A Move to Sustainability: Launching an Instructor Interface

Abstract

Sketch Mechanix, an NSF-IUSE funded research project, launched a new feature with the Fall 2022 semester: an instructor interface. Sketch Mechanix's development had previously focused upon converting to an html platform and then expanding problem types. The initial problem that was featured was truss analysis (method of joints). The second problem type was free body diagrams with point loads at any angle. The most recent sketch recognition feature was the addition of applied moments, using a curved arrow. For any of these problem types, Sketch Mechanix features sketch recognition and automatic feedback to students on their free body diagrams through an online homework platform.

With this latest innovation, instructors adopting this novel homework system can now input their own problems, view student scores broken down by problem, and adjust assignment due dates. Prior to the launch of this interface, all of these features involved emailing the development team. For instance, the instructor previously had to email the desired problems, their solutions, and points awarded, as well as wait for the developer to email back student scores to be able to see how students were doing. While sketch recognition has long been the key draw to using Sketch Mechanix, the addition of the instructor interface will aid in the project's sustainability as it nears the end of the grant period. This paper and poster describe the instructor interface, including screen shots, share feedback from instructors who tested the interface in classes, and detail the future of the program.

Introduction

Free body diagrams (FBD) are a basic and useful concept taught in entry-level undergraduate courses that help students understand the fundamentals in several fields of engineering. Since FBD are frequently used in most introductory engineering courses such as physics and statics, where there can be hundreds of students enrolled, receiving effective feedback becomes an issue. In addition to feedback, grading becomes more of a burden on the instructor due to the vast number of students in these entry level courses. As a result of this burden left on the instructor, many resort to web-based homework systems to handle grading and provide feedback for students without relying on the instructor for it [1].

Background

The issue this research project aimed to resolve was a student's ability to properly sketch and have a better understanding of FBDs. FBDs help increase learning by decreasing a problem's cognitive load [2]. Furthermore, when drawn correctly, FBDs can significantly assist students, and having thorough feedback when students are moving in the wrong direction is critical to learning properly without forming misconceptions on the topic [3]. Martin-Erro et al. [4] further argues that sketching is a core component for facilitating creativity and visual thinking.

As a result of these findings, this research project developed a software called Sketch Mechanix to assist with addressing the shortcomings of online homework systems. Mechanix was developed as a web-based software platform that utilized sketch recognition technology to provide immediate feedback to students on sketching whereas traditional online homework systems struggled to deliver. Since immediate and informative feedback has been proven to improve learning capabilities for students [5], Mechanix solves the issue by giving informative

feedback immediately about the student's FBD. When using Mechanix, students are assisted by means of scaffolded learning, where they are given hints to guide them in the right direction if ever confused on any aspect of the problem. Scaffolded learning is a proven tool to facilitate learning of complex topics [6] by giving hints [but not the answer] when they run into an error. Once the students have successfully sketched the FBD, they are then able to proceed with the problem and begin to enter numeric values, including units, into the provided text boxes. Figures 1 & 2 show a FBD and truss problem, respectively, just after the FBD has been recognized, which is when the textboxes on the left-hand side become available for students to fill in. Mechanix is then able to provide feedback on the units and numerical values entered into the same text box and then check to see if the student answered correctly.

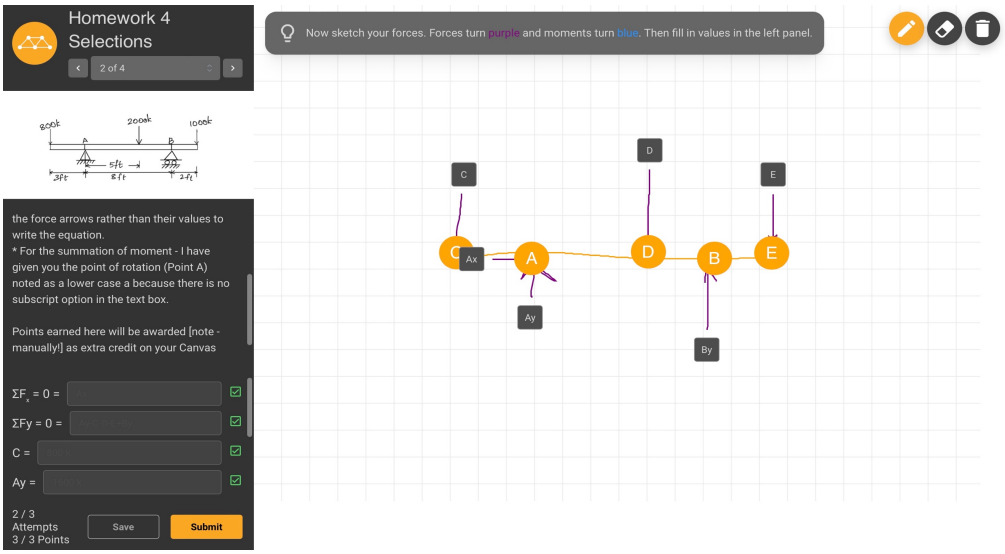

Figure 1 An example of a FBD drawn and labeled with forces.

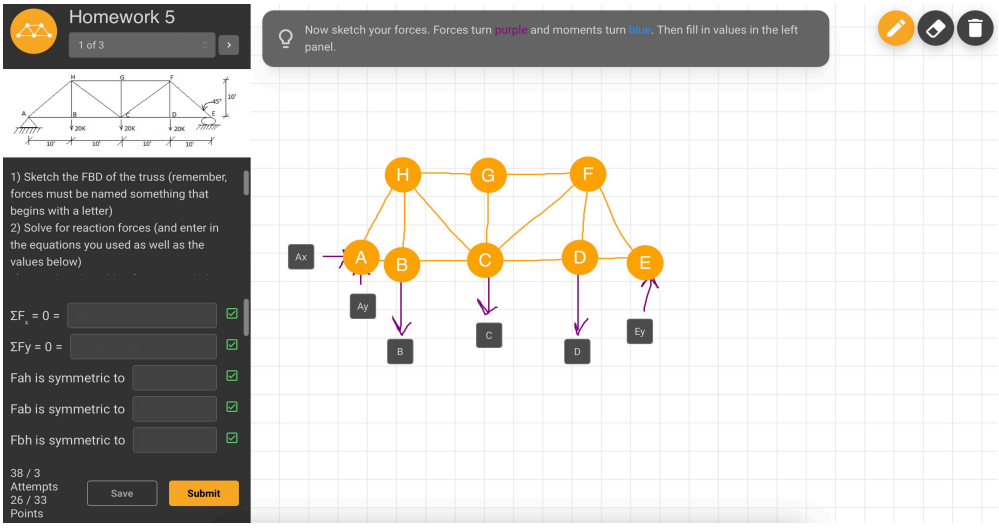

Figure 2 An example of a FBD for a truss drawn and labeled with forces.

The prior scenario for inputting problems and reporting results heavily involved the developer.

The instructor would email problems (both the initial art/text for the problem and the solution) to the developer and then check the problem once the developer had entered everything into Sketch Mechanix for that instructor's profile. If there were any issues, there was another email trying to explain the situation. After the students took the assignment, the developer would email the scores back to the instructor, but there was no way for the instructor to monitor their students' progress during the assignment.

Methodology

The instructor interface was tested in Fall 2022 at TXST in two sections of Structural Analysis (CSM 3360). Students were randomly assigned to test or control groups within each section. The instructor created two homework assignments (one on FBD and the other method of joints truss analysis) within Sketch Mechanix in order to evaluate the interface. Throughout this process the instructor and the developer were in contact via email whenever issues arose. Some of these interactions resulted in additional features being included in the instructor interface – especially in the area of grade reporting to the instructor.

Instructor Interface

Assignments

Upon logging into the website with instructor credentials (the developer set the instructor's account to be an instructor one rather than a student account), the instructor initially sees the existing assignments as shown in Figure 3. The drop-down menu at the top center of the page (beneath the word "Assignments") allows the instructor to toggle between their various classes. The names of the drop-down menu items are the registration codes for those group of students. This page allows the instructor to preview the assignments they have created.

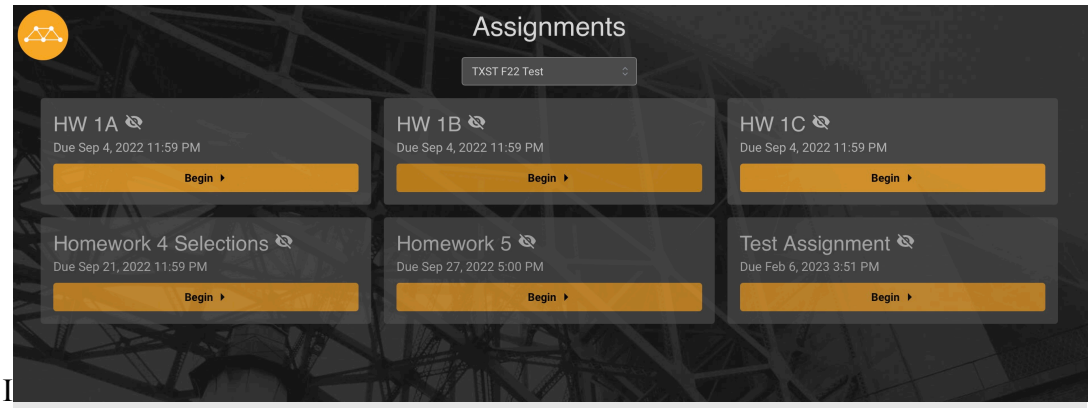

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Figure 3 Instructor assignment's page.

Management

Selecting the orange truss logo in the upper left-hand corner brings up the menu of pages within the interface. By selecting "Management" the view changes to the Assignment Manager. This page allows the instructor to set open and close dates for assignments as shown in Figure 4. It is also the place to create new or modify existing problem sets. As seen in Figure 4, assignments can be links to surveys, which were needed for this research study, as well as problems solved within the system. For an assignment with problems, clicking on the icon with the number of

problems reveals thumbnail images from the assigned problems as well as the accompanying text, as shown in Figure 5. From these thumbnail versions of the problems, the instructor can reorder the problems using the up and down arrows on the right-hand side, delete them using the trash can icon, or edit them using the pencil icon.

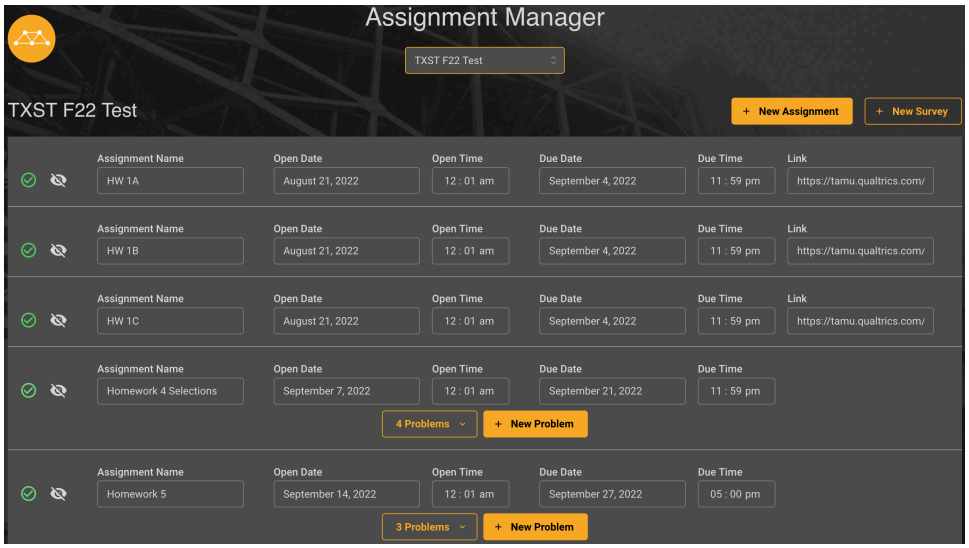


Figure 4 Assignment manager page.

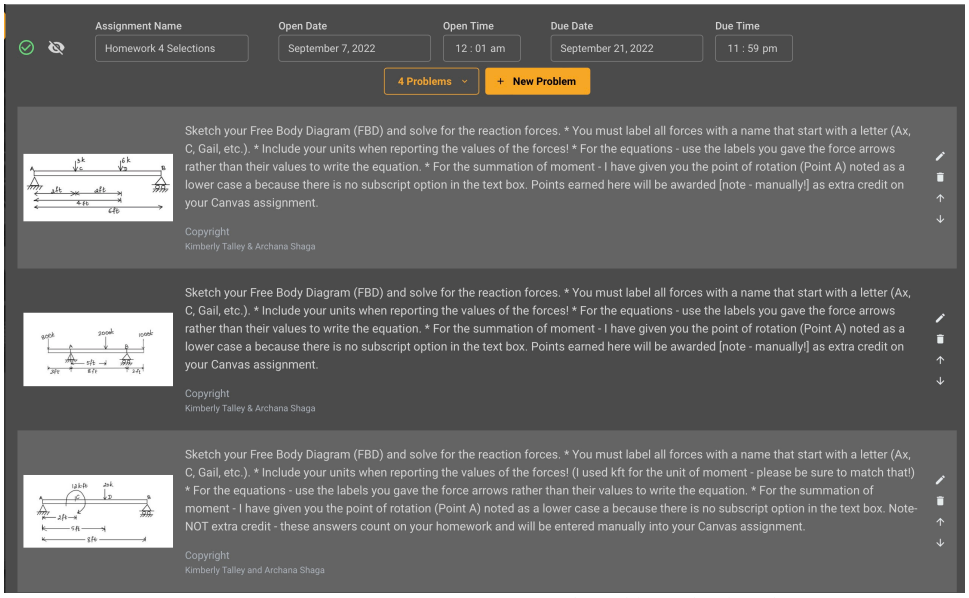


Figure 5 Assignment manager page with problems displayed.

When creating a new problem, the instructor either selects “New Assignment” at the top if that is the case, or “New Problem” within an existing assignment. The New Problem page prompts the instructor to select the type of problem (truss, FBD, or point mass) to help the program know what sort of sketch to analyze. As shown in Figure 6, there is a place to upload an image for the problem statement, text for the problem, and copyright information. Below these items is the answer section. The equations of force equilibrium are initially populated but can be removed if not desired. To prompt students to fill in values, the instructor must add an “equation” and type

in the variable and "=" into the equation textbox. The instructor will need to type in all answers in the answer textboxes, assign points to each, and sketch the FBD that is the solution for the problem.

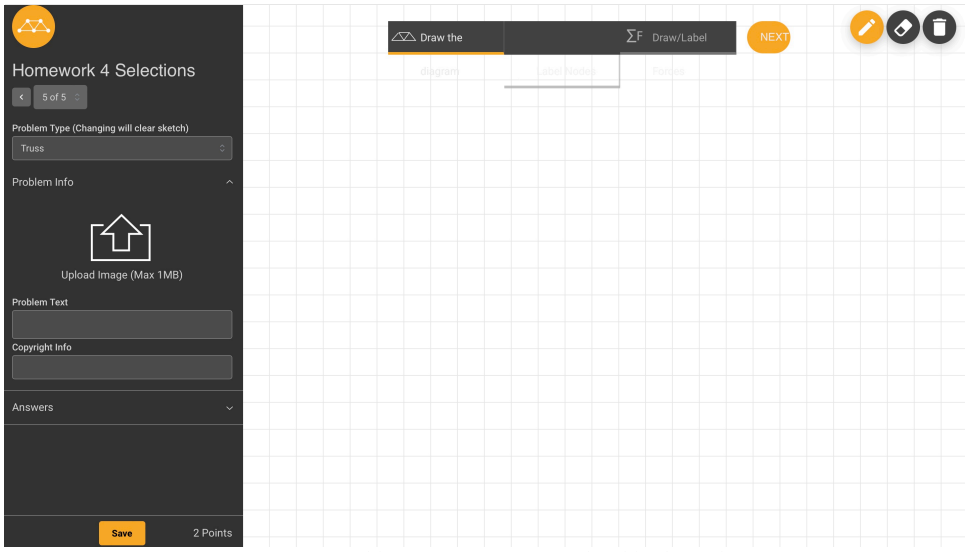
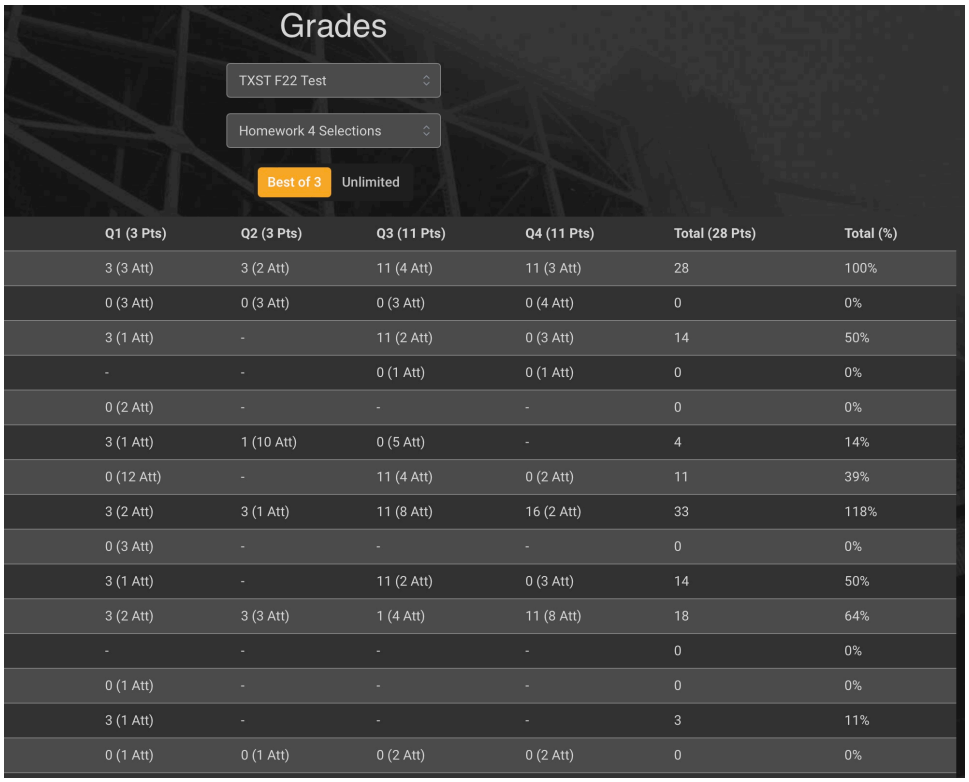


Figure 6 New problem creation page with a blank workspace.

Grades

Navigating back to the orange truss logo, the selection of "Grades" from the menu brings the instructor's view of student performance. A drop-down menu at the top center of the page allows the selection of the section, and then the next drop-down menu allows selection of the homework assignment, as shown in Figure 7. The student grades are displayed by question (with number of attempts taken in parenthesis), as well as the total points and percentage of points earned on the assignment. The instructor must transfer this information to their gradebook manually, although the user can highlight the text with their curser and use their keyboard to copy and then paste the text into a spreadsheet.



Q1 (3 Pts)	Q2 (3 Pts)	Q3 (11 Pts)	Q4 (11 Pts)	Total (28 Pts)	Total (%)
3 (3 Att)	3 (2 Att)	11 (4 Att)	11 (3 Att)	28	100%
0 (3 Att)	0 (3 Att)	0 (3 Att)	0 (4 Att)	0	0%
3 (1 Att)	-	11 (2 Att)	0 (3 Att)	14	50%
-	-	0 (1 Att)	0 (1 Att)	0	0%
0 (2 Att)	-	-	-	0	0%
3 (1 Att)	1 (10 Att)	0 (5 Att)	-	4	14%
0 (12 Att)	-	11 (4 Att)	0 (2 Att)	11	39%
3 (2 Att)	3 (1 Att)	11 (8 Att)	16 (2 Att)	33	118%
0 (3 Att)	-	-	-	0	0%
3 (1 Att)	-	11 (2 Att)	0 (3 Att)	14	50%
3 (2 Att)	3 (3 Att)	1 (4 Att)	11 (8 Att)	18	64%
-	-	-	-	0	0%
0 (1 Att)	-	-	-	0	0%
3 (1 Att)	-	-	-	3	11%
0 (1 Att)	0 (1 Att)	0 (2 Att)	0 (2 Att)	0	0%

Figure 7 Grade management page for homework 4 selections.

Results & Discussion

There were some challenges that were conquered during the semester of implementation as well as various improvements to the interface that were identified.

Challenges Faced and/or Overcome

There currently is no way to move or copy an assignment between student groups/sections. When the instructor accidentally made an assignment in the control group, which was only going to take the pre- and post-semester surveys through the platform, the developer was able to move that assignment to the test group. While this short-term solution alleviated the immediate issue, it showed an area for future improvement.

Initially, the student grades displayed in the Grades section were only the total points and percentage of points earned by student for each assignment. The instructor wrote to the developer during the semester to request question-level scores, and that change was incorporated into the instructor interface immediately.

The students reported some issues with having their sketches recognized, but there was nothing the instructor could do to help them, which was frustrating.

The only way that appears to exist for having students sketch the joints within Sketch Mechanix for their method of joints truss analysis is to break the problem into multiple “problems” and use the point mass feature for each joint within the truss. The subsequent ordering of problems would force the students to complete the problem in a certain order (assuming students work one

problem at a time) but would allow them to submit their joint FBDs, which is otherwise not possible in the Truss problem mode.

There were times that the instructor in this study sketched a rectangle for the FBD solution, but the problem changed the correct solution into a straight line. There was no way to force it to draw a rectangle. While not ideal, this issue was one that was lived with.

Areas for Future Improvements

The instructor interface still has some areas to improve to provide similar functionality as other online homework platforms, such as Canvas. These features are a wish list for future work on the interface:

- Add a way to delete assignments
- Add a way to copy assignments and/or problems between class sections (it would not be practical to keep adding new semesters' worth of students to existing classes and feels like a waste of effort to keep recreating identical assignments)
- Add a way to see students' submissions and detailed grading breakdown. (The instructor has a chance of determining what is causing the students confusion if they can see their wrong answers.)
- When creating a FBD problem, the original problem image is shown in the sketching field (akin to a watermark) for use in tracing the FBD. Increasing the time that watermark image is shown to include sketching the forces/moments applied to the body would assist students in accuracy of their sketches.
- Add a way to note dimensions on the FBDs. As the current version of Sketch Mechanix does not allow sketching the dimensions, it leads to reinforcing the misconception that an incomplete FBD is a correct FBD.

While it was great to have the developer available to add features (such as changing the Grades page to include question level scores instead of just the total scores) and to fix instructor errors – like building the test homework in the control section – it would be more ideal to already have the functions on the wish list. That way the developer does not need to be so involved with all faculty and the program can run more self-sufficiently. Even with some of the challenges, it was far preferable to be able to input and edit homework sets and collect the grades rather than to constantly email the developer.

Conclusions

Having an instructor interface (especially if can add the ability to copy problems from one class to another!) frees up the developer from being so involved in every homework assignment and helps transition the project to a sustainable platform. The current instructor interface is a step in that direction and was a far better experience than not having one at all.

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