen below in *Figures 13 and 14*.

Figure 13: A close-up view of the OSF reference information, added in ticket ET-177.

MY EXPERIMENTS / MY STUDY 2

Problem Varied: Overview

Draft

● Overview   ● Problem Sets   ● Deploy

Study Name

My Study 2

Name for others to identify your study

Research Question

My research question

Description of the question your study seeks to answer

Recruitment Plan

Auto Deploy: 500-1000 Students

Automatically recruit any learners assigned the problems you select. Conditions can only consist of different tutoring strategies (Hints, Explanations, or Scaffolding Questions) for the selected problems.

Experimental Paradigm

Problem Set

Build a pool of problems from existing curricula across skills. Students must complete all problems within a randomly assigned condition. Same day posttest optional. Only available in ASSISTed and Manual Recruitment designs.

OSF Reference Information

Researcher ID: N/A
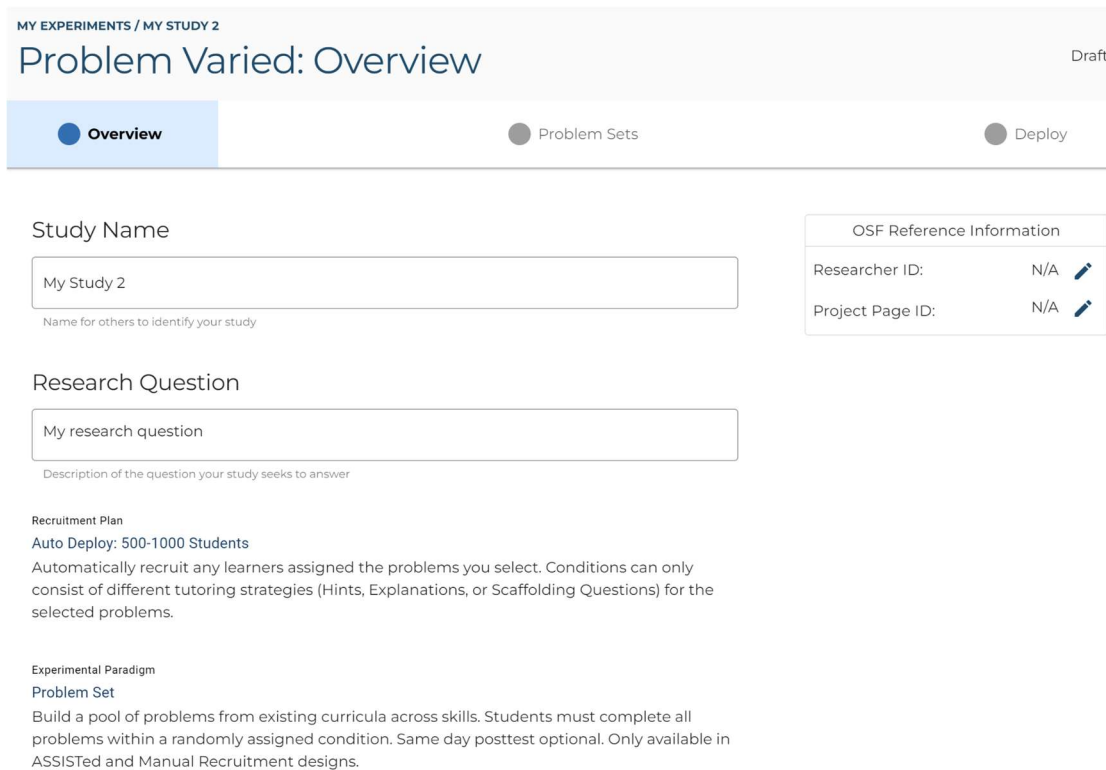
Project Page ID: N/A

Figure 14: The OSF reference information, as displayed on the Overview page.

After adding the OSF Reference Information to the build page, it became clear that in the event that the Researcher ID or Project Page ID are incorrect, are changed, or are simply not visible, the administrator should be able to change the respective ID themselves. In ticket ET-214, which was an expansion on ET-177, the fields were modified to be editable. When the edit mode is open, the user can modify the ID to the correct value, as seen in *Figure 15*.

OSF Reference Information

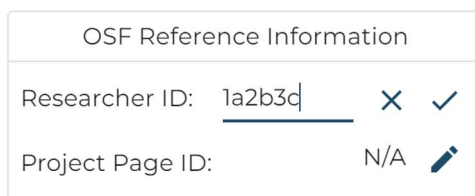Researcher ID: 1a2b3c   ✕ ✓

Project Page ID: N/A

*Figure 15: The OSF reference information in edit mode.*

Another feature requested by the learning scientists to make the E-TRIALS platform easier to navigate was the inclusion of the "Browse Sets by Id" option to the modal where problem sets were added to studies. This functionality already existed but was more challenging

to use with the current designs. In its initial release, the browse option was not clearly seen on the modal, as seen in *Figure 16*.
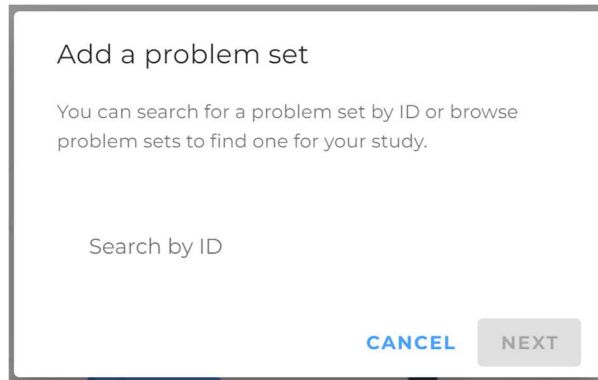
Figure 16: The 'Add problem set' modal before ET-114.

This system was not only inconvenient to use, as the researchers needed to know the id of the exact study they were looking for, but it was also difficult because the users could not see if another study would have fit the learning concept better. By introducing the 'Browse Problem Sets' option, when creating a study, the researcher could choose to look at the available sets, or add one specific one by ID, if they knew what they were looking for. The new feature is seen in *Figure 17* below.
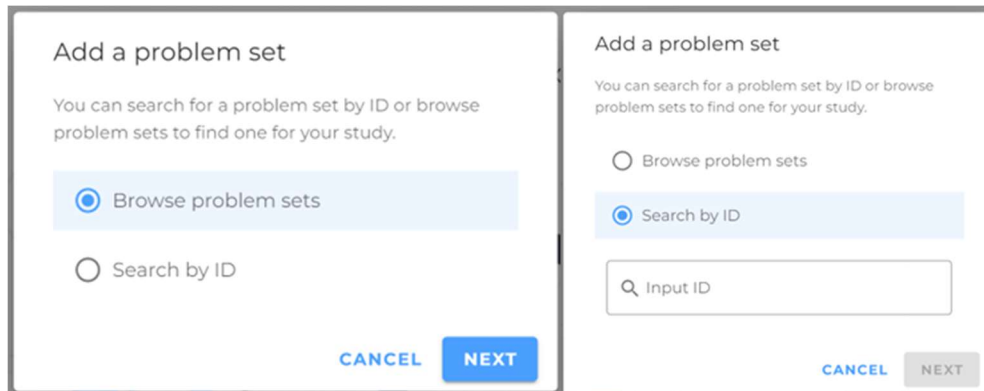
Figure 17: The 'Add problem set' modal after ET-114.

Another feature that was requested was to include the number of participants in a study. This feature, while easy to implement from a developer standpoint and considered a minor

change, included a major benefit to the administrators using the platform. Once a study is deployed, it is important to make sure the participant count is high enough to collect the results, and by displaying this number easily on the study page, the researchers can quickly determine if a study needs to be released to more students. The number of participants is displayed in the top right corner of a study page, when logged in as an administrator, and an example is shown in *Figure 18* below.

Figure 18: The number of participants in a given study.

5.0 Results

5.1 Future Work

At the current stage of E-TRIALS' life cycle, much of the future work will look like the contributions made in this project. Going forward, design and usability updates can be expected, with the goal of adding features that will be helpful as the platform evolves. This consistent update of the codebase will help cement E-TRIALS as a valuable educational research tool in the eyes of learning scientists and researchers.

Another area to build upon will be adding a greater number of possible types of research that are possible to conduct within E-TRIALS. As more study types are introduced to the platform, the user base of educational researchers that are able to use the ASSISTments' research platform will grow. Creating different types will also be a large undertaking, and future MQP projects could focus all effort on organizing, designing, and implementing such a large feature into the E-TRIALS environment.

5.2 Final Thoughts

Throughout the course of this project, I have built my skills in web development, Vue.js, and general coding practices. Working alongside full-time developers allowed me the experience to understand how a software engineering company functions and what my role as a developer would look like in my work. The ASSISTments Foundation is a fantastic company and the E-TRIALS platform is an incredibly meaningful tool that I am grateful to have had the opportunity to have worked on. Knowing that my work will have an impact on researchers, teachers, and students and is making education more accessible and approachable is something I will always be proud of.

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