



WPI

Improving ASSISTments E-TRIALS Service

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Abstract

Online learning has been growing in its popularity especially during past few years of COVID-19 pandemic. However, the research on learning science to find an optimal ways teachers can utilize online learning platform still lacks. The ASSISTments Foundation launched the E-TRIALS (EdTech Research Infrastructure to Advance Learning Science) to provide an easy and viable option for learning science researchers to explore different ways to experiment with how students best learns in a given situation. In this project, contributions were made on both user and developer side to expand the usability of the E-TRIALS platform.

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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 This is partly due to the overall complexity of the tool but is exasperated due to outdated design implementations.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 and IQP 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 IQP project is to improve the developer and user experience of E-TRIALS by making quality of life improvements through improving on 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*.

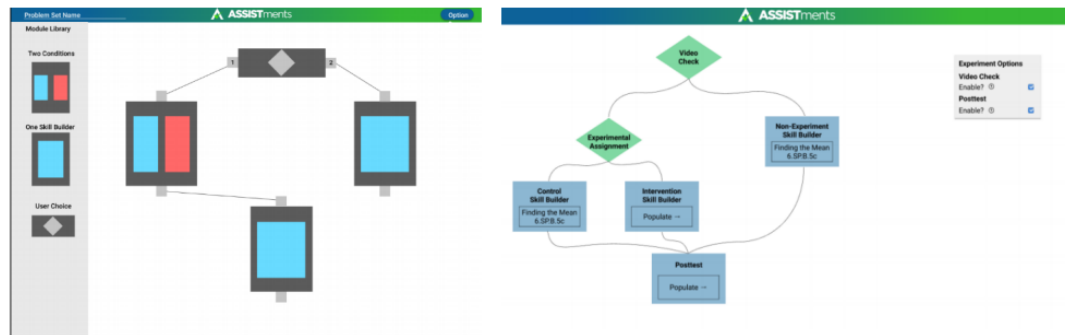


Figure 1: Examples of studies built in Mr. Krichevsky's prototype (left), and Mr. Spinelli's prototype (right).

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.

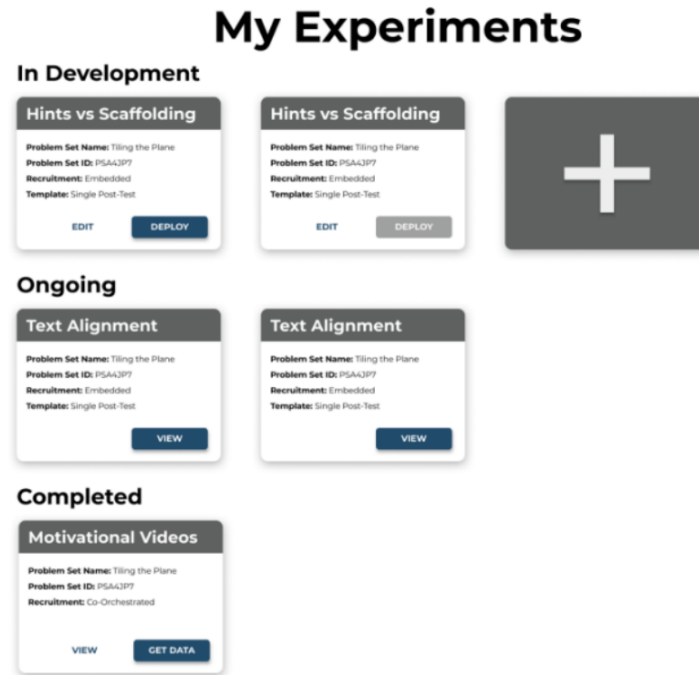


Figure 2: Homepage of the prototype E-TRIALS interface.

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*.

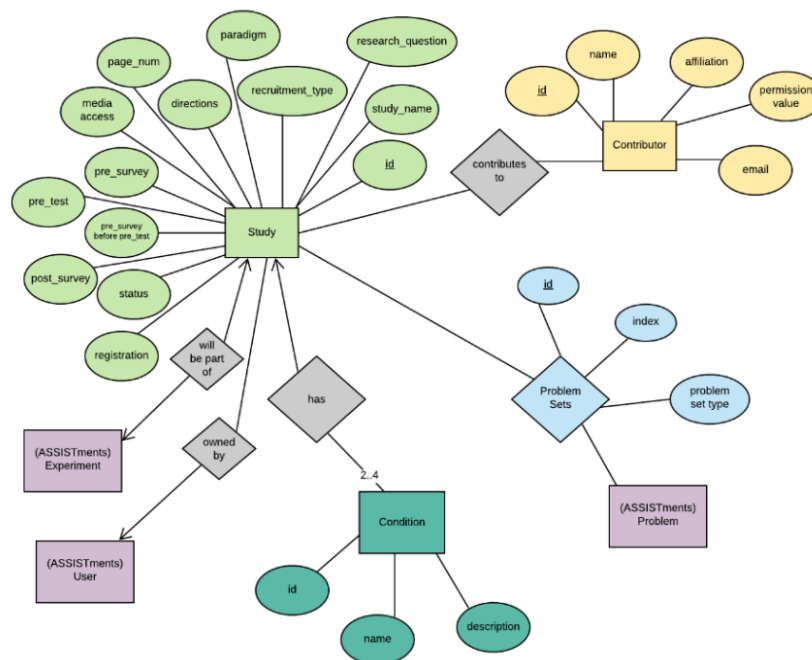


Figure 3: The conceptual diagram for the E-TRIALS tables.

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*.

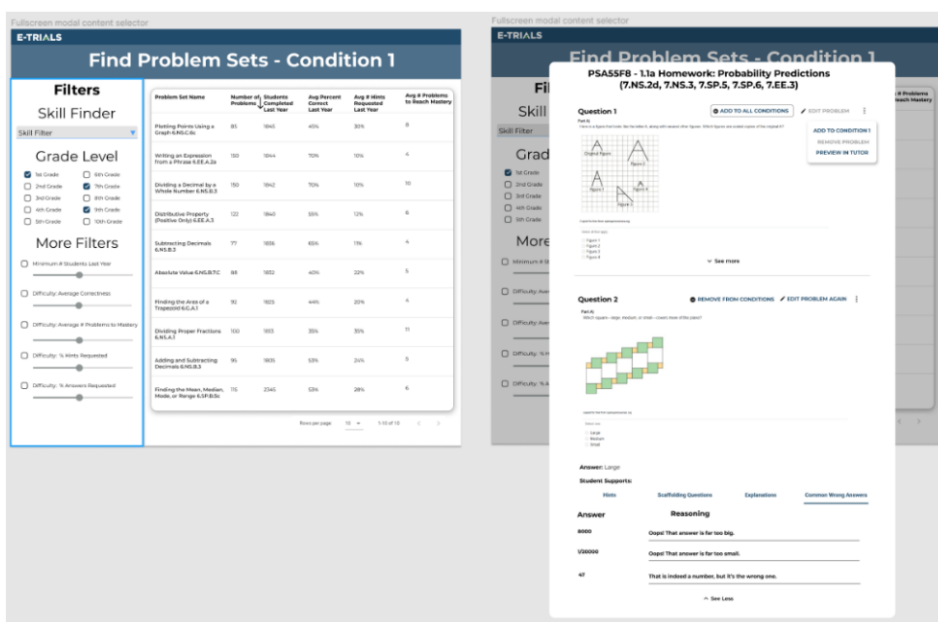


Figure 4: The content selection modals designed in Figma.

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*.

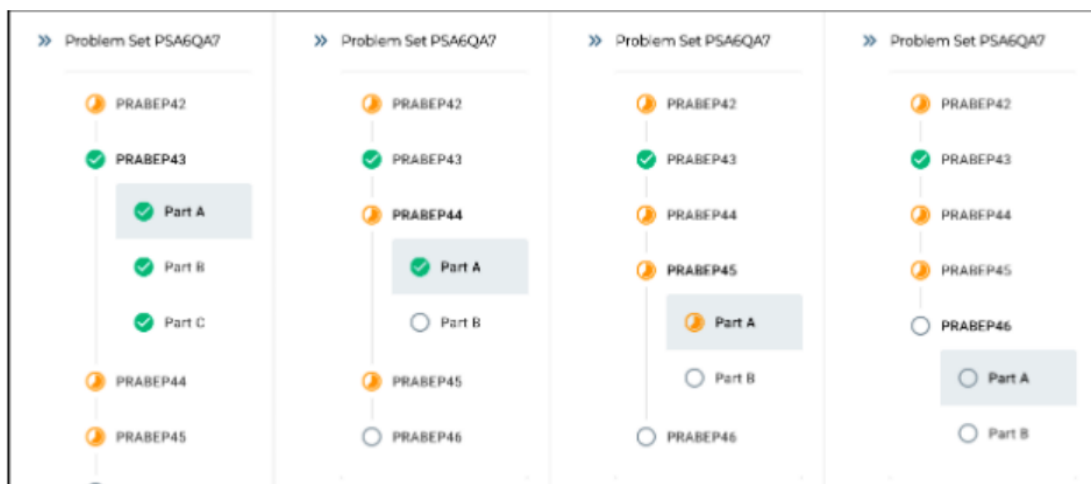


Figure 5: viewing different problems with the problem set stepper.

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*.

<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.

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.

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

This IQP project works 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

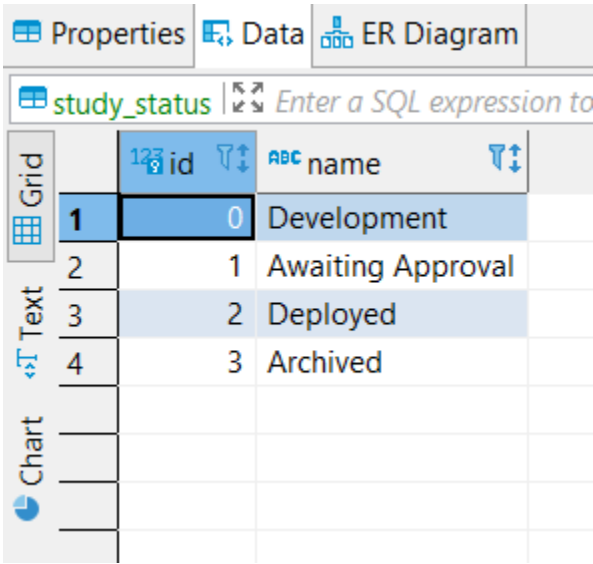
4.1 Improving Developer Experience

Fast-paced development in the E-trials team has resulted in multiple tech debts. This means there are multiple parts of the product that work, but causes the cost of additional rework by choosing an easy solution now instead of using a better approach that would take longer. Having multiple tech debts has limited the maintainability and expandability of the product.

The project lacked uniform structure in styling. There was a mixture of raw css on the page, separated css styling sheet, and use of Vuetify elements. This had made it hard to maintain and unify the detailed styling of the product. Implementing SASS with converting most elements into Vuetify has multiple advantages with the biggest one being having a single uniform place to change all elements that are within certain groups. For example, all the elements within that styling sheet could be changed in one SCSS file if the team decides to darken the text color for research descriptions, in contrast to the original method where developers would manually

change each usage of description. Moreover using Vuetify will guarantee the uniform styling providing consistent user experience interacting with different elements in the website.

Having developers understanding variables used in blocks of code are crucial to effective programming. Enum is an effective way to keep the mechanism simple while making it understandable by humans. An integer was used to represent different status of a certain study, but having enum would be able to have more descriptive names while keeping the advantage of keeping simplicity of using an integer. There were two parts to implementing the enum: the frontend and the backend. The backend needed to be established in order to store what each integer meant. A new table was made with a link to the status column of the original rows. This allowed for easy access to representation of each integer as shown in figure 7.



The screenshot shows the DBBeaver interface with the 'Data' tab selected. The table 'study_status' is displayed with the following data:

	id	name
1	0	Development
2	1	Awaiting Approval
3	2	Deployed
4	3	Archived

Figure 7: Enum table from DBBeaver

The frontend had to accommodate the changes made in the backend. Every call made to the server was updated to utilize the enum variables instead of arbitrary integers. This increases the readability of the code and reduces the chance of confusion when coding.

Biggest improvement made on the developer side is the implementation of typescript. Typescript is a language derived from javascript which is a strictly syntactical superset. The addition of typescript has been desired by the team for a while due to multiple advantages

typescript would provide such as preventing errors with type checking and better structure with interfaces. Two big stages to the implementation of typescript was refactoring of the structure of the project and abstraction of codes for type checking and readability. A lot of initial setup was referenced from the TNG vue project which is another project in ASSISTments with typescript already implemented. Modules under store into new structure from having a single file per module to separating different aspects into other files under a folder. Within the folder there were five distinct files with the same names. Index file for initializing state and tying all the files into one, types file for initialization of interface with types of all the variables used in the module, getters, actions, and mutations for getters, communicating with the server, and altering states represented in the frontend client. Abstraction of the codes were made after the structure was settled in to take full advantage of the typescript such as preventing type errors. New folder domain was created with a collection of interfaces to abstract different classes and objects. By having a defined interface, json files can have set variables as well as ensure uniform types.

4.2 Improving User Experience

Though not as significant as some changes made in developerside, fixes and new features were made to improve the user experience. Multiple bugs were fixed with the biggest being fixing logout. The logout button took the user back to the login page, but did not fully log out behind the scene. It was found out that this was due to it only partially removing cookies, and it was fixed by removing all cookies related to the logged in user. Another major fix was on the admin page where administrators can manage different studies created by all users. It would only pull from the server when it was first accessed which meant anything that was changed by other users after the first access by admin would not be reflected in the page. The logic was fixed to refresh the page every time administrator accesses the page as well as the deploy button being active by the frontend client when a study is deployed.

A big feature developed during the IQP was the onboarding page. Previously the user had no method of changing their information or preferences. However, with E-TRIALS now collecting more information about the user, an onboarding page was necessary. A full onboarding experience was provided when a new user first login to the system by redirecting them to onboarding pages shown in figure 8. The OSF ID prompt has also been moved into this page.

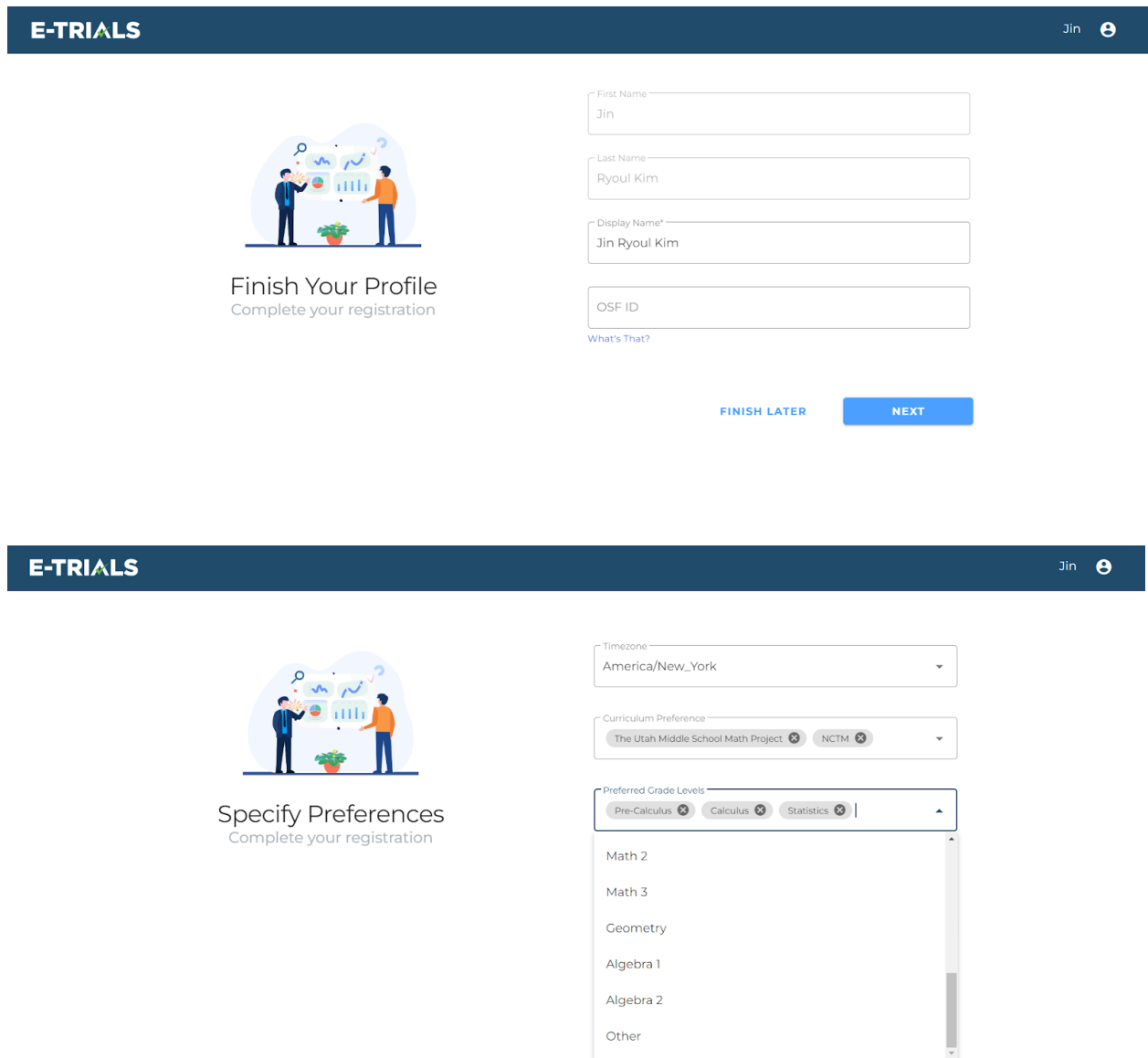


Figure 8: Onboarding pages.

The pages were created with a combination of regular text boxes, uneditable text boxes, and drop downs. Some dropdowns had to be pulled from existing files such as timezones. There also is a finish later button to give the user the option to skip the entire onboarding process. The onboarding process had to only appear once when the new user is accessing the page for the first time. To solve this, a new field in the user attribute had to be created as shown in the last row of figure 9.

	id	partner_xid	name	description	internal_data_type_id	is_active
1	4	8	driverSeatTeacher	Is this user a driver seat teacher?	3	[v]
2	3	8	subdomain	What is this users subdomain	1	[v]
3	8	1	curriculumAligned	Curriculum Aligned	3	[v]
4	9	1	15min	Longer than 15 minutes?	3	[v]
5	1	1	courseEndTime	When does this class (group) end	5	[v]
6	12	1	gradeLevel	Grade Level	2	[v]
7	11	1	ncesPublicSchool	NCES America's Public School	1	[v]
8	13	1	attribution	Attribution	2	[v]
9	10	1	curriculum	Curriculum	2	[v]
10	14	2,762,283	ETSONboardingCompleted	ETS user completed onboarding?	3	[v]

Figure 9: attribute table in the database, onboarding attribute at the last row.

This created an attribute ESTONboardingCompleted with boolean when a user creates their account and defaults to false. The onboarding page is only shown if the attribute is false and when they do complete the onboarding process or decide to skip it, the attribute is set to true resulting in the onboarding page to not appear anymore. This meant the router had to also be modified to let the client know which page it should take when the user is logged in. Initially separate conditions were made to redirect to the onboarding page. However it had to be changed due to a vulnerability that a user that is not logged in could access the page through typing in a specific url. This was fixed by having the landing page as onboarding but redirects to home if the user has already completed it. It was a small change but had a large impact on how the website was directed everytime it was accessed.

5.0 Discussion

3.1 Future Work

The E-TRIALS platform is a continuously developing service with more features, improved user experiences, and more to come. There are lots of ways that the platform will develop but the area with most growth available is definitely on the developer side. The typescript implemented is still far from perfect and the team needs to adjust to the new structure of the project. Furthermore as the platform grows, it would need more structure to how different source codes are organized. The project has a fast turnover cycle for who is involved due to the property of MQP meaning project structure should be as clear as possible for new developers to adjust quickly.

3.2 Final Thoughts

The E-TRIALS project was one of my first real-life developing environment I have ever worked on. The fact that whatever I create would have an impact on real people stressed me at the beginning, but helped me learn a lot more and become a better programmer. I loved the fact that this was not another project that whatever I created would be graded and never seen again. Instead, other people will use, view, and edit my work in the future. I give another acknowledgement to Mr. Ryan Emberling and Mr. Brian Rojas who gave crucial advises and supported me throughout entire project as well as Dr. Neil Heffernan for providing this opportunity.

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