Capstone Proposal – Christopher Hansen

1. Project Scope

1.1 Project Title
Digital Twin – A digital replica of a complex physical object for instructional purposes.

1.2. Project Goal
The goal of this capstone is to create a digital replica of a complex physical object. This object will be composed of varying components. The digital replica would be broken down into a set of instructions that demonstrate and guides a user through assembly of the object. This representation would be done online utilizing webgl to render 3d objects.

1.3. Learning Goals
I believe the technology exists to create a feasible highly curated environment for technical/vocational learning and intend to use these tools to investigate this. My goal is to investigate and implement the viability of technologies that could allow this to happen. My skills developed during this process will be the capability of utilizing front end web languages to address the educational needs of technical training/instruction.

1.4. Target Audience
The current audience for the proposed implementation of the project will be owners and operators of the Dremel 3d45 3d printer.
Users will utilize this project to aid in the repair and maintenance of their 3d printers. This set of instructions will be made available online and accessible to anyone with an internet connection and a browser that supports webgl. The current demographics are individuals in educational institutions (high school, college). These could be faculty who purchase a machine for research or instructional purposes, technicians who manage equipment, students who work in labs, shops or makerspaces that help to maintain the equipment in these spaces.
Given the skill range, knowledge, experience and expertise, this tool is intended to close that gap and offer all users a thorough and comprehensive set of instructions on the repair of these machines. The current number of users for this machine based on the number of units that have been sold are about ~10,000 (Harvard alone currently owns over 100 of these units that I am aware of). This could be expanded as the equipment supported by this representation is increased.

For purposes of this project, the intended audience would
be a curious individual who would like to endeavor on a project that they do not feel they have the knowledge of skill set for. Larger audiences could be educational

institutions wanting to create online courses/instruction for technical/vocational skills or commercial industries providing training in an online environment.

Sample User Profiles:

Persona 1 - lab manager
Thinks - how do I maintain and fix this equipment? How do i train other to fix this equipment?
Feels - uncertainty, anxiety
Does - educates themselves. Gathers and evaluates all available resources

This tool will help to reduce anxiety and uncertainty about how to maintain and repair equipment. Allowing piece of mind to the manager in having a clear set of instructions they can give to others.

Persona 2 - student worker
Thinks - i don't know what i'm doing
Feels - uncertain, not confident in abilities
Does - waits to be shown what to do

This tool will help this user feel confident in their ability to fix and be shown how to maintain the machines.

Persona 3 - company representative
Thinks - how do i help owners of the equipment?
Feels - overwhelmed, confused
Does - impart knowledge they have as clearly as possible

This tool will give a customer rep the confidence to tell a potential customer that they have documentation and information that will enable the customer to maintain this equipment.

1.5. Elevator Pitch

Take a Haynes technical manual and repurpose it for the digital age with it being curated similar to the lynda.com learning environment.

The product will be an interactive technical manual. It will display, in a 3d environment, technical documentation accompanying a 3d model of a specific piece of hardware. This will be accessible via and web enabled device and present itself in a highly curated step-by-step manner.

1.6. Metrics

The digital twin of a piece of hardware would ideally have a commercial component, meaning users could order parts from it, click on a component and have part and price info of that component. I believe the success could be measured by how many people use the interactive instructional environment to order components

represented. So the viability and success would be self-evident in its ability to generate revenue. Additionally, the project could exist on a website where users are required to create accounts to access the tool. Success could then be measured by the amount of user accounts are created to access this tool.

Survey questions:
1. Was the presentation of instructions intuitive?
2. Is a 3d environment difficult to navigate?
3. Were instructions clear?
4. Does each step clearly define and illustrate tasks to be done, what tools needed etc?
5. Would you like to see this presentation used for other pieces of hardware repair and/or training?
6. Have you used a tool like this before?
7. Where you able to follow this tutorial to completion?
8. Would you use this again?
9. Would you recommend this to others?
10. Was this tool frustrating to use?

Rubric used to evaluate progress and project and capstone attributes

	1	**2**	**3**	**4**	**5**
User able to complete Tutorial	No	User can get part way through	User can complete barely	User can complete with help	User can finish unaided
User frustrated by Tutorial	yes	Yes, but with coaching can complete	Can complete with minimal help	Can complete but something unclear	Can complete easily and intuitively
All steps are clear	No, unusable	No, but with clarification is usable	Not intuitive, but doable	Yes, but some clarity needed	yes
All tools needed are Properly identified and Associate	No, no secondary tools identified	Tools identified but not associated with steps	Tools loosely associated with appropriate steps	Tools associated with steps but could be clearer	All tools needed for steps are clearly identified for specific task

Each step clearly lustrated And described tasks to be done	No step has secondary illustrations	Illustration exist, but not identified with each step	Illustration exist and are loosely associated with steps	Illustration are clear	Illustrations can exist as stand alone objects.
d with each step					
Each step clearly lustrated And described tasks to be done	No step has secondary illustrations	Illustration exist, but not identified with each step	Illustration exist and are loosely associated with steps	Illustration are clear	Illustrations can exist as stand alone objects.

1.7. Life of the project beyond capstone

Currently, there is a tentative agreement with bosch tools for them to utilize this tool and make it available to their customers on their website.

In a larger sense, this presentation could be used to represent other tools and technical processes. Which could lead to the online presentation and learning of hands on skills, which currently does not exist in a very informative/intuitive format with distance learning.

The final form I would like to see this project become is a platform for users to upload their own 3d files and annotate them for instructional purposes. Much like youtube allows users to upload videos for others to watch.

2. Competitor review

Competitor 1:

Lynda.com

Lynda.com offers a wide range of software tutorials. They provide access to training, expert knowledge for various software programs. Users can access these trainings and tutorials from any device that has an internet connection and work at their own pace. This website is subscription based and tracks all user use of content.

Pros: accessible to anyone with an internet. Lots of content.
Cons: membership/paid subscription. No real person to contact or ask questions to

Competitor 2:

Haynes manual

The Haynes manuals are highly detailed assembly instructions for primarily automotive vehicles. They break the automobile into different parts and components in exploded diagrammatic drawings that illustrate how everything fits together. Labeling components in the drawings with their names.

Pros: beautifully graphically illustrated. All components are labelled. Is a physical product so users can take and user anywhere
Cons: is physical , so users have to purchase and maintain a copy. All graphics are status 3d images which can lead to ambiguity.

Competitor 3:
Dozuki.com
Dozuki is a website that allows individuals to create technical instructions. These instructions can include text and pictures and allows users to annotate images. Additionally, users can break down technical tasks into steps for users to follow. It also allows for the tracking of users in the instructions/tasks assigned or selected. How long it takes users to complete, how long they spend on each step.
Pros: online, user tracking of progress to create metrics. Easy for users to create instructions much like a wysiwyg editor in a CMS system.
Cons: subscription based. Only allows 2d content.

Each competitor offers different solutions to a similar problem. They have different target audiences which may be a reason for their different styles of delivery of information. Additionally, the time in which each competitor developed its product very clearly shows the discrepancies in technology available at the time. As with everything, each competitor has its strengths and weaknesses.

Summary Table Highlighting Difference with Competitors

	Lynda.com	Haynes	Dozuki.com	My Project
Accessible	x		x	x
Intuitive		x	x	x
Graphically clear		x	x	x
Self paced	x	x	x	x
Accessible online	x		x	x
Clear UI	x			x
Easy content creation			x	x
3d environment				x
2d graphics	x	x	x	x
Videos	x		x	x
Optimized for mobile			x	x

3. Technology requirements
Technologies Needed

Webgl/HTML canvas element
Webgl allows for the rendering of 3d objects in a web browser.

Course: DGMD E-15   Screen-Based, Physical Computing.
Description:
This course allowed me to explore the library of three.js and its implications in generating/displaying 3d objects in the browser.

Alternative Technology:
There really isn't an alternative, this technology is deployed in various mediums. Through canvas element on a webpage or through a proprietary web browser plugin. The precursor to this was flash, but that is no longer relevant. I've chosen this as opposed to unity3d, as no special download are needed and any user with a

webgl compatible browser can simply navigate to the webpage to view 3d renderings.
This technology will be used to render 3d objects in a browser.

3d modeling software

3d modeling software allows for the creation of 3d objects that can be interacted with. I will likely make use of rhino3d to generate and edit 3d models.

Course: DGMD E-70   Principles of Game Design.
Description: This course offered introduction to maya and 3d modeling. But my 3d modeling experience comes from my formal education in Architecture and Design.

Alternative Technology:
There are several alternative 3d modeling software. Maya, 3dsmax, solidworks are a few alternatives. I've chosen to work with rhino 3d since I am most familiar with it.

HTML/CSS/JS

The project will be presented in a webpage. As such, front end web technology will be used for this presentation. The only current known library that will be used is three.js. This library allows for the rendering of 3d models in a web browser.

Course: CSCI E-3   Web Programming/JavaScript, DGMD E-12   Creative Exploration/Web, CSCI S-12   Website Development, DGMD E-15   Screen-Based, Phys Computing.
Description: The listed courses exposed me to front end web development and its applications. These courses are largely why I am able to do this project and present it in a web format.
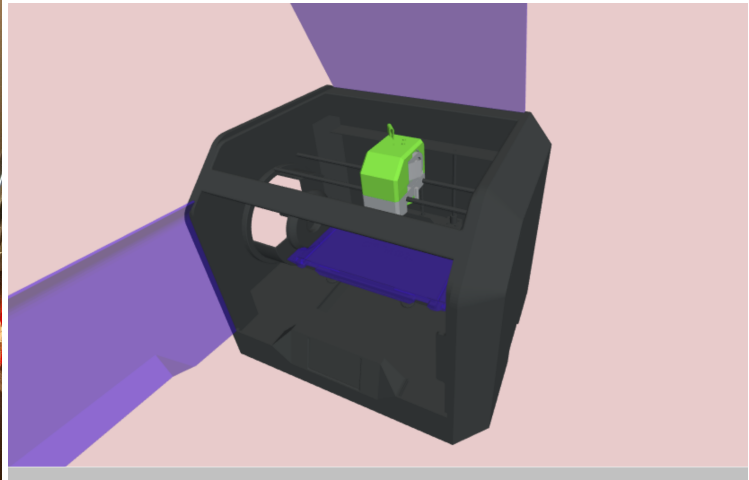
Alternative Technology:
This project could be done somewhat similarly utilizing a game engine and php/c# programming. But given using a game engine as a medium for presentation may make the project less accessible, requiring special downloads or plugins, where my intent is to make this as accessible as possible.

4. Visuals describing how your product will be used

The project will consist of a webpage. This webpage will render and display a digital replica of a physical piece of hardware. This webpage will act as an interactive guide to perform a technical task.
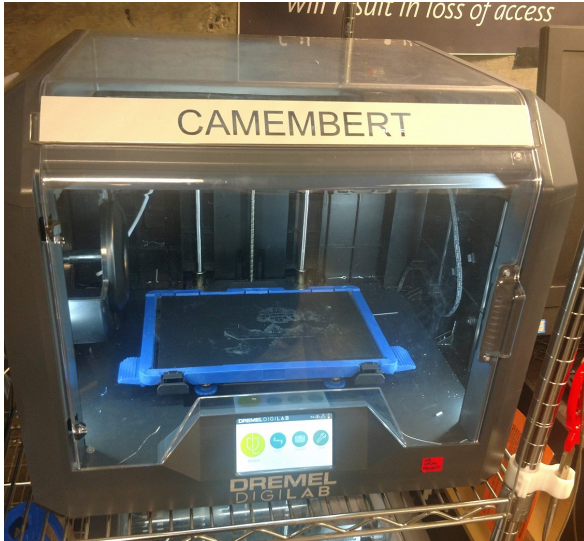
Dremel 3d printer webpage   3d model of 3d printer rendered in a

This 3d model that is rendered in a webpage will be interactive. Users will be able to zoom in/out, pan and rotate around the model. This is meant to simulate, as much as possible, interacting with the physical object. Components will be modeled as they currently exist.

This environment is meant to be interactive with relevant information being displayed depending on the task the user would like instructions on. The display may look something like the following image, with annotations/menys overlayed on the 3d model.
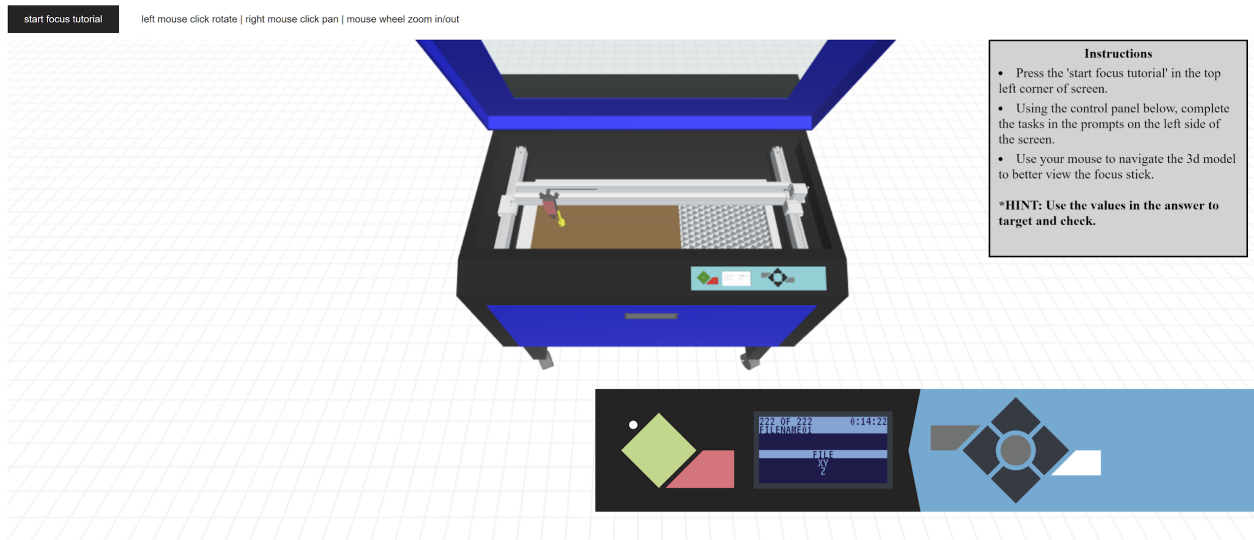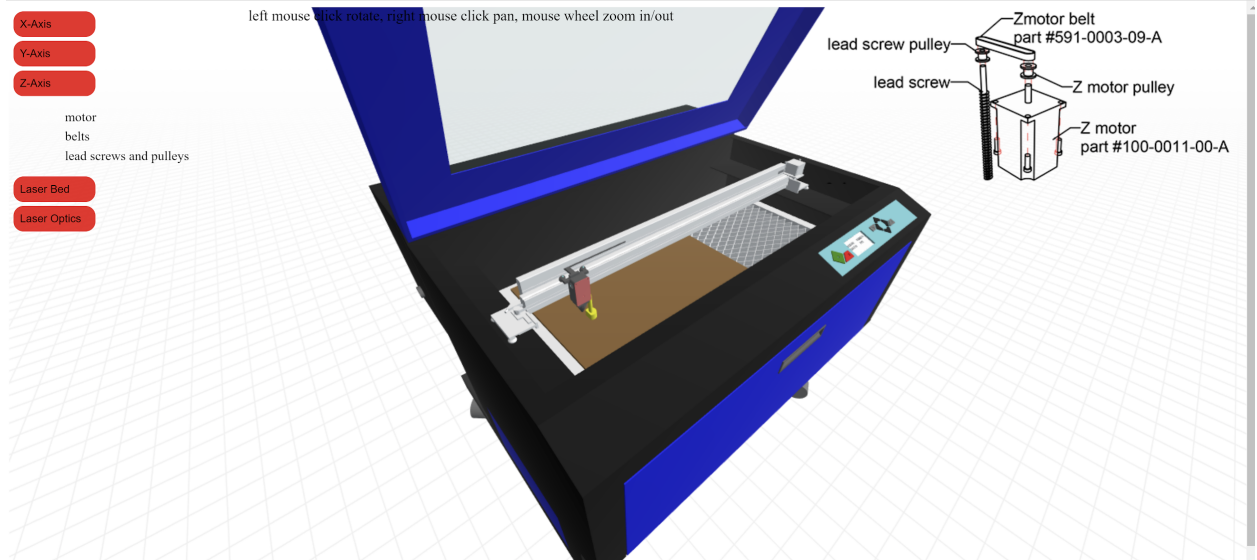

Source:
https://fablabgsd.s3.amazonaws.com/lasertraining/focus_ui/laser/focus.html
Interactive hardware training environment

The information will vary, some of it will be dynamic to the model, some of it will be illustrations/images/videos or whatever format best describes the current process.Tools needed for a step will also be included.As well as part numbers.
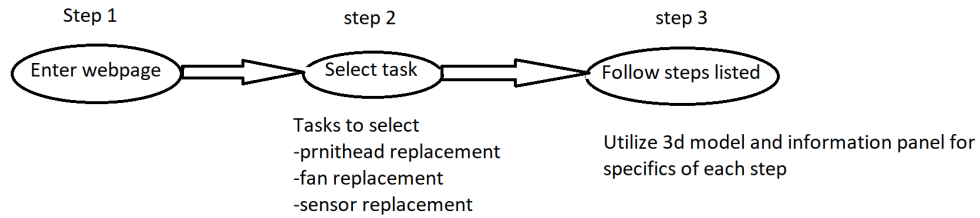

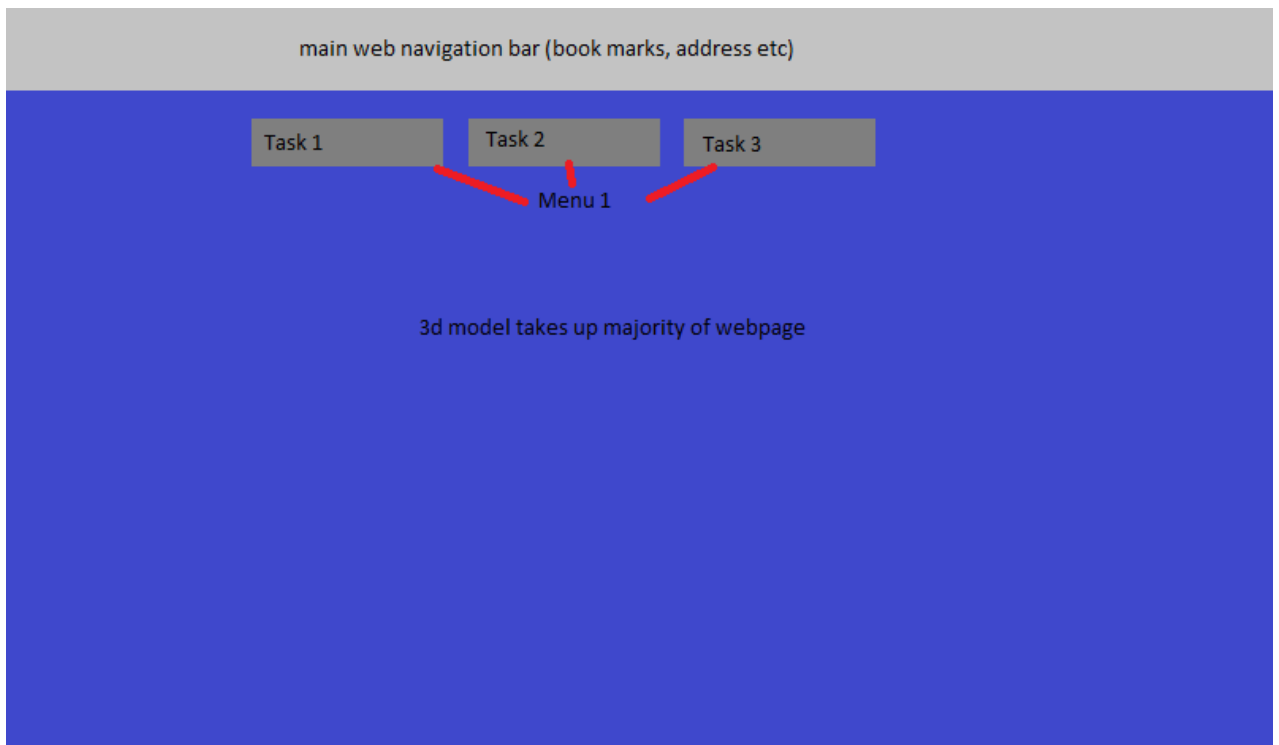
Example of extra information embedded into webpage
Source:
https://fablabgsd.s3.amazonaws.com/lasertraining/focus_ui/laser/laser.html

Steps in using this tool/environment would be as follows:

Step 1	step 2	step 3

Enter webpage ⟹ Select task ⟹ Follow steps listed

Tasks to select
-prnithead replacement
-fan replacement
-sensor replacement

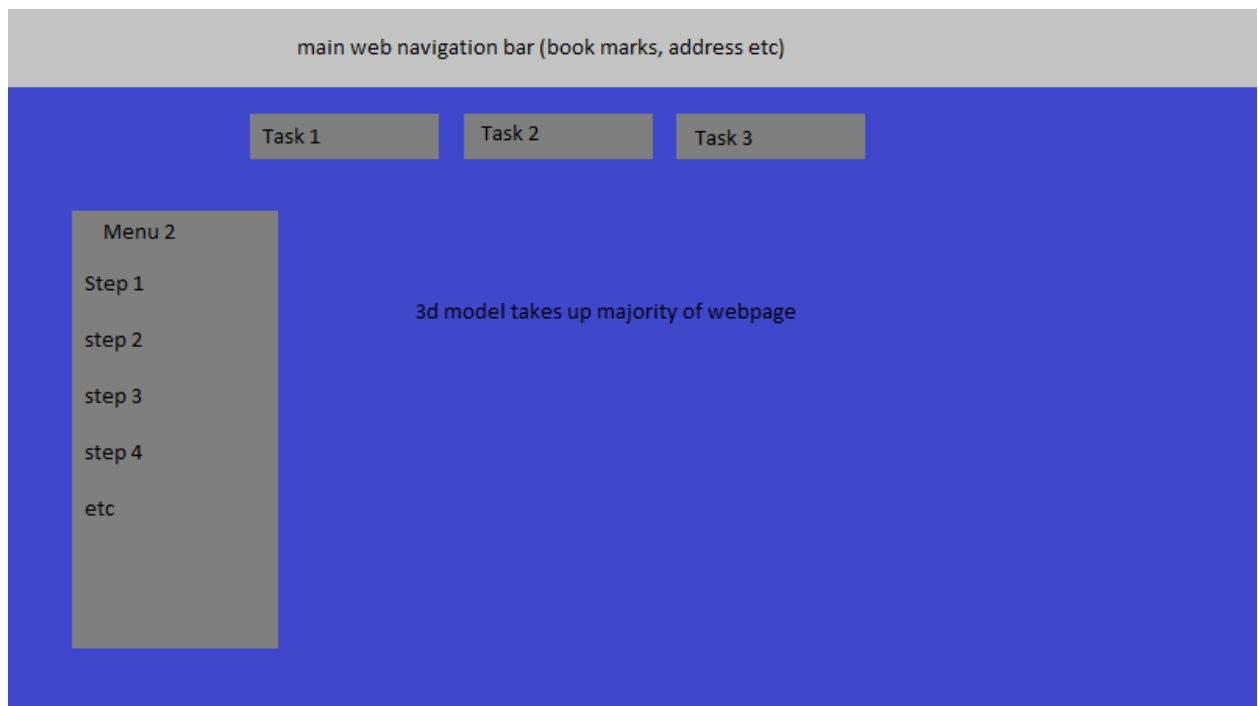Utilize 3d model and information panel for specifics of each step

Step 1:

User navigates to a webpage the display a digital replica of hardware they are engaging with. From this initial page they will select the task they want to perform.

main web navigation bar (book marks, address etc)

Task 1   Task 2   Task 3

Menu 1

3d model takes up majority of webpage

Step 2:

From a menu, the user would select the process they would like to be given a tutorial of how to perform. In this case it would be maintenance/repair tasks of a dremel 3d45 3d printer. Once selected a second menu of the task broken down by steps would appear. Users would click on the steps in menu 2 and follow instructions presented.

main web navigation bar (book marks, address etc)

Task 1   Task 2   Task 3

Menu 2

Step 1

step 2   3d model takes up majority of webpage

step 3

step 4

etc

Step 3:

Once a task is selected, a list of steps will be displayed. Users will sequentially select each step. When selecting a step, the 3d model will change to display the machine in the appropriate state of disassembly/assembly. Additional annotations/tool needed will be displayed in a separate information panel. The info panel supplies extra annotation where the users can click on links and images here.

main web navigation bar (book marks, address etc)

Task 1   Task 2   Task 3

Menu 2

Step 1

step 2

step 3

step 4

etc

3d model takes up majority of webpage

3d model would change and display/hide and annotate components as steps are selected.

Info Panel

Information/instructions revelvan to step selected shows here.

i.e. tools needed for step, additional annotations (videos or 2d images)

This will be a self-paced exercise, where users can toggle back and forth or jump between steps as they would like.

5. Work plan and milestones

Generate Digital Assets
Now - August 30th

This task is creating/gathering 3d objects/models that will be the backbone of the webpage. This creation of 3d object will be done in rhino3d.

Generate supporting graphics (images, videos)
Aug 1 - Aug 30th

In addition to the 3d objects, supporting graphics will be needed to add clarity to each step of tasks users will engage in. This task will entail creating 3d objects, gathering/creating necessary animations and/or videos. These 2d graphics will be generated in photoshop/illustrator.

Label Digital assets and create staging in 3d modeling software
Aug 30 - Sept 15th

The project will be prototyped and laid out roughly in the 3d modeling software. Part of this is labeling and annotating each step on layers in the 3d software to give a good visual indicator before heavy web programming is done. This will be done in rhino3d.

Develop UI for web page
Now - Sept 30th

Web development of the interface for the webpage. Attention being given to intuitiveness and simplicity for accessibility by all users. This is done using html/css/js.

Incorporate Assets into webpage
Sept 30th - Nov 15th

Take the digital assets (3d and 2d objects) and program them to display and interact properly in the webpage. This will be accomplished using html/css/js.

Test
Nov 15th - Nov 25th

Testing the page and determining problems. I will do the testing and perhaps recruit students who, I employ and would use this tool, to provide feedback.
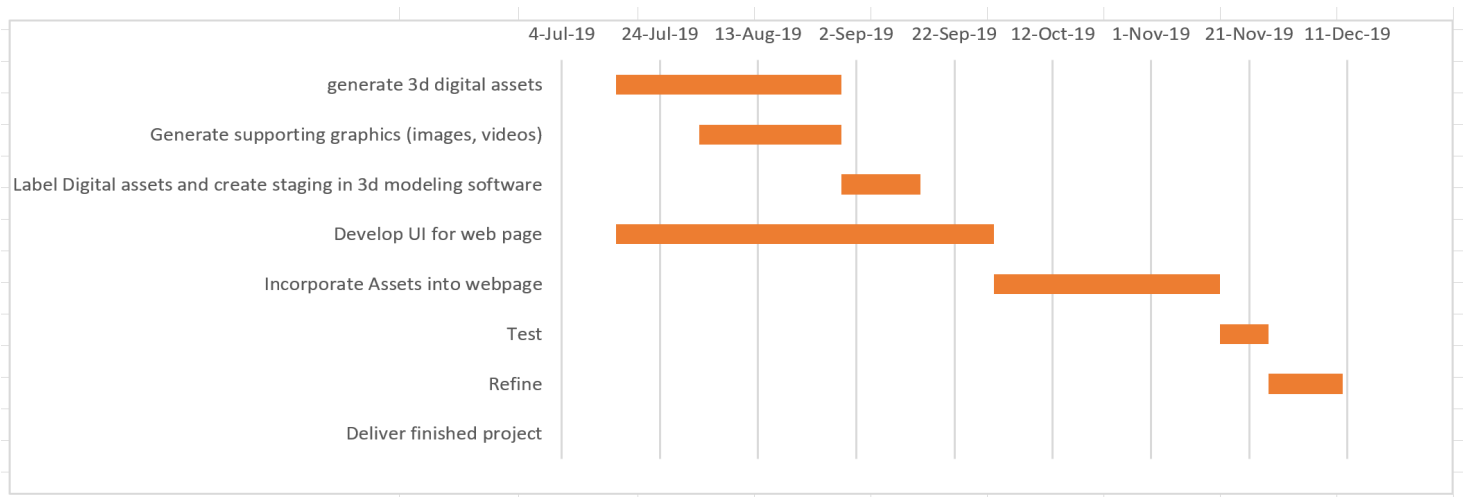
Refine
Nov 25th - Dec 10th
Applying solutions to identified problems. Problems could exist in clarity of the 3d model, requiring more digital assets to be generated. Problems could exist in the intuitiveness of the UI requiring adjustments to the webpage.

Deliver finished project
Last day of Semester.

	4-Jul-19	24-Jul-19	13-Aug-19	2-Sep-19	22-Sep-19	12-Oct-19	1-Nov-19	21-Nov-19	11-Dec-19
generate 3d digital assets		██████████████							
Generate supporting graphics (images, videos)			██████████						
Label Digital assets and create staging in 3d modeling software				████████					
Develop UI for web page		████████████████████████████████							
Incorporate Assets into webpage							████████████████		
Test								████	
Refine									██████
Deliver finished project									

Milestones
The big milestones are:
- Getting all relevant 3d assets created, properly annotated and layed out diagramatically in the 3d modeling software. This should be completed by August 30th.
- Creating a skeleton UI for the digital assets to be plugged into. This should be completed by September 30th
- Plugging in all digital assets into the skeleton UI. This should be completed by November 15th.

Accomplishing these 3 tasks, will at a minimum accomplish what the larger project idea is about. Everything else is to add clarity to the project i.e. secondary 3d graphics and videos, Labeling of part numbers etc.

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ep1&type=pdf

This paper discusses the origins of simulations. It discusses the need for
simulated training that arose during WW1 when training had to
accommodate training of large numbers of people. I find academia struggles
to adequately train students in developing skillsets to accomplish tasks and
assignments given. And believe that simulated environments, much like
aviation simulations can help to bridge this gap.

National Center for Education Statistics. "Vocational Education in the United States: The Early 1990s". January 10, 2016.
http://nces.ed.gov/pubs/web/95024-2.asp

This webpage discusses vocational education in the 90's. The relevant portions discuss how students take vocational courses or degree programs to develop a skillset that can used to acquire a job. It also discusses how the skillset is specialized to a certain trade or function. It also discusses on a cursory level the attempt to integrate academic courses with vocational courses and how programs used a method of integrating academics into existing courses rather than restructuring programs. This lead to increased collaboration and coordination between academic instructors and vocational teachers. This is relevant in that this training would exist in an academic environment and attempt to impart technical skills to students in academic programs.