



Improving the E-TRIALS User Experience

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Abstract

Online learning has become increasingly popular in recent years, and educators feel a growing need to positively impact their students' livelihood by learning how to best support their students remotely. To provide a platform for educational research purposes, the ASSISTments Foundation launched E-TRIALS (EdTech Research Infrastructure to Advance Learning Science). Student projects in the past at WPI have contributed to building and supporting the E-TRIALS platform before its launch in 2022. In this project, contributions were made to improve the user experience for creating and deploying educational research studies through E-TRIALS.

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Chapter 1. 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 This is partly due to the overall complexity of the tool but is exasperated due to outdated design implementations.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 on designs, usability, and clarity throughout the E-TRIALS product.

Chapter 2. 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 supports 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*.

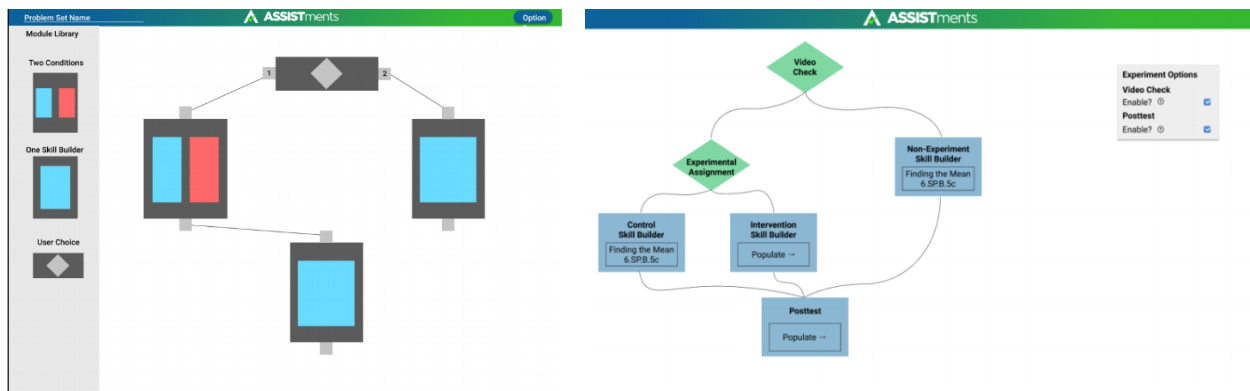


Figure 1: Examples of studies built in Mr. Krichevsky's prototype (left), and Mr. Spinelli's prototype (right).

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.

My Experiments

In Development

The 'In Development' section contains two identical cards for an experiment titled 'Hints vs Scaffolding'. Each card displays the following information: Problem Set Name: Tiling the Plane, Problem Set ID: PSA43P7, Recruitment: Embedded, and Template: Single Post-Test. Below the information are two buttons: 'EDIT' and 'DEPLOY'. To the right of these cards is a large, dark gray square button with a white plus sign, indicating a 'Add New Experiment' function.

Ongoing

The 'Ongoing' section contains two identical cards for an experiment titled 'Text Alignment'. Each card displays the following information: Problem Set Name: Tiling the Plane, Problem Set ID: PSA43P7, Recruitment: Embedded, and Template: Single Post-Test. Below the information is a single 'VIEW' button.

Completed

The 'Completed' section contains one card for an experiment titled 'Motivational Videos'. The card displays the following information: Problem Set Name: Tiling the Plane, Problem Set ID: PSA43P7, and Recruitment: Co-Orchestrated. Below the information are two buttons: 'VIEW' and 'GET DATA'.

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*.

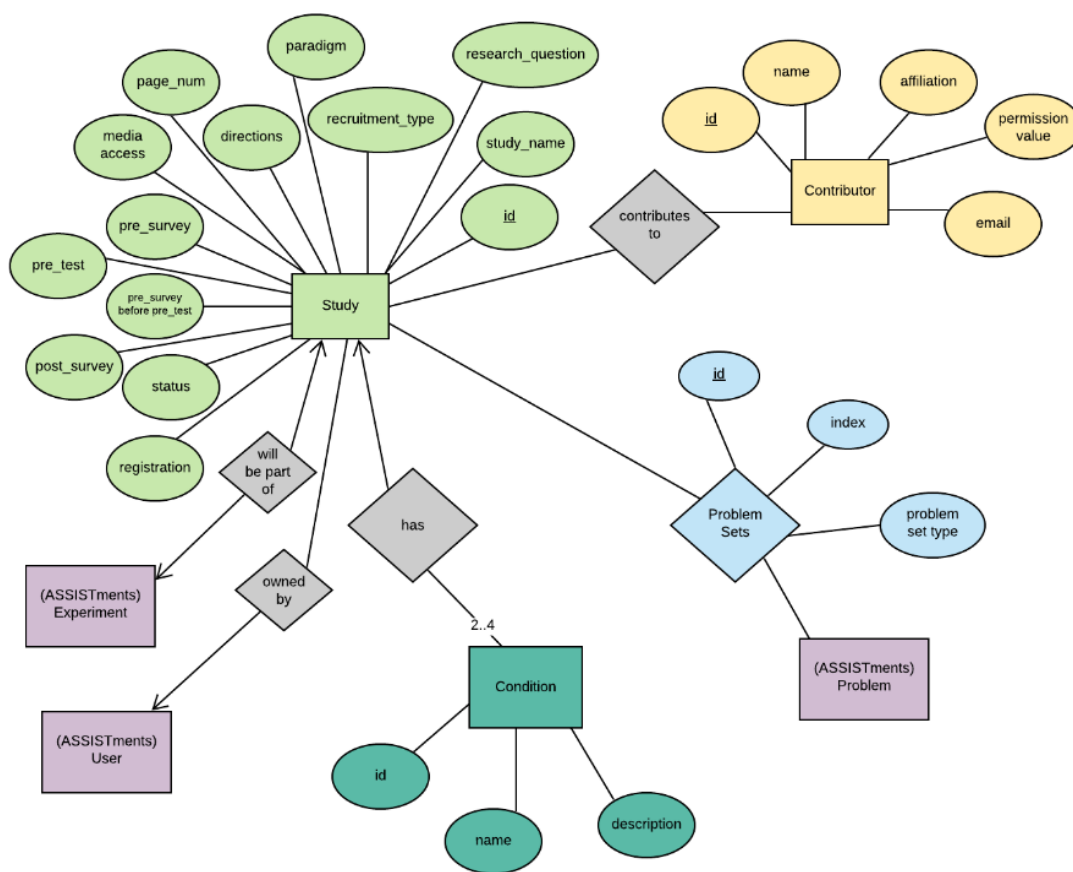


Figure 3: The conceptual diagram for the E-TRIALS tables.

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*.

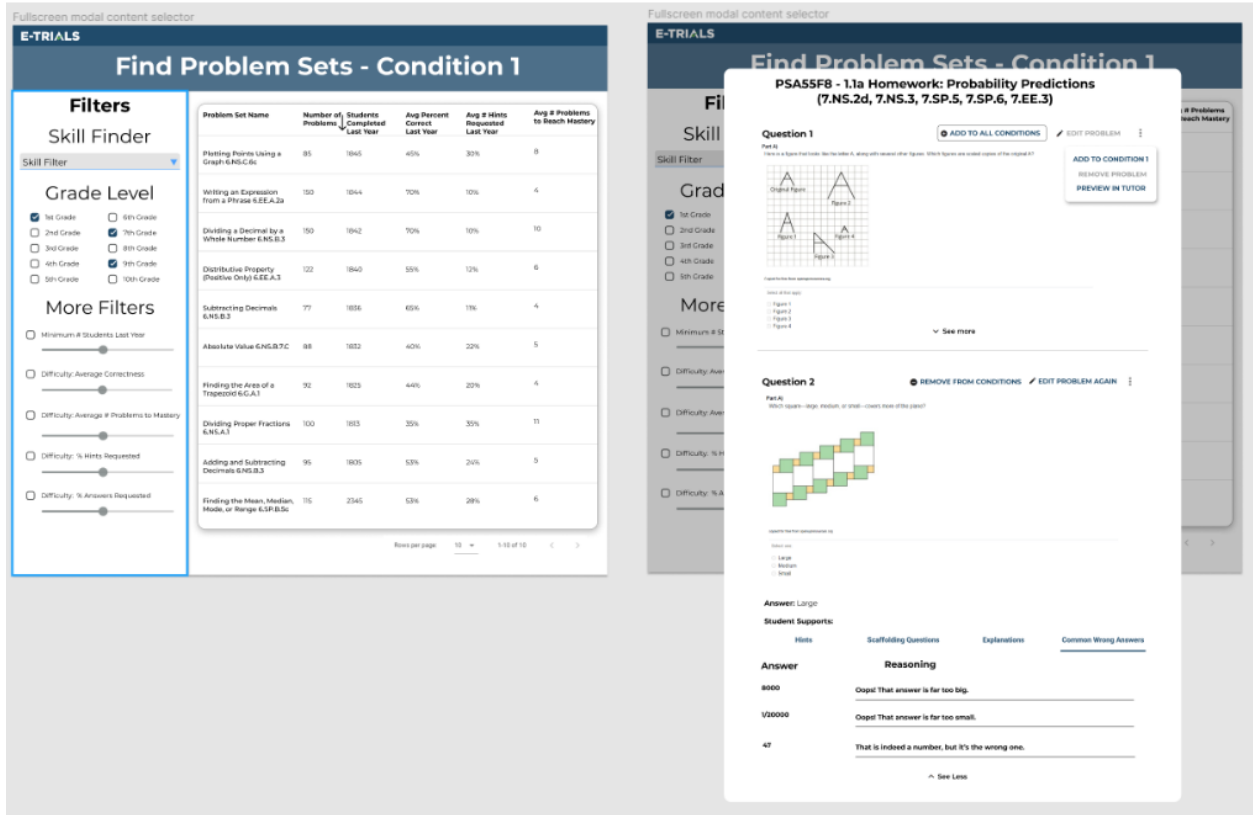


Figure 4: The content selection modals as designed in Figma.

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 Philipo 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*.

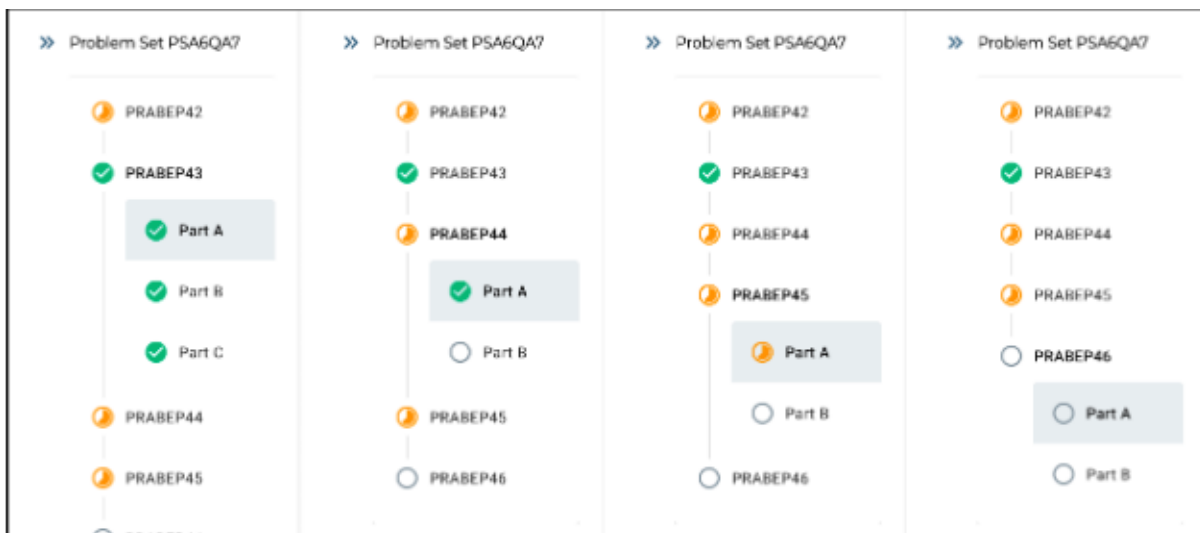


Figure 7: viewing different problems with the problem set stepper

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*.

<u>Study Phase</u>	<u>Study Owner Actions</u>	<u>Administrator Actions</u>
<i>Development</i>	View, Edit, Remove	View, Edit
<i>Awaiting Approval</i>	View, Edit	View, Edit
<i>Deployment</i>	View	View, Edit
<i>Disseminate</i>	View	View

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

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. Filippo 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.

Chapter 3. Methods

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..

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.

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.

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).

Chapter 4. Results

4.1 - Improving Designs

Working on making improvements to designs were some of the biggest contributions of this project. The specific design changes made pertain to two steps of the study building process in particular, the “Conditions” page and the “Deploy” page for Support Comparison and Single Support studies. In the original E-TRIALS platform, the Deploy page is almost an exact replica of the Basics page that is first presented to a researcher when they decide to create a study. All the information on this page is easily viewable from the Basics page that is just one click away (shown in *Figure 7*). As a result, the Deploy page ends up feeling like useless repeated information with the only noticeable change being to the “Submit for Deployment” button. The goal for changing this design is to remove the repeated and useless information in the Deploy page and replace it with a useful overview of the study that the researcher had created.

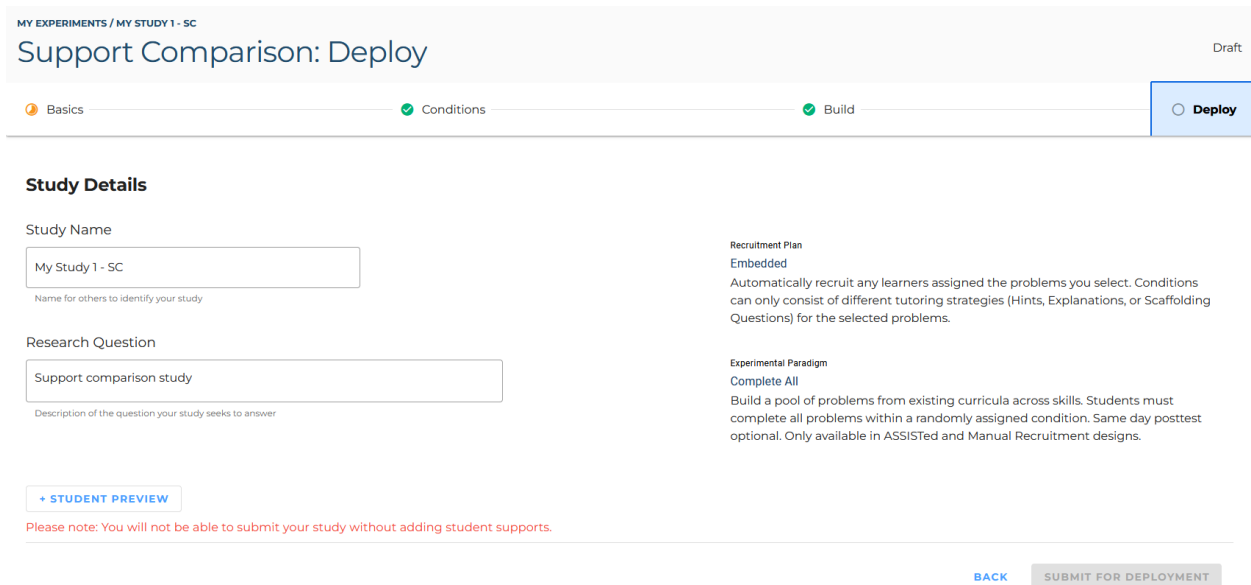


Figure 7: The original Deploy page in the Study Builder.

In the new design, the Deploy page becomes the “Preview” page (shown in *Figure 8*). At this step in the study building process, the researcher is now shown the collection of everything that they have included in their study so far in every condition. Researchers are provided all this

information in a single, scrollable page that contains every problem including the problem type, the list of answers, the correct answer(s), and the different supports that the researcher had authored for each question. Across from each problem set ID and problem is a vertical ellipsis. By clicking this, the researcher is provided a menu that allows them to view the problem or problem set from a student perspective or remove that content from the study altogether. Details about how this design was implemented are available in *Appendix A*.

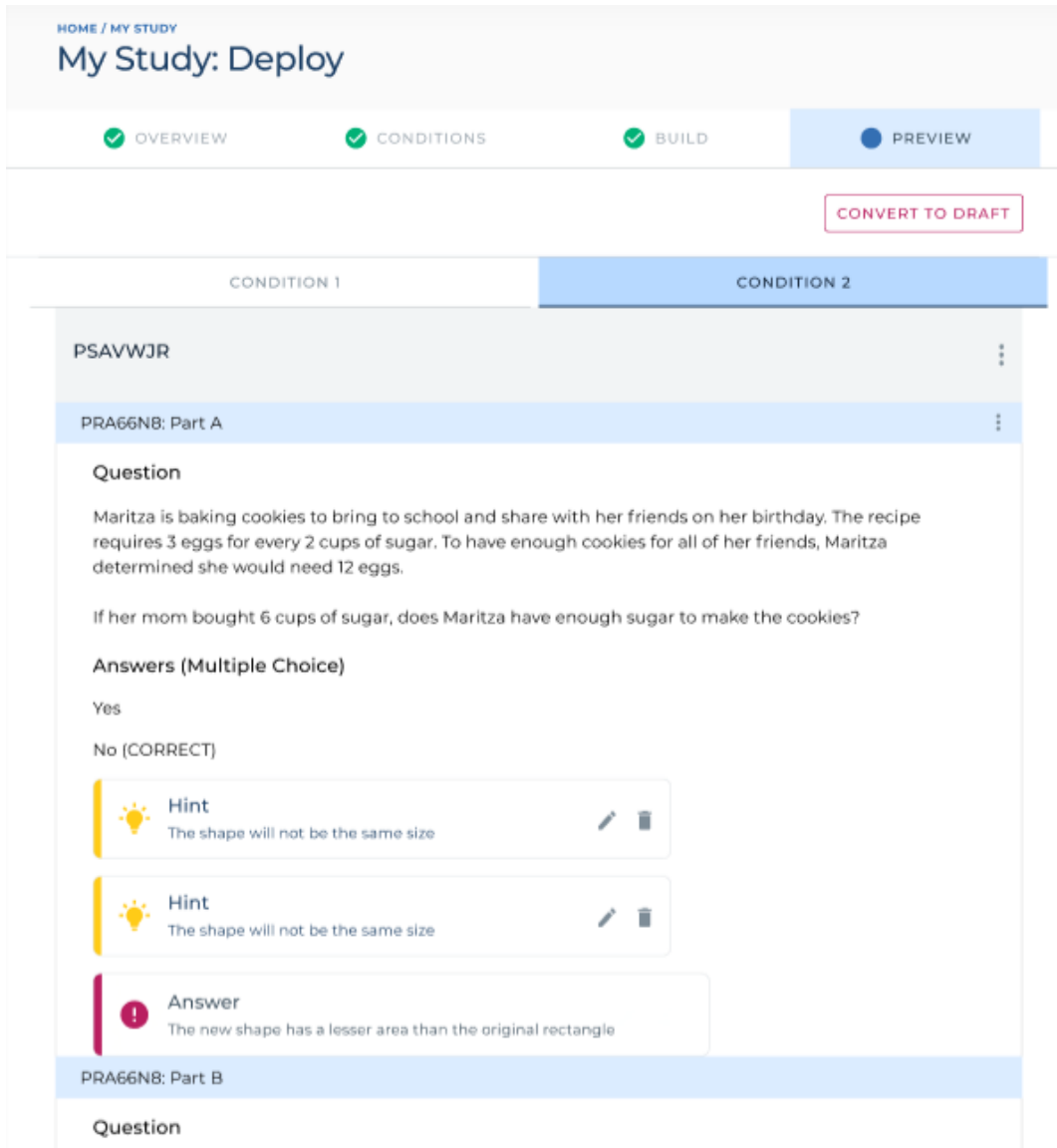


Figure 8: The newly designed Preview page that replaces the Deploy page.

The change to the Conditions page is to distinguish the way that a Single Support study works in comparison to a Support Comparison study. In a typical Support Comparison, the researcher has a minimum of two conditions that will then be populated with different supports that are authored by the researcher. A study of this type can have more than two conditions, but no less than two. These conditions are stored in a table structure that stores information about each condition, with the option to delete any condition so long as the number of conditions is greater than two. This page is shown in *Figure 9*.

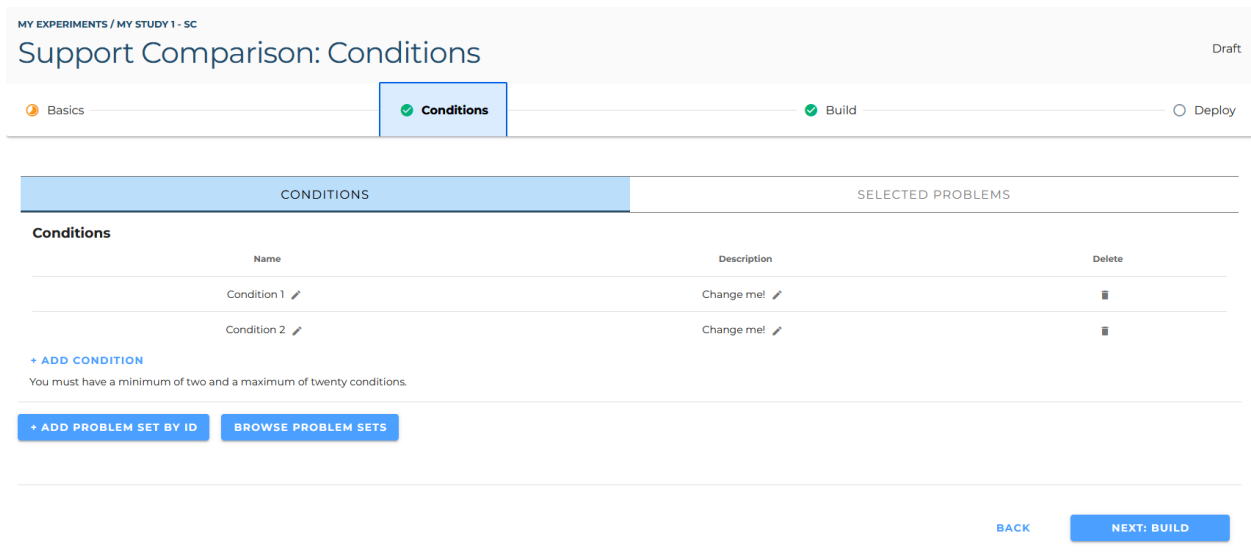


Figure 9: The Conditions page of a Support Comparison study.

A different type of study is created to use only a single condition, which is the Single Support study. The purpose of a Single Support study is to accommodate users such as Math Education faculty who might not be interested in constructing a study that looks at several distinct conditions, but they wish to contribute an alternative way of writing student supports that is then compared against the existing content at ASSISTments. In a Single Support, there is no longer a need to add or delete from a list of conditions, which means that there were several extraneous buttons in the design that were taking up space despite being disabled for that study. The goal of the redesign is to fundamentally change how a condition in a Single Support study is written and stored on the page such that the researcher is no longer given options for actions that could not be made for the selected study type. In addition, the redesign would pull in the information about any selected problem content and display these in the same page as the

condition itself. This differs from the Support Comparison page which separates this information into two distinct tabs. An example of this redesigned page is available in *Figure 10*, and the information for how this was implemented is available in *Appendix B*.

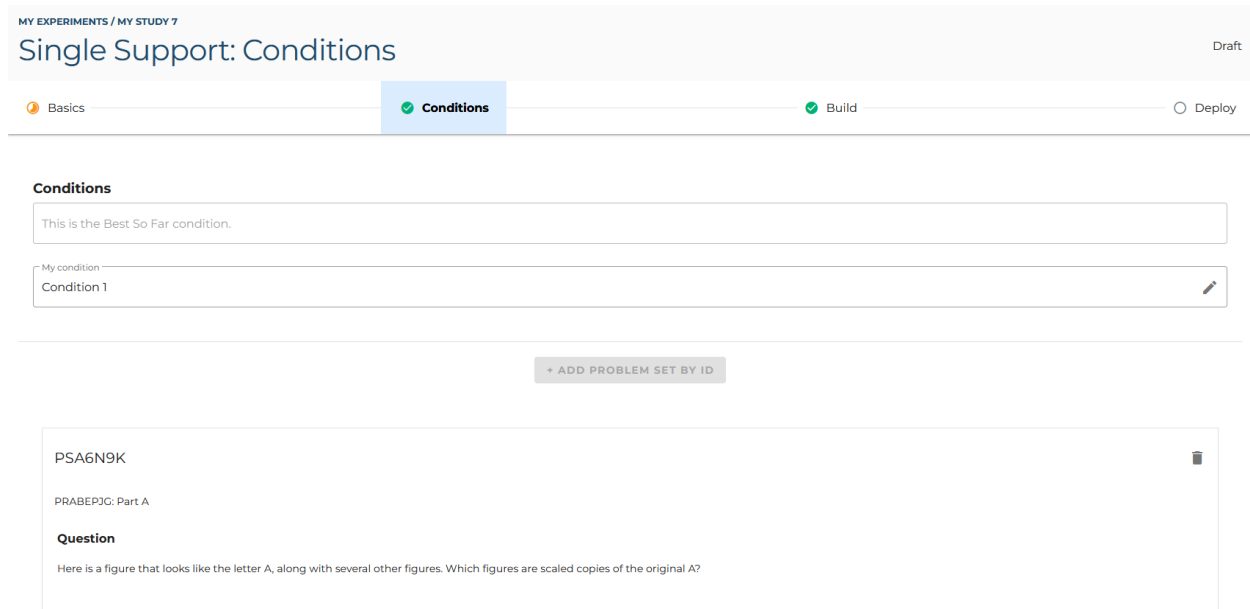


Figure 10: The new Conditions page for a Single Support study.

4.2 - Improving Usability

When a researcher is using the E-TRIALS platform to construct their study, the goal of the platform is to give that researcher the tools they need to complete that task successfully. Part of increasing the usability of the platform means making continuous quality of life updates over time that make using the product an easier experience. An example of this type of update that was made in this project was providing information about the answers to problem set questions directly to the researcher as they build their study. As the researcher goes about adding supports to the problems in their study, it is unreasonable to expect the researcher to waste time finding the correct answer to any particular problem.

The first step towards resolving this usability issue is to create a place that the researcher can see the answer to a question while they are authoring a student support. When a student is presented with a problem while learning on the ASSISTments platform, they can be presented

with a “Show Answer” button that will present the answer to them in a specific format. In this update, this format is replicated in the builder when a researcher begins creating student supports. This resolves the issue of the researcher themselves being unsure about the exact answer to the question, while also providing them with the student’s perspective of what they would see upon clicking the “Show Answer” button. An example of this update is available in *Figure 11* and the implementation is shown in *Appendix C*.

Conditions / Student Supports

CONDITION 1

CONDITION 2

You selected **hints for condition #1**. Click [HERE](#) to add explanation instead.

HINT 1

Hint
This is my hint!

+ ADD HINT

SAVE

Show Answer
The answers are Figure 2, Figure 4

Figure 11: The updated Show Answer box below the authored student supports.

The second step towards resolving this issue with problem answers is providing this information directly on the Build page. Previously, the researcher was only presented with the information pertaining to the question, without being informed of the possible responses. With this in mind, another update was made to pull the answers from the problem information and display this below the question in the Build page. By laying out the possible responses to the question the researcher is provided with all the information they need to write tailored student supports that can fulfill the purpose of their proposed research study. An example is shown in *Figure 12* and the implementation is available in *Appendix C*.

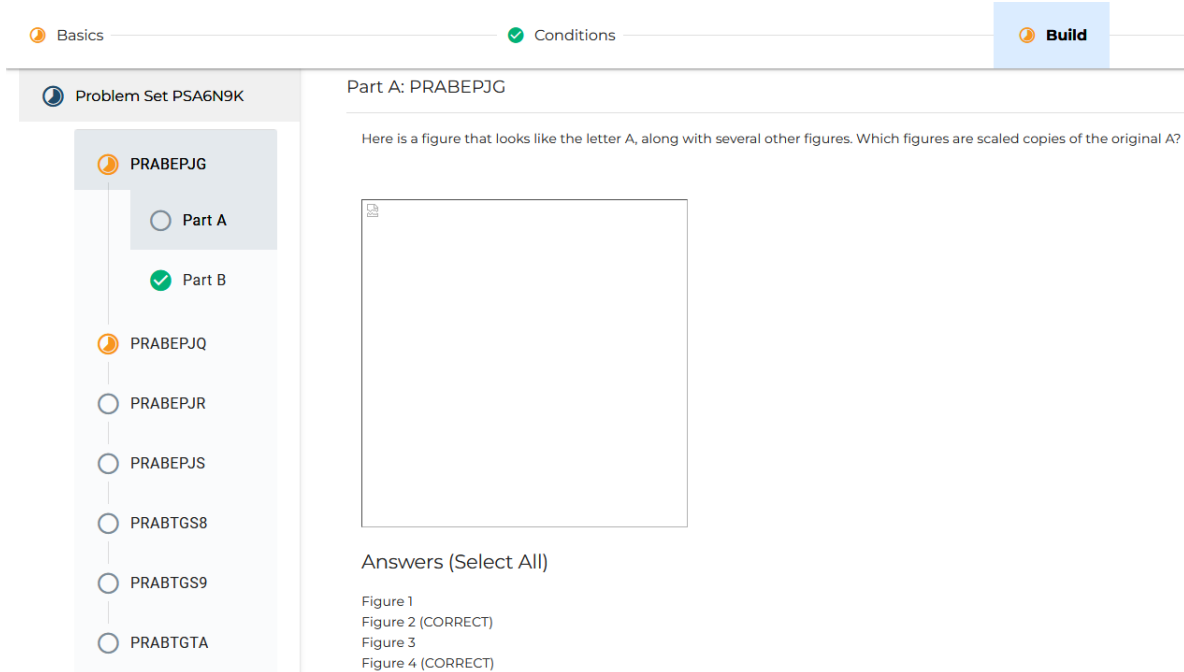


Figure 12: The possible question responses now included below the given problem.

An additional update made in the hopes of increasing usability of the platform involved changes to the problem set content selection table. This table (displayed in *Figure 13*) is a way that researchers can easily look up information about problem sets that they might wish to include in their study. To start, one change made to this table included removing the “Problem Set ID” column. However, one might notice that in the updated table shown in *Figure 13*, the “Problem Set ID” column still exists. In ASSISTments, a problem set has both an assigned Problem Set ID and a value known as the External Reference (Xref). Throughout a researcher’s experience building a study in E-TRIALS, the value that they recognize as the Problem Set ID is the Xref value. In order to reflect this in the content selection table, the “Problem Set ID” column values were removed and the “Xref” column was renamed to “Problem Set ID”. This helps reconcile the researcher’s perception of a Problem Set ID with how ASSISTments makes problem sets available to researchers in the building process. In addition, functionality was included to stick the table column headers to the top of the screen while scrolling, which allows researchers to always be aware about the contents of each column. Finally, the ability to filter the problem sets by availability was also included in this update, to help show researchers only the problem sets that are currently available to be used in the study they are constructing.

Find Problem Sets - All Conditions

Filters SEARCH Students Completed By Month

Only Show Available

Skill Finder
 Curriculum

Grade Level

- Grade 1
- Grade 2
- Grade 3
- Grade 4
- Grade 5
- Grade 6
- Grade 6 Accelerated
- Grade 7
- Grade 7 Accelerated
- Grade 8

Folder Path	Problem Set Name	Lesson Type	Problem Set ID	Problem Count	Open Response Count	Grade	August	September	October	November	December	January	February	April	Ma
Open Up Resources 6-8 Math/Grade 7/Unit 5 - Rational Number 3---Changing Elevation	7.5 Lesson 3: Changing Elevation (7.NS.A.1.a, 7.NS.A.1.b, 7.NS.A.1.c, 7.NS.A.1.d)	Cool-Downs	PSA9QXX	3			0	256	129	311	386	1135	335	206	635
Open Up Resources 6-8 Math/Grade 7/Unit 5 - Rational Number 1---Interpreting Negative Numbers	7.5 Lesson 1: Interpreting Negative Numbers (7.NS.A.1, 7.NS.A.1.b, 7.NS.A.1.c, 7.NS.A.2.d)	Cool-Downs	PSA9QXV	1			0	237	90	341	210	1192	176	103	46
EngageNY/Eureka Math (6 by Great Minds) /Grade 6/Module 4 - Expressions and Equations (6.EE)/Lesson 6---The Order of Operations	6.4 Lesson 6 (6.EE.1)	Exit Tickets	PSAV3VQ	3			0	139	292	104	277	1210	970	415	80

Figure 13: The updated problem set content selection table.

A few small changes were also included for the Administrator view of the E-TRIALS platform. In particular, the table columns have been shifted to better reflect the deployment process chronologically, as well as adding functionality to open studies in a new tab. This helps prevent admins from routing away from the administrator view while allowing multiple studies to be viewed at a single time. Finally, a small visual update was included for the “Participants” column to better reflect the deployment status of a given study, denoted by a “-” in the case of an undeployed study, and a numerical value for deployed studies. These changes are shown in Figure 14, and the implementations are available in Appendix D.

Project Name	Researcher Name	Study type	View Study	Study Status	Deploy	Created date	Deploy date	Participants	Researcher E-mail	OSF Id	Regis
My Study 1 - SC	Mr. Robinson	Support Comparison		err				-	your.name@gedu.demo.assistmentsbed.org	bjw92	
My Study 2 - PV	Mr. Robinson	Problem Varied		err				-	your.name@gedu.demo.assistmentsbed.org	bjw92	
My Study 3 - SC	Mr. Robinson	Support Comparison		err				-	your.name@gedu.demo.assistmentsbed.org	bjw92	
My Study 4 - PV	Mr. Robinson	Problem Varied		err				-	your.name@gedu.demo.assistmentsbed.org	bjw92	
My Study 5 - SC	Mr. Robinson	Support Comparison		err				-	your.name@gedu.demo.assistmentsbed.org	bjw92	
My Study 6 - PV	Mr. Robinson	Support Comparison		err				-	your.name@gedu.demo.assistmentsbed.org	bjw92	
My Study 7	Mr. Robinson	Single Support		err				-	your.name@gedu.demo.assistmentsbed.org	bjw92	

Figure 14: The updated Administrator view table.

4.3 - Improving Clarity

Clarity in regard to a platform like E-TRIALS means ensuring that the information on any given page is presented in a comprehensible and coherent fashion. In this project, ensuring clarity required that updates be made in different places throughout the application that help make the information displayed on the page accurate and easily understandable by any possible user.

The first step towards improving clarity involved adding additional highlights to certain steps found in the study building process. An example of this change was previously shown in *Figure 12*. While this specific feature likely goes unnoticed by most, in the original problem set stepper, the only highlighted step was the step indicating the current problem part. To make the precise problem set, problem, and problem part overwhelmingly clear to all users, additional highlighting was built into the problem set stepper which indicates to the user where in the structure the user is currently working.

In a similar fix to the previous issue, highlighting was also reworked when viewing some menu items. Previously, in some instances, certain menu items would present as significantly larger or smaller than other selections within the same menu. This could potentially cause confusion about the significance of any option in the menu, when each selection within the menu was meant to be given equal priority. Menu highlights in these places were realigned to better present this information to the user.

Lastly, in a different issue from the previous fixes, a step towards improving clarity involved making changes to an SQL script that is used periodically to pull problem set information from the ASSISTments databases. Additional filtering was required to pull out a subset of problem sets that were problematic in regard to problem IDs. The problems associated with these problem IDs were duplicated with other problem IDs, which was causing confusion issues when a researcher attempted to include the problems in their study, only to find that the problems they wanted were already in use. The implementation for these clarity improvements is available in *Appendix E*.

Chapter 5. Discussion

5.1 - Significance of Work

The E-TRIALS platform is an incredibly important tool for empowering educational researchers to carry out research studies with a greatly increased number of research participants at a greatly reduced cost. By making improvements on designs, usability, and clarity, this project helps improve the quality of life for the researchers that make use of the platform, which is vital to both the success and longevity of such a product. In perpetuating the success of the platform, this project also plays a role in growing educational research as a discipline and, in turn, improving students' potential for learning in the future.

In the contributions of this project, updates and changes were made throughout the platform, from the design of pages in the building process, to the tools used to pull content from the ASSISTments databases. By improving designs, this project helps E-TRIALS create an efficient and valuable experience for researchers attempting to create innovative and novel education studies. By improving usability, this project makes it easier to go about creating a research study using the E-TRIALS study builder. Finally, by improving clarity, this project ensures a consistent and well-organized interface to prevent confusion or misconceptions about how the E-TRIALS platform can be utilized to perform learning science research.

5.2 - 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. As a product that is currently in use by researchers, the primary focus will be making updates to the current user-facing frontend of the platform as well as making efficiency updates to the backend. Going forward, design and usability updates can be expected, with the end goal of helping the platform remain relevant and modern. In doing so, this helps cement E-TRIALS as a valuable educational research tool in the eyes of learning scientists and researchers.

Another key focus will be adding a greater number of possible types of research that are possible to conduct within the E-TRIALS system. As a greater variance of study types is

introduced to E-TRIALS, this only helps grow the potential audience of educational researchers that are willing to make use of ASSISTments' research platform. 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.

5.3 - Final Thoughts

Working on this MQP project has been an extremely valuable experience for me as an individual who is interested in software development. Cooperating with the E-TRIALS development team has helped me learn a plethora of new skills and introduced me to many new tools that I expect to be quite valuable going forward. By working on this project in a more realistic environment, it has helped provide me with insight into how I would like to approach further opportunities in the future. Additionally, it feels substantially more satisfying knowing that the work that is produced in this project eventually makes its way to the eyes of real people, as opposed to a more typical school project that might be immediately locked away upon being graded.

Throughout the course of this project, I was fortunate to have a great amount of help from several people working on E-TRIALS. From Mr. Ryan Emberling, who has helped immensely with getting me up and running and helping me solve many issues along the way, to Ms. Hannah Pandolph, who was always available and encouraging regarding the tasks assigned for this project. Another big thanks is due to Mr. Brian Rojas, for helping fix development issues and reviewing my work throughout my time at ASSISTments. Recognition is also due to the students working on E-TRIALS alongside me, Mr. JR Kim and Ms. Emily Gorelik. Finally, thank you to ASSISTments and Mr. Neil Heffernan for allowing me the opportunity to work on this project!

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Appendix

Appendix A: StudyDeploy.vue

...

```
<div class="d-flex justify-end">
  <v-row
    class="pb-7 mr-4 d-flex justify-end"
  >
    <v-btn
      class="mb-4"
      color="secondary"
      :loading="loading"
      :disabled="unableToDeploy"
      @click="handleClickedSubmit"
    >
      SUBMIT FOR DEPLOYMENT
    </v-btn>
  </v-row>
</div>
<v-tabs
  v-model="currentSelections.conditionIndex"
  class="tabs"
  grow
>
  <v-tab
    v-for="(cond, index) in
this.$store.state.currentStudy.conditions"
```

```

        :key="index"
        @change="currentConditionId = cond.id"
    >
        {{ cond.name }}
    </v-tab>
</v-tabs>
<template>
    <div
        v-if="(problemSetsInfo.length === 0)"
        class="d-flex justify-center py-6"
    >
        No Problem Sets added.
    </div>
    <div
        v-for="(pair,index) in problemSetsInfo"
        :key="index"
    >
        <v-card
            outlined
            tile
            class="mx-8"
        >
            <v-card-title
                class="problem-set-xref py-6 d-flex
justify-space-between"
            >
                {{ pair.xref }}
            <v-menu
                bottom

```

```

        offset-x
    >
    <template #activator="{ on, attrs }">
        <v-btn
            icon
            class="float-right mr-2 mt-2"
            v-bind="attrs"
            v-on="on"
        >
            <v-icon>mdi-dots-vertical</v-icon>
        </v-btn>
    </template>

    <v-list class="mr-8">
        <v-list-item
            @click="showStudentPreviewModal =
true"
        >
            <v-list-item-title>STUDENT
PREVIEW</v-list-item-title>
        </v-list-item>
        <v-list-item
            @click="openDeleteDialogProblemSet(pair.id)"
        >
            <v-list-item-title>
                DELETE
            </v-list-item-title>
        </v-list-item>
    </v-list>

```



```

        </v-menu>
    </v-card-title>
    <div
        v-for="(problem,j) in
problemsInProblemSets(pair.id) "
        :key="j"
    >
        <v-card-subtitle
            class="problems-xref py-2 px-4"
        >
            <span v-if="isMultiPartProblem(problem)"> {{
problem.xref }}: {{ getProblemPartLetter(problem.position - 1) }} </span>
            <span v-else> {{ problem.xref }} </span>
            <v-menu
                bottom
                offset-x
            >
                <template #activator="{ on, attrs }">
                    <v-btn
                        icon
                        class="float-right mr-2
problem-three-dots"
                        v-bind="attrs"
                        v-on="on"
                    >
                        <v-icon>mdi-dots-vertical</v-icon>
                    </v-btn>
                </template>
            </v-list class="mr-8">

```

```

        <v-list-item
            @click="showStudentPreviewModal =
true"
        >
            <v-list-item-title>STUDENT
PREVIEW</v-list-item-title>
        </v-list-item>
    </v-list>
</v-menu>
</v-card-subtitle>
<v-card-text class="pa-5">
    <div>
        <h3 class=" font-weight-bold pb-5">
            Question
        </h3>
        <div v-html="problem.body" />
        <h3 class="font-weight-bold mb-4">
            Answers ({{ answerType(problem.type)
    </h3>
    <div
        v-if="problem.type != 'RANK'"
    >
        <div
            v-for="answer in problem.answers"
            :key="answer.value"
            class="mb-2"
        >
            <span>{{ answer.value }}</span>
        <span v-if="answer.isCorrect"> (CORRECT) </span>

```

```

        </div>
    </div>
    <div
        v-for="answer in problem.answers"
        v-else
        :key="answer"
    >
        {{ answer.value }}
    </div>
</div>
</v-card-text>
<div
v-if="supportContent[`${problem.id}_${currentConditionId}`]['content'][0]
!= ''
        &&
supportContent[`${problem.id}_${currentConditionId}`]['simplifiedContentTy
pe'] != 'EXPLANATION'"
    >
        <v-card
            v-for="index in
supportContent[`${problem.id}_${currentConditionId}`]['content'].length"
            :key="index"
            outlined
            class="mx-7 my-3 rounded-lg"
            style="border-left: solid 12px #FFCB17;
width: 50%;"
        >
            <v-row class="d-flex pl-6">
                <v-icon
                    large

```

```

        color="yellow darken-2"
    >
        mdi-lightbulb-on
    </v-icon>
    <div>
        <v-card-title> Hint
    </v-card-title>

        <v-card-text
v-html="supportContent[`${problem.id}_${currentConditionId}`]['content'][i
ndex - 1]" />

        </div>
    </v-row>
</v-card>
</div>
<div
v-else-if="supportContent[`${problem.id}_${currentConditionId}`]['content'
][0] != ''">
    <v-card
        outlined
        class="mx-7 my-3 rounded-lg"
        style="border-left: solid 12px #B91E60;
width: 50%;"
    >
        <v-row class="d-flex pl-6">
            <v-icon
                large
                color="#B91E60"
            >
                mdi-alert-circle
            </v-icon>
            <div>

```

```

                <v-card-title> Answer
</v-card-title>

                <v-card-text
v-html="supportContent[`${problem.id}_${currentConditionId}`]['content']"
/>

            </div>
        </v-row>
    </v-card>
</div>
</div>
</v-card>
</div>
</template>
<base-confirm-modal
    v-model="showDeleteDialog"
    :message="deleteMessage"
    button-text="DELETE"
    button-color="error"
    @confirmed="deleteProblemSet"
/>
...
<script>
import { cloneDeep, uniq } from 'lodash';
import { pageUrls } from '../store/util/pageUrls';
import statuses from '../store/util/StudyStatuses';
import getPartLetter from '../utils/getPartLetter';
import groupProblemsByAssistmentId from '../store/util/ProblemUtils';
import ProblemType from '../store/util/ProblemType';
import WIPStudentSupport from '../store/util/WIPStudentSupport';
import BaseConfirmModal from './BaseConfirmModal.vue';

```

```

export default {
...
  components: {
    BaseConfirmModal,
  },
  data() {
    return {
      ...
      currentConditionId:
this.$store.state.currentStudy.conditions[0].id,
      assistmentIdToProblemsMap: new Map(),
      currentSelections: {
        problemSetIndex: 0,
        problemIndex: 0,
        problemPartIndex: 0,
        conditionIndex: 0,
      },
      supportContent: {}, // dictionary of concatenated
{problemID}_{conditionID}, inside dict of type WIPStudentSupport
      problemIdsToRemove: [],
      ...
    };
  },
...
</script>

<style scoped lang="scss">
...
.active-tab {

```

```

        color: black;

        background-color: #BBDEFB;
    }

    .tabs{

        border-bottom: 1px solid #0000008A;

        border-top: 1px solid #0000008A

    }

    .tab-item {

        width: 50%;

    }

.problem-three-dots {

    position: relative;

    top: -5px;

}

</style>

```

Appendix B: StudyConditions.vue

...

```

<div v-if="singleSupport">
    <v-text-field
        outlined
        :disabled="true"
        class="px-5 pt-2 my-0"
        label="This is the Best So Far condition."
    />
    <v-text-field
        v-model="singleCondition"

```

```

        outlined
        class="px-5"
        label="My condition"
        append-icon="mdi-pencil"
        :rules="[nameMaxChars, notBlank]"
        @change="saveSingleCondition"
    />
</div>

...
export default {
    ...
    data() {
        return {
            singleCondition:
this.$store.state.currentStudy.conditions[0].name,
            ...
        };
    },
    methods: {
        saveSingleCondition() {
            if (this.nameMaxChars(this.singleCondition) === true &&
this.singleCondition.length > 0) {

this.updateConditionName(this.$store.state.currentStudy.conditions[0].id,
this.singleCondition);

            this.$store.state.currentStudy.conditions[0].name =
this.singleCondition;

            this.snackText = 'Condition successfully saved';
            this.showSnackBar = true;
        } else {

```



```

        this.snackText = 'Condition must be < 40 characters and
field cannot be blank';

        this.showSnackbar = true;
    }
},
}
...

```

Appendix C: StudyContent.vue

```

...
<v-card-text v-if="currentSupport.simplifiedContentType == 'HINT_SET' &&
currentSupport.content[0].length > 0">
    <v-text-field
        readonly
        outlined
        label="Show Answer"
        :value="getAnswers(currentProblem)"
    />
</v-card-text>
...
<div v-if="currentProblem.type == 'RANK'">
    <h2
        v-if="currentProblem.type == 'RANK'"
        class="mb-4"
    >
        Answers (Order)
    </h2>
    <div
        v-for="answer in currentProblem.answers"

```

```

        :key="answer.value"
      >
        {{ answer.value }}
      </div>
</div>
<div v-else>
  <h2
    v-if="currentProblem.type == 'CHOOSE_N'"
    class="mb-4"
  >
    Answers (Select All)
  </h2>
  <h2
    v-if="currentProblem.type == 'CHOOSE_ONE'"
    class="mb-4"
  >
    Answers (Multiple Choice)
  </h2>
  <h2
    v-if="currentProblem.type ==
'NUMERIC_EXPRESSION'"
    class="mb-4"
  >
    Answers (Numeric Expression)
  </h2>
  <h2
    v-if="currentProblem.type == 'NUMERIC'"
    class="mb-4"
  >

```

```

        Answers (Numeric)
    </h2>
    <h2
        v-if="currentProblem.type ==
'EXACT_FRACTION'"
        class="mb-4"
    >
        Answers (Exact Fraction)
    </h2>
    <h2
        v-if="currentProblem.type ==
('OLD_ALGEBRA' || 'ALGEBRA')"
        class="mb-4"
    >
        Answers (Algebra)
    </h2>
    <h2
        v-if="currentProblem.type == 'FILL_IN'"
        class="mb-4"
    >
        Answers (Fill In)
    </h2>
    <h2
        v-if="currentProblem.type ==
'FILL_IN_IGNORE_CASE'"
        class="mb-4"
    >
        Answers (Fill In - Ignore Case)
    </h2>
</div>

```

```

        v-for="answer in currentProblem.answers"
        :key="answer.value"
      >
        <span>{{ answer.value }}</span> <span
v-if="answer.isCorrect"> (CORRECT) </span>
      </div>
    </div>
  </div>

```

...

Appendix D: StudyModalProblemSet.vue & AdminDataTable.vue

...

```

<v-switch
  v-model="availabilityFilter"
  label="Only Show Available"
  color="secondary"
/>

```

...

```

<v-data-table
  v-else
  id="content-data-table"
  :headers="headerData"
  fixed-header
  height="85vh"
  :items="content"
  :items-per-page="30"
  :item-class="itemRowBackground"
  :search="search"
  sort-by="studentsCompletedSeptember"
  :sort-desc="true"

```

```

        :footer-props="{
            itemsPerPageOptions: [10, 30, 50,
100],
            }"
        @click:row="displayProblems"
    >
...
methods: {
...
    filterByAvailability(pset) {
        return !this.availabilityFilter ? true :
!this.problemSetsInUse.includes(pset.problemSetId);
    },
},
};
...

```

```

-
...
if (item.studyTypeId === StudyTypes.supportComparison || item.studyTypeId
=== StudyTypes.singleSupport) {
    const route =
this.$router.resolve(`${pageUrls[0]}/${item.studyId}`);
    window.open(route.href);
} else if (item.studyTypeId === StudyTypes.problemVaried) {
    const route =
this.$router.resolve(`${problemVariedPageUrls[0]}/${item.studyId}`);
    window.open(route.href);
}
...

```

Appendix E: StudyContentSelector.vue

...

```
<template v-for="(data, index) in problemsData">
    <v-stepper-step
        :key="data.problemSet.id"
        :step="index"

:edit-icon="problemSetIdToProblemSetStatusIconMap.get (data.problemSet.id)
|| 'mdi-help-circle-outline'"
        class="problem-set problem-part-step"
        complete
        editable
    >
```

...

```
    <v-stepper-step
        :key="problem[0].assistentId * 2"
        class="text-body-1 problem-part-step"
        :class="getStepperStepClass (problem) "
        :step="probIndex"
        :edit-icon="getStepperStepIcon (problem) "
        editable
        complete
    >
```

...