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Nineteenth-Century Scientific American Illustrations and the Development of American Mechanical Drawing

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Nineteenth-Century *Scientific American* Illustrations and the Development of American Mechanical Drawing

Interactive Qualifying Project Report

Submitted to the Faculty of the

WORCESTER POLYTECHNIC INSTITUTE

in partial fulfillment of the requirements for the

Degree of Bachelor of Science

Submitted by:

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Abstract

This project, sponsored by the American Antiquarian Society, involves work on the database that allows researchers to search illustrations of inventions in the early volumes of *Scientific American* (1845-1869). This database has been actively developed in a series of WPI IQPs over the last twelve years. The current project focuses on improving the website user interface. This report also discusses the history of mechanical drawing pedagogy and the adoption of professional methods for producing mechanical drawings in America during the 1800s.

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Introduction

The *Scientific American* Database sponsored by the American Antiquarian Society is an online search engine that allows academic researchers to search thousands of illustrations of newly patented inventions from Volume 1 (published in 1845) through Volume 14 (1859) of the old series and Volume 1 (1859) through Volume 21 (1869) of the new series of *Scientific American* for specific technical drawings. This project has been under development since 2007 by ten different IQP project groups. The previous IQP group earlier in 2019 totally rebuilt and redesigned the website using Python and Django coding languages that are more suited for database development.

The most pressing remaining issues of the website to be dealt with concern its usability. The database search functionality was much improved, yet the user interface left much to be desired. After the database migration prior to the 2019 group, one of the remaining issues yet to be corrected is the linking of images to the database searches to search strings. This issue will require the need of a future IQP group member with experience in database and script coding. One more attainable goal was that of improving the user experience in terms of creating an eye-catching logo, adjusting the layout and color scheme of the website, and fixing broken and missing components.

The rebuilt website utilizes a combination of modern coding languages used for database development. Those trying to make improvements to the website without experience in these new languages would find significant difficulty. Brian Flanagan, a student from the most recent IQP group, was very helpful getting the project off the ground. Since most of the new website design is based around Python and Django architecture rather than a simpler HTML website design it was important to understand the fundamentals of how these programming languages

worked. This aspect of the project had a steep learning curve. Rather than a typical WYSIWYG (What You See Is What You Get) environment in which edits can be made and then viewed, this aspect of programming involved establishing a local server on one's computer and then making edits and adjusting. Since the existing HTML code uses Python and Django commands that create routes to different iterations of title pages and design, trying to use these websites without a modern code editor can ultimately be a fruitless task. Trying to run the coded HTML pages in a standard website development software, like Adobe Dreamweaver, left the CSS and Python code unreadable. Obvious edits that needed to be made were unviewable and therefore uneditable. Many hours were spent watching and reviewing online Python and Django tutorials and following along while coding myself.

Brian helped me establish a Github account and gave me access to the Github repository where the total archive of the *SCIAM* project is stored. He also established a separate branch within Github for my personal development and improvement on this project. This was done as to not affect the master backup files of the database. One issue that I ran into early was establishing an active server using the GitHub repository and learning how to modify the "manage.py" and "urls.py" file in order for the website to direct correctly to the various pages.

After performing these preliminary tasks, the goals of this IQP became: 1. Create a new Logo for the database, 2. Fix the broken Help and History links, 3. Adjust the positioning of the search bar to be more obvious, 3. Create a new masthead incorporating the new graphics, 4. Work on a new color scheme, 5. Perform general maintenance on the website for a professional appearance

<u>Website Improvements</u>

<u>Logo Design</u>

Creating a new modern logo for the *SCIAM* database was the first task to be addressed on this project. The primary graphic that currently exists on the index webpage is a masthead directly taken from *Scientific American*. While this image looks good, a modern logo with some reference to previous website iterations would help bring the website closer to a modern design. I found through the website that the first *Scientific American* fonts modern equivalent was a typeface called "Journalistic" which follows the same serif style that can be found in the original. Additionally, one of the original technical drawings within *Scientific American* from this era that I found interesting was that of Richard Hoe's rotary printing press. This image is found in the May 1, 1847 issue of *Scientific American*.[1]

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[1] *R. Hoe & Co. - History.* R. Hoe & Co. - History | VintageMachinery.org. Accessed July 28, 2019. http://vintagemachinery.org/mfgindex/detail.aspx?id=1670.
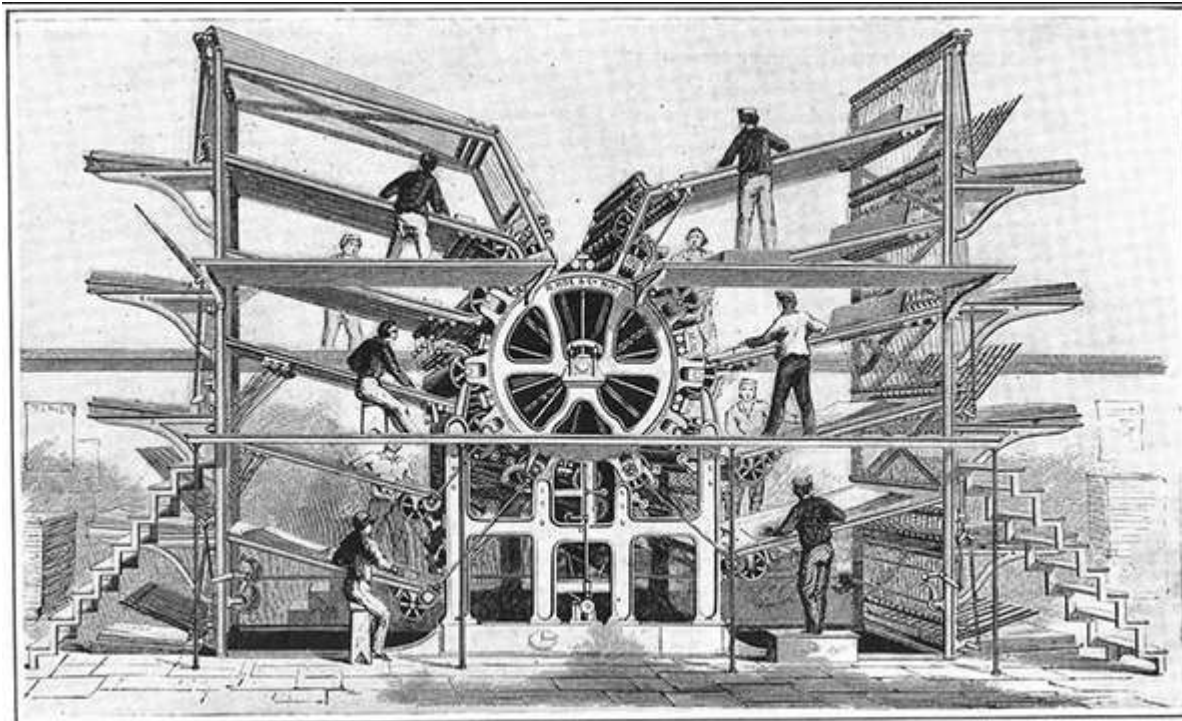
Hoe's Printing Press in <u>Scientific American</u>, May 1, 1847

This image provides what I believe to be an iconographic view of this project. It recalls the drawings that were created in *Scientific American* but brings the point of this project to the present. I took the image of the printing press and vectorized it using Adobe Illustrator to make a simpler drawing that could serve as an icon or logo for the database.

While we have yet to decide what the actual title of the website should be, it will be along the lines referencing "illustrations," "inventions," "index," etc. Some version of the alliteration of those words along tied in with modern graphics will make for an eye-catching website.

<u>Logo Figures</u>

Potential Logo Design #1
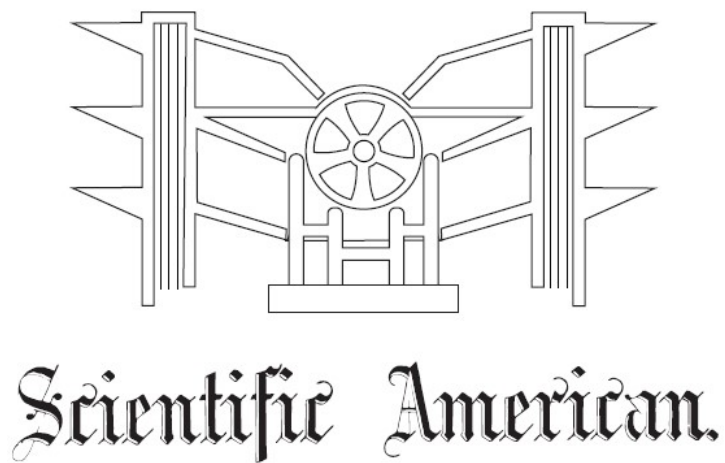
Potential Logo Design #2
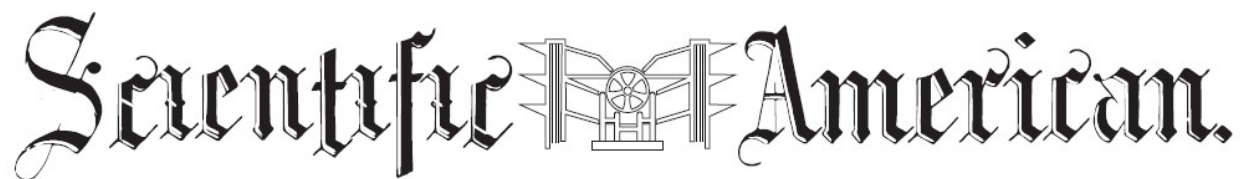
Potential Logo Design #3

<u>Existing Fonts in *Scientific American*</u>

For future reference for any students wanting to pursue this project from a graphic design standpoint, I thought having a reference of modern fonts that are similar to those used in the original *Scientific American* would be useful. Using the website "What The Font" (https://www.myfonts.com/WhatTheFont/), I imported various snapshots of the text from the PDFs of *Scientific American*. The main masthead font and general text of *Scientific American* from the earliest versions are variations of the modern font "Journalistic."

It should be noted that these fonts are copyrighted property and proper licensing must be acquired before using the fonts in an actual "live" website. These fonts are relatively inexpensive, being under $20 each. The current font being used in iterations of the logo and masthead are utilizing vectorized images taken directly from scans from the old versions of *Scientific American*, so there should not be any licensing issues using these graphics.

<u>CSS Themes</u>

The existing modular website formatting used by the previous group utilizes a CSS webpage styling and framework known as Bulma. Bulma is very convenient in terms of writing customizable code for creating fast loading and professional looking websites. However, the code needed to build the *SCIAM* database from the ground up requires significant redesign of the webpage styling. Fortunately, many developers online have created open source styling libraries that could easily be changed by modifying the "bulma.min.css" file located in the "Static/CSS" folder. These Bulma CSS changes can be instantly instituted by changing the CSS reference in the "Test_base.html" and "Test_Base_Index.html" files.

My first color iteration was based on a black background with white text as it was more visually appealing. The suggestion of Professor Bullock was that the contrast of the text to the background was too great and not ideal for researchers using the website. Instead, I opted to use a subtler color background potentially with a background image to enhance the plain appearance of the website. The documentation that is available on the Bulma website and complimenting code made it easy to understand the general formatting of the color schemes for each page. This was easily modifiable for every page on the website using the commands within the "Test_base.html" and "Test_base_index.html" files. Now the color scheme is configured appropriately.

<u>Website Layout and Design</u>

While beginning to understand how the code for the website is parsed among Python and Django, the first thing experimented with was bringing the main search bar on the index page that was initially located on the upper right-hand corner to the center of the screen below the logo. The existing layout of the website did not immediately highlight its function as a search engine. I took existing code from the frames page that creates the search bar and inserted that code into the index page and adjust its sizing based on the documentation online available for the open source CSS framework, Bulma.

The next milestone was to bring the non-functioning Help and History pages online. The HTML site for the Help page existed but when trying to access these pages, it just brought up a "Page Under Construction" progress bar. The previous group had worked on the Help page, but it had not been properly formatted for the Bulma CSS framework. I found the existing scheme that was being used and was able to reformat the existing information on the help page to finally work. One issue was to arrange the framing of the titles of subjects so they would format correctly and look appealing. This was accomplished by researching the styling pages that are available on the Bulma website. By allowing certain style definitions it was easy to set up a visible grid that would conform to the data of the different searchable topics. Once that definition was added to the Help/FAQ page everything was formatted correctly and looks appropriate for the website.

Definitions of Subjects Used to Catalog Entries

View by Letter: A C F G H L M N P S W

Subject	Definition
Agricultural Implements and Operations	Agriculture is the cultivation of live products to sustain human life. This subject refers to all tools needed to perform agricultural activities. This includes implements for operations such as cultivation, harvesting, processing, packaging, storage, and transport of agricultural goods - e.g. cattle, grain, potatoes, etc.
Arts: Fine, Polite, and Ornamental	This subject refers to any forms of art, either visual, conceptual, or musical, and the tools required to produce them. This can include actual works of art and performance pieces, as well as implements such as cameras, instruments, and other related items.
Calorifics, Lamps, Stoves, etc.	A calorific is anything relating to or generating heat or calorie burning devices. Therefore, this subject refers to heat- and energy-giving inventions, such as lamps, furnaces, chimneys, and stoves.
Chemical Process, Manufacture and Composition	A chemical process involves a reaction that changes the chemical composition of one or more substances. The manufacture and composition of chemicals would be any process for creating, mixing, or changing these substances. Examples include combustible gases, batteries, and other processes.

Updated Help/FAQ Page Table

The History page had yet to be established on the website development side and needed to have new routing configured on the "views.py" and "urls.py" files. Once these changes were established, the website could the effectively link to the new HTML file established for the history page. It was decided to use material from Frank Luther Mott's, *A History of American Magazines*, (Appendix C), a standard reference book on the subject.[2]

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[2] Mott, Frank Luther. *A History of American Magazines 1850-1865.* Vol. II. Cambridge, MA: Harvard University Press, 1938.

Website Figures
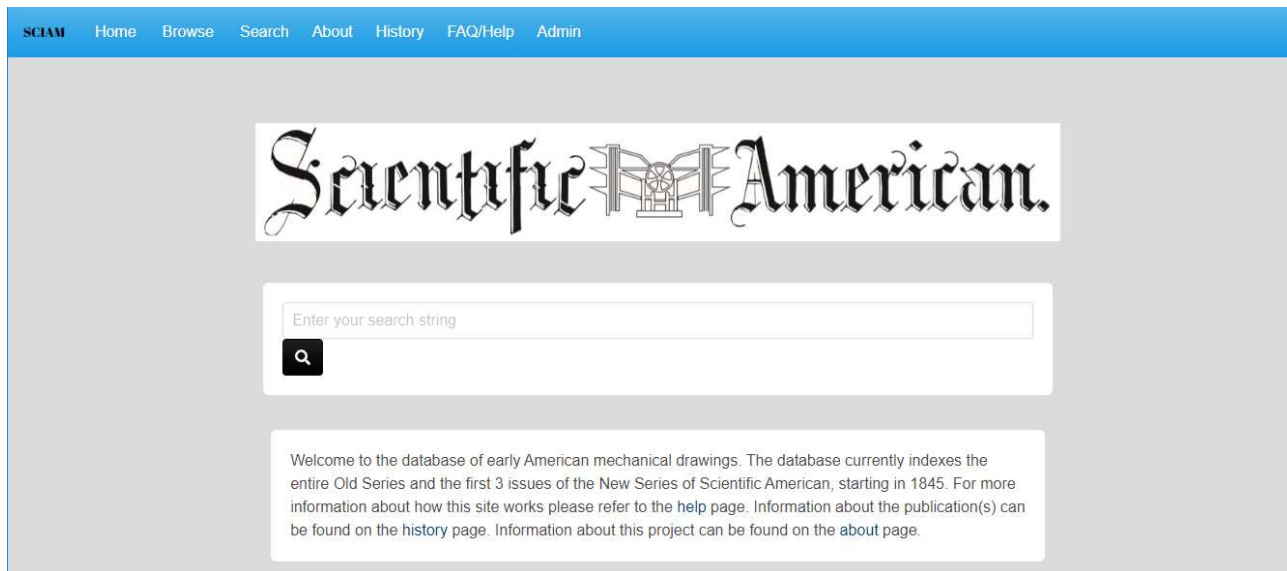
Updated Home Page Layout
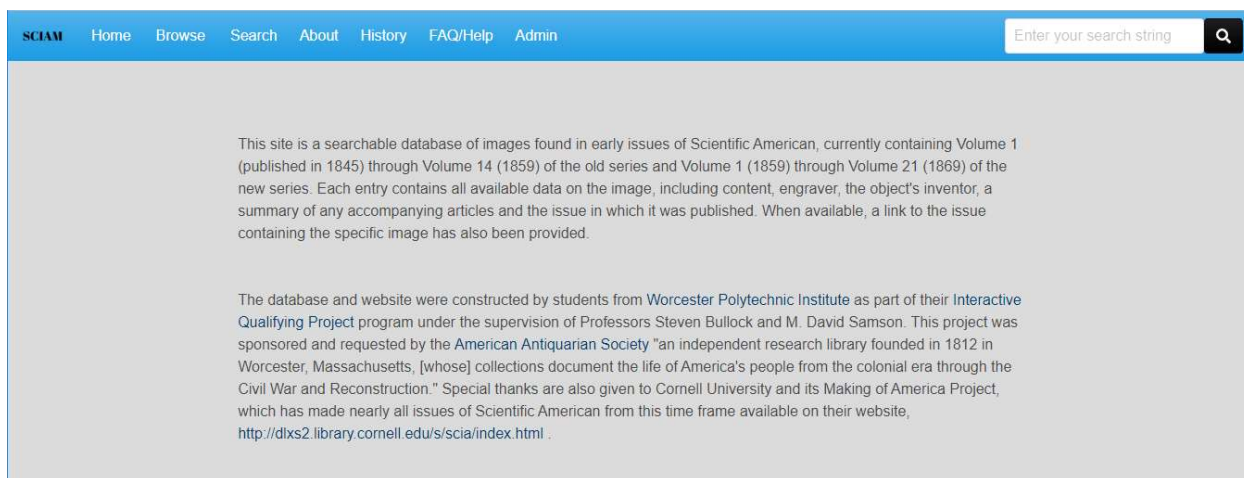
Updated About Page Layout

History of Mechanical Drawing in the United States

A previous IQP group discussed the printmakers who reproduced inventors' and patent lawyers' drawings for publication in *Scientific American*. No previous group has discussed the standards and methods that were established for producing mechanical drawings in America before 1870. These drawings are critical to the development of technical discourse in western civilization and their history begins long before the establishment of the United States. Drawings were used to convey technical information in Europe in medieval times, but a new paradigm began to develop in the Renaissance, which saw a need for representations that matched reality. Advances being made in science created a renewed interest in practical uses of geometry and a growing intention of mastering nature using technology.

In the eighteenth century, attempts were made in creating advanced drawing styles to display increasingly complex information. These drawings, although not mechanical drawings of machines, are precursors to the technical drawing style established by the mid-1800s. Most notable was that of the contribution by William Playfair (1759-1823), a Scottish engineer and economist who created graphical methods for statistical analysis. Playfair apprenticed as a draftsman under Andrew Meikle, the inventor of the threshing machine, and eventually went to become the personal assistant and draftsman for the renowned inventor and engineer James Watt. Playfair was not an inventor himself but was skilled in piecing together information from different sources to create a bigger picture. In the process of trying to make sense of his research he invented the bar chart and the pie chart.[3] The primarily goal of these early drawings were to show movement and the use of devices while remaining static. Most technical representations were made of charting and trying to find new ways to display information. Such examples were

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[3] Spence, Ian, and Howard Wainer. *Visual Revelations: Who Is Playfair.* Chance, 1997, 35-37.

that of graphing national debt levels, contour lines of maps, as well as graphic representation of the movement of animals.[4]

The French mathematician Gaspard Monge faced a similar issue at the advent of the Industrial Revolution when he served as the "Minister of Marine" during the French Revolution. He is credited with developing a system known as orthographic projection which to this day is commonly used drawing technique of representing a three-dimensional object in two dimensions.[5] During this time, Monge's advancements were held as classified due to their strategic importance. It was several years before his system was permitted to be published but according to Eugene Ferguson, in *Engineering and the Mind's Eye*, "the nineteenth century development of three-view orthographic projection was not a definitive method handed down from above but a collaborative effort of teachers, textbook writers, and anonymous draftsmen in Europe and America…Monge's book had little influence on drafting practice in Great Britain or the United States…technical drawing is not the child of descriptive geometry." James Watt and his assistants beginning around 1775 started developing a British system of technical drawing to show two or three views of engine subassemblies simultaneously that incorporated elements of orthographic projection before it had been published by Monge in 1795.[6] These configurations of multiple view drawings are a direct ancestor to modern computer created drawings and can be understood just as easily.

[4] Giedion, Siegfried. *Mechanization Takes Command: A Contribution to Anonymous History.* New York, NY: Oxford University Press, 1970. pp. 19.

[5] *Engineering Drawing History.* Engineering Drawing History | Gaspard Monge and Orthographic Projection. Accessed July 28, 2019. http://tolerancing.net/engineering-drawing/engineering-drawing-history.html.

[6] Ferguson, Eugene S. *Engineering and the Mind's Eye.* Cambridge, MA: MIT Press, 1992. pp. 83.

Start of Technical Drawing Education in America

The earliest inventions created in the American colonies had been created by craftsman using their own gained knowledge with the occasional help of European periodicals when they were available. Because of the lack of established technical drawing educational programs, most formal training was established by apprenticeships. Students trying to find such apprenticeships within an occupation of architecture or engineering was difficult because of the lack of experts in a new country willing to train students. Most often apprentices acquired these skills through work experience. During the course of the 18th century, recognized institutions of learning began incorporating formal education in these fields.[7] Some notable American inventors like Samuel Morse and Robert Fulton (the inventor of the steamboat) were both fine artists who became inventors engaged with technology later in their careers.[8]

It is important to discuss the importance of architectural draftsman training in Europe before to set a stage for the development of technical drawing as an important skill and discipline. In the late 18th century, German technical schools focused on specific scientific and technical disciplines that encompassed technical drawing skills. The Ecole de Beaux Arts in France had most technical based drawing skills taught within a classical fine arts style education through independent studios. Great Britain had a more archaic technical educational system compared to the rest of Europe at the end of the 18th century. Artists and architects charged students for instruction independent of schools. Occasionally higher learning institutions offered

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[7] Sugarman, Jane E. *Observations on the Materials and Techniques Used in 19th Century American Architectural Presentation Drawings.* Accessed July 28, 2019. https://cool.conservation-us.org/coolaic/sg/bpg/annual/v05/bp05-05.html.
[8] Ferguson, Eugene S. *Engineering and the Mind's Eye.* Cambridge, MA: MIT Press, 1992. pp 155-156.

courses for students of higher social class. Prior to 1894, no European country taught technical drawing as an academic discipline at their institutions of higher education.[9]

In the early 1800s, additional training was offered by some newly-established technical institutions. The earliest American school to offer a technical drawing program was the Military Academy at West Point in 1817. Colonel Sylvanus Thayer reorganized West Point during this period to use the teaching style of the French Ecole Polytechnique focusing on core mathematics classes along with a strict examination policy.[10] An 1803 act of Congress established a peacetime "Corps of Engineers" which had also included the appointment of a "teacher of drawing." The early iterations of this program were relatively rudimentary. The appointment of the distinguished American artist Robert W. Weir in 1834 incorporated more classical training to the field of technical drawing at the Academy. His instruction included figure drawing, landscapes, "the art of shading and finishing geometrical figures with India ink, sketches from nature, and elements of topography with the pen and pencil, and with India ink and colors."[11] The utilization of these classical art skills allowed draftsman to make more realistic technical drawings and could convey their purpose more readily. The skills being taught at West Point were being utilized for military applications and were essential for commanders and engineers in the field. West Point graduates who then entered military service could then expand the drawing skills learned in an actual real-life environment which was then applicable to a career after military service.

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[9] Sugarman, Jane E. *Observations on the Materials and Techniques Used in 19th Century American Architectural Presentation Drawings.* Accessed July 28, 2019. https://cool.conservation-us.org/coolaic/sg/bpg/annual/v05/bp05-05.html.

[10] Ferguson, Eugene S. *Engineering and the Mind's Eye.* Cambridge, MA: MIT Press, 1992. pp 74.

[11] Sugarman, Jane E. *Observations on the Materials and Techniques Used in 19th Century American Architectural Presentation Drawings.* Accessed July 28, 2019. https://cool.conservation-us.org/coolaic/sg/bpg/annual/v05/bp05-05.html.

With the success of the program at West Point and noticed need for such educational programs, technical drawing curriculums were established throughout the United States during the 1800s. Technical drawing programs included those founded at Philadelphia's Franklin Institute (1824), the University of Virginia (1836), Harvard University's Lawrence Scientific School (1847), Rensselaer Polytechnic Institute (1849), Yale (1852), University of Michigan (1852), New York University (1854), and the University of Wisconsin.[12] Most American engineering schools followed a curriculum similar to the French Ecole Polytechnique that was adopted at West Point, and its vast influence can be seen today in American technical education.[13]

By this time, textbooks on the history of drawing and techniques, and figures demonstrating the process and application of orthogonal projection were readily available in the US. *The Useful Arts* (1840) published by the Massachusetts Board of Education, gave detailed explanations of the advancement of technological processes and instructed students how to utilize that information. The book's discussion of mechanical drawing offers a basic history of the topic and emphasizes the importance and underlying factors to creating drawings with multiple perspectives and angles. This book also explained the basics of orthogonal projection and multi point perspective. Additionally, it explained to those interested in the subject, the materials and tools needed for such endeavors and how to achieve a desired result.[14] Prior to a text like *The Useful Arts* being available such information would have to have been relayed to a student from a teacher and then practiced.

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[12] Sugarman, Jane E. *Observations on the Materials and Techniques Used in 19th Century American Architectural Presentation Drawings.* Accessed July 28, 2019. https://cool.conservation-us.org/coolaic/sg/bpg/annual/v05/bp05-05.html.

[13] Ferguson, Eugene S. *Engineering and the Mind's Eye.* Cambridge, MA: MIT Press, 1992. pp. 74.

[14] Bigelow, Jacob. *The Useful Arts, Considered in Connexion with the Applications of Science.* Vol. I & II. New York, NY: Arno Press, 1972.

Most of the precision tools required to create mechanical drawings, like protractors and compasses, before the start of the Industrial Revolution were created by hand and most commonly produced by the artists creating the drawings. Not until the mid-19th century did manufacturers begin mass production of pencils, compasses, protractors. There was no specialized manufacturing of these tools until 1853, when the British industrialist W.F. Stanley started production of drawing tools for scientists and engineers that were both a combination of being "technically efficient yet simple"[15] to use. Stanley published a book titled the *Treatise on Mathematical Drawing Instruments* (1866). This book is considered a landmark publication in the history of the development of technical drawing implements and was expanded upon by many different editions. It covers the evolution of drawing tools and the specific functions that they performed and dramatically influenced the tools for drafting that were used and adopted by professionals at the time.[16]

The development of technology in the United States during this time followed a pattern established by the art world. Technical societies were directly influenced by the London Society of Arts, by encouraging works to be created in both technology and fine art by offering gallery showings as well as monetary awards. The Franklin Institute, along with being one of the first institutions to offer a technical drawing program, was also one of the first to hold exhibitions of mechanical and architectural drawings of students as a new way of displaying that technology and art can be intertwined. Based on the popularity of these prospects, similar exhibitions began being held in major institutions across the US.[17] Similarly, the advent of the first World's Exposition in 1851 in London showed the possibilities of progress from industrialized nations

[15] Higgott, Gordon. *Journal of the Society of Architectural Historians 49*, no. 1 (1990): 111-12. doi:10.2307/990507.
[16] Higgott, Gordon. *Journal of the Society of Architectural Historians 49*, no. 1 (1990): 111-12. doi:10.2307/990507.
[17] Ferguson, Eugene S. *Engineering and the Mind's Eye.* Cambridge, MA: MIT Press, 1992. pp. 156.

and allowed for American invention and progress of developing those skills to a much wider audience in Europe than otherwise would have experienced them before.[18]

Scientific American

The new federal constitution of 1787 allowed the granting of patents to 'promote the Progress of Science and Useful Arts." In his first annual message to Congress, President George Washington urged that "I cannot forbear intimating to you, the expediency of giving effectual encouragement, as well to the introduction of new and useful inventions from abroad as to the exertion of skill and genius at home." This recognition of the need for scientific progress from a newly established nation was a way to move forward in gaining international standing.[19]

Established in 1790, the patent office only approved 57 patents within its first three years. By 1836, a more modernized patent office was established and close to 10,000 patents had been granted to inventors and manufacturers. The process of acquiring a patent was a difficult task and required those with special skills in order to navigate through the procedures and requirements of the patent office.[20] Patent applications had to follow strict guidelines that required specific technical drawings established by the patent office. Patent application drawings would require a multitude of views and perspectives in a confined space. It is assumed that one studying the drawings who has some skill in the machines being represented would be able to understand the

[18] Giedion, Siegfried. *Mechanization Takes Command: A Contribution to Anonymous History.* New York, NY: Oxford University Press, 1970. pp. 30.

[19] Pursell, Carroll. *The American Patent Agency: The Embedded 'Lone Inventor' in American History.* Icon 17 (2011): 31-39. http://www.jstor.org.ezproxy.wpi.edu/stable/23789958.

[20] Pursell, Carroll. *The American Patent Agency: The Embedded 'Lone Inventor' in American History.* Icon 17 (2011): 31-39. http://www.jstor.org/stable/23789958.

function of the machine being represented and be able to construct one from the information given.[21]

The most common help sought by inventors was offered by "patent agencies" that could prepare applications and drawings to submit to the patent office. The most recognizable patent agency of the time was, "Munn & Co." which purchased the then new publication *Scientific American* which had only been in business for one year prior. Munn & Co. turned *Scientific American* into the nation's most important journal for scientific and technological advances. *Scientific American* also served as a promotional tool for its client's inventions they were looking to market. Over the course of their agency, they worked with such notable inventors as Samuel Morse, Elias Howe, and Dr. John Gatling.[22] To this day, *Scientific American* is the oldest continuing technical journal in the United States.

The first identifiable engraver working for "Munn and Co." was A.R. Haight who was hired in 1848. Haight operated his own engraving business that advertised in the first issues of *Scientific American* before joining the firm. He was solely responsible for preparing 737 patent drawings in 1857. The popularity of *Scientific American* and the patent agency required "Munn and Co." to start hiring more qualified personnel by 1849. Finding qualified workers for the patent agency was a difficult task because of the lack of trained professionals able to create technical drawings. The newness of the concept of a patent agency and lack of scientific

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[21] Ferguson, Eugene S. *Engineering and the Mind's Eye.* Cambridge, MA: MIT Press, 1992. pp. 87.

[22] Pursell, Carroll. *The American Patent Agency: The Embedded 'Lone Inventor' in American History.* Icon 17 (2011): 31-39. http://www.jstor.org/stable/23789958.

institutions to provide training were given as reasons to this difficulty. In 1849, "Munn and Co." only hired one new employee to work on patent drawings.[23]

By 1859, *Scientific American* published 30,000 copies per week. By 1900, the patent agency had gained 100,000 patents for their clients.[24] A contributing factor to the popularity of *Scientific American*, rested in the belief that these inventions and ideas contained untold wealth for those who could advance the ideas printed and then create business empires of their own with some ingenuity and having the right idea at the right time.

William Sellers

The culmination of the teaching of a standardized drawing system resulted in the developments made by the American industrialist William Sellers. Sellers established a system of screw thread designs that were later established as an American standard. During the evolution of a rapidly modernizing time, he saw the need for standardization of technical drawing systems to convey appropriate information that product manufacturers needed for quality control across all aspects of production. Sellers is also critical in the history of American production for establishing the use of piece rates for production, cost accounts for every machine produced, as well as creating patent pickets to protect his own intellectual property. Seller's work is defined by "parts designed proportionately and without any embellishment, use of precise

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[23] Borut, Michael. *The Scientific American in Nineteenth Century America*. PhD Diss., New York University, 1977. pp. 89-90

[24] Borut, Michael. *The Scientific American in Nineteenth Century America*. PhD Diss., New York University, 1977. pp. 2

standards and fixed tolerances in production--all to make machines that in operation would curtail or replace costly and skilled hand labor."[25]

Technical drawings of the mid-19th century were created to serve two primary functions. One purpose was the establishment of detailed and properly toleranced designs in order to eliminate manufacturing errors. The second was to create divisions of labor within certain manufacturing processes. The realization of the need for specialized processes for certain aspects of production was a critical step in advancing overall productivity and throughput in certain production scenarios. Sellers' most notable innovation was the establishment of a centralized technical drawing office within his company. This office operated as a library at the time for the various inventions being created as well as established a database of documentation for specialized processes that may be needed during manufacturing of his devices. The three purposes that were fulfilled by the design drawings of Sellers: "general arrangement drawings as an aid to marketing, design plans that established a product's form, and production or shop drawings to guide workers on the factory floor."[26] By 1855, all draftsmen working for Sellers demonstrated consistent use of colors and line weights as well as establishing a catalog of symbols to be used in the drawings. The visual style used by Sellers's drawing office established a consistent standard around 1870. One of the last drawing elements to be established in Sellers' drawings was the placement of the legend. After 1878 they always appeared in the bottom right position now familiar to most engineers. Even the content of the title block became standardized

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[25] Brown, John K. *When Machines Became Gray and Drawings Black and White: William Sellers and the Rationalization of Mechanical Engineering.* IA. The Journal of the Society for Industrial Archeology 25, no. 2 (1999): 29-54. http://www.jstor.org/stable/40968876. pp 31.

[26] Brown, John K. *When Machines Became Gray and Drawings Black and White: William Sellers and the Rationalization of Mechanical Engineering.* IA. The Journal of the Society for Industrial Archeology 25, no. 2 (1999): 29-54. http://www.jstor.org/stable/40968876. pp 34.

after about 1885 when Sellers adopted a standard "Dewey-decimal-like" number based on an established system of machine and drawing types.[27]

Emerging in the 1860s, experienced designers, much like Sellers, used algebra and geometric techniques as the design basis for complex shapes. Most of the men working in these drawing offices were unfamiliar with higher level mathematics having never received any formal training in these fields. In the event when one of these draftsmen needed advanced math skills to complete their drawings, they were able to refer to general reference materials created specifically for the purpose at hand.[28]

Drafting emerged as a legitimate career in the 1860s and represented an important skillset needed for aspiring engineers. Technical drawing became more focused on engineering design and less about artistic ability. Both the drawings themselves and the machines they represented were changing rapidly. Industrial machinery designers began moving away from elaborate paint and ornamental designs and instead opted for standardized drab finishes and more functional designs which suited the character of the devices being produced.

The evolution of images from the early editions of *Scientific American* to the 1870s demonstrate the progress made in the field of mechanical drawing and its effect on the production of mechanical devices. Early drawings that appear in *Scientific American* are relatively ornate with classical style figures and flourishes. Eventually these drawings shed those additional unneeded details and instead opted for clear illustrations that demonstrated the

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[27] Brown, John K. *When Machines Became Gray and Drawings Black and White: William Sellers and the Rationalization of Mechanical Engineering.* IA. The Journal of the Society for Industrial Archeology 25, no. 2 (1999): 29-54. http://www.jstor.org/stable/40968876. pp 52.

[28] Brown, John K. *When Machines Became Gray and Drawings Black and White: William Sellers and the Rationalization of Mechanical Engineering.* IA. The Journal of the Society for Industrial Archeology 25, no. 2 (1999): 29-54. http://www.jstor.org/stable/40968876. pp 43.

construction and operation of machines. This shift from artistic interpretation of inventions to exacting, toleranced designs allowed for future progress to be made by inventors even faster expounding upon the ideas printed in *Scientific American* and new scientific knowledge available to them.

Recommendations for Future Groups

For future IQP groups continuing this project there is still meaningful work that needs to be completed in order for this website to be considered finished. One of the most important issues for functionality of the website that needs to be addressed is the direct linking of images from returned search results. This aspect of the project was beyond my coding abilities and needs to be approached by a student who has experience in Python and Django coding experience. This addition must be made by incorporating links from the Hathi Trust database. The previous project group suggested using an external database migration tool such as cypress.io, to allow a more efficient automated process of linking every search string. Making these coding changes manually would be incredibly time intensive and difficult.

Additionally, the current iteration of this website development and backups exists on Github and is being administered by the previous IQP group member, Brian Flanagan. Since we will eventually not be able to help every future IQP group, it is recommended that a future group takes control of the database on Github and the WPI servers and transfers ownership to the WPI IT or ATC department. This will allow any future IQP group to have immediate access to development files and the hosting server and gain assistance from professionals with experience in these development techniques.

Conclusions

Once I had a "crash course" in Python and Django the improvements that I hoped to make on the website were possible. A new logo design for the website has been created. These images and vectorized typefaces are now available on the shared WPI "*SCIAM*" drive for any future groups to use for any further graphic development of the website. The previously non-functioning Help/FAQ and History pages are now working online and are formatted correctly using the Bulma CSS templates for consistent formatting across the entirety of the website. The color scheme for the site and link bar has been adjusted and is easily modifiable if it needs to be adjusted according to recommendations from those using the website in a research capacity. The main search bar on the home page has been moved to the center of the page to make it more obvious that this website is a search engine. The website appearance and functionality has been much improved and should hopefully be easier for researchers to use as a tool for serious academic research.

Appendix A

Getting Started with Development on the *SCIAM* database

Future groups should refer to the IQP documentation created by the 2018-2019 group of Brian Flanagan and Jacob Ganoe. Their final report has an excellent overview to the file configuration of the database structure that they developed and explains how it works with clarity.

Those wanting to develop the website with little coding knowledge must gain some experience with Django and Python beforehand. Thankfully there are a multitude of online resources (YouTube, Mozilla, etc.) for beginners wanting to understand how these coding languages work.

This website was developed on Windows/PC architecture. Those working on Apple or Linux computers must know that there may be compatibility issues.

The following applications must be downloaded for future website development:

1. GitBash- Front end for GitHub that will allow for the database to be uploaded to your personal computer
2. Visual Studio Code- This is a lean code editor by Microsoft that will allow for all coding changes to be made internally that works with Python and Django.
3. Python- Must be installed from Windows Command Line or Powershell
4. Django- Must be installed from Windows Command Line or Powershell

The development library for this website is located on GitHub. Future groups must establish a user account on GitHub and request access to the files from Brian Flanagan, bflanagan@wpi.edu.

The library is hidden but is located here: https://github.com/briflan26/sciam

Appendix B

Early Technical Drawing at WPI: Some Original Sources

Excerpts from WPI Journals from the late 1800s

1889 WPI Journal, Volume 4, Issue 4, pg 63.

"It appears, on investigation, that, of the graduates of our Institute, from the department of Mechanical Engineering, about 75% fill positions for which they directly fitted by their course; and of these, 25% are earning a living by draughting (sic). The course in draughting is a good one but does it give better preparation to the student than his work in other branches of the department? In other words, does the Institute graduate better draughtsmen than machinist, foremen or other shop worker and if so does it give draughting any precedence of mechanical investigation and work in the machine room? Or, is there a greater demand for draughtsmen than for other workers? Or, do students prefer the milder labor, and let the occupation which necessitates dirty hands and the use of overalls and jumper pass unheeded?

We are inclined to think that the result is caused by all these conditions, rather than a single one. If the course in draughting, which is designed to be a help, and is a necessity to the success of the Mechanical Engineer, receives more attention than the shopwork in proportion to its possible practical development, the best interests of the pupil are doubtless subserved; for granted that both are necessary for the greatest progress, and that the student has only a limited time in which to prepare for his lifework, will he not advance faster and surer in his work with a good knowledge of draughting than would warrant his curtailing the amount of time given than subject, and increasing the number of his practice hours?" …"Do not consider draughting an end but a means. It is a valuable requirement and the most should be made of it."

1890 WPI Journal- Volume 5, Issue 9, pg 216

A letter from Chester B. Albree '84

"This character of knowledge in drawing does not at all call for proficiency in making pictures but is really indispensable to the scientific man. In the course at the Institute the geometrical studies are very prominent. In analytical and descriptive geometry, and in mechanics, problems are constantly occurring in which one must have a mental conception of imaginary things…"

1891 WPI Journal, Vol. 7, Issue 1, pg 10

Protest from a Civil

"It does seem too bad that excellent as is the instruction given in shop practice, that mechanical drawing is made subsidiary to all out studies except free drawing. In even the High School,

models are given the students to study and to reproduce, but here a blue print is handed over to a man and he is expected to take as much real interest in his work and to derive and much real advantage from it as though a piece of a mechanism were set before him, instead of the second hand work of another."

1892 WPI Journal, Vol 7, Issue 9, pg 180

"Suggestion to the student in Free hand drawing" -George E. Gladwin

"Here is where your practice of hand, your power of manipulation, will be found to be very deficient. But start off. Do as well as you can in producing these effects. There is no royal road to the end you seek except through labor. There is no treadmill manner of work about it. Some will get the effect desired in one way and some in another. As you practice you will find out the easier and better way of handling your pencil and of producing the better finish. Artistic grace and beauty will be imparted to your work, which result will be a gratifying thing, and give far more than a transient reward to the faithful student."

Course content analysis of a catalog of student made drawings located in the WPI Archives.

"Technical School Course of Free-Hand Drawing and Design, Worcester, MA 1884"

1. Free hand exercise from blackboard
2. Free hand exercise in printing
3. Free-hand working drawings
4. Free-hand working drawings in section (plan sections)
5. Free-hand original design (elementary)- ornamental designs, floral motifs
6. Free-hand original design (brackets)- corners of pages
7. Free-hand original design (miscellaneous)
8. Free-hand isometric drawings
9. Free-hand parallel perspective (elementary)
10. Free-hand parallel and angular perspective
11. Free-hand angular perspective
12. Free-hand model drawing
13. Free-hand drawn from models
14. Free-drawn from Cast
15. Free-drawn from models in group
16. Free-hand perspective drawing of interior
17. Free-hand shading from models
18. Free-hand shading from models and drapery
19. Free-hand shading from models in group
20. Free hand shaded from cast
21. Free- hand sketch from nature
22. Exercise in printing with india ink and brush
23. Free-hand shading from model with india ink and brush
24. Free-hand shading from working model with india ink and brush
25. Free hand study of natural surface with india ink and brush
26. Free hand study of natural surface with color and brush
27. Free hand study of interior with brush from copy
28. Free hand study of figure with brush from copy
29. Free hand sketch from nature in sepia
30. Free hand sketch from nature in color
31. Free hand course in design- Elementary sheet (color combos)
32. Free hand course in design. Conventional treatment of natural forms
33. Free hand course in design- Oil cloth
34. Free hand course in design. Design for prints
35. Free hand course in design. Design for Dado
36. Free hand course in design. Designs for Book Covers
37. Free hand course in design. Design for paper hanging
38. Free hand course in design. Design for Mug
39. Free hand course in design. Design for Wrought Iron Railing
40. Free hand course in design. Design for Oil Cloth.
41. Free hand course in design. Design for Ceiling Centre piece

Appendix C

Frank Luther Mott. *A History of American Magazines 1850-1865.* Volume II.

Scientific American- pgs. 316-318

The founder of the *Scientific American* was one of those inventive Yankees whose versatility, "handiness," and restless "projecting" life have made his type a legend. Rufus Porter was apprenticed to a shoemaker at fifteen, but cobbling was too dull for him; he liked better to play the fife for military companies on their field days and the fiddle for dancing parties. So he ran away from his cobbling. Then he was apprenticed to a house painter, and during the War of 1812 he painted gunboats and fifed for the Portland light infantry. Later he painted sleighs, beat the drum for soldiers, taught drumming and wrote a manual on the subject, and then became a country schoolmaster until his wandering feet and impatient mind took him away from the schoolhouse. In 1820 he invented a camera obscura with mirrors so arranged that with its aid he could draw a satisfactory portrait in fifteen minutes. This gave him a motive for the wandering life which he craved. Soon he added a revolving almanac to peddle as a sideline. Experiments with a horsepower boat ate up his savings, and he returned to portrait painting and later to landscape painting. But his itch for invention would not let him rest; and he produced in succession a cord-making machine, a patent clock, a steam carriage, a portable horsepower, a corn sheller, a churn, a washing machine (of course), a signal telegraph, a fire alarm, a revolving rifle, a flying ship, a trip hammer, a fog whistle, an engine lathe, a rotary plow, a portable house, and many other devices. Some of these were successful and gave him the funds to sink in failures."

In the intervals of invention, Porter edited the *New York Mechanic* in 1840, moving it to Boston the following year and calling it the *American Mechanic*; but he left it in 1842 to do some more inventing. He returned to the editorial field, however, in 1845; and while experimenting with electrotyping processes in New York he founded a weekly paper which he called the *Scientific American*. The first number, a four-page small folio at $2.00 a year, was issued on August 28, 1845. It was illustrated by a few woodcuts and bore the subtitle: "The Advocate of Industry and Journal of Mechanical and Other Improvements." It was devoted primarily to new inventions, but it also contained from fragmentary essays on moral subjects "selected" from other periodicals, as well as some poetical "pieces," the choice of which would reflect no credit on the editor's literary judgement. Circulation amounted to only a few hundred. It would have been too much to expect of Porter that he should stick to his new paper for very long; and accordingly he sold it for a few hundred dollars in July 1846, although his name was carried as editor for ten months longer.

The purchasers were Orson Desaix Munn and Alfred Ely Beach. Beach was the son of Moses Y. Beach, famous editor and publisher of the *New York Sun*. The elder Beach was himself an inventor of importance, and the son inherited his mechanical interests and ability. When the younger Beach, not yet twenty-one, working with his father on the *Sun,* heard that the *Scientific American* was for sale, he suggested to his old schoolmate Munn, then conducting a mercantile

business in a small Massachusetts town, that they should going into it together. Thus was the firm of Munn & Company organized, issuing its first number July 23, 1846.

As the publisher of a paper devoted chiefly to patents, Munn & Company found themselves in close contact with inventors of all sorts and besieged by questions about the methods of patenting and about patent law. A patent agency was accordingly setup. Unlike many others of its class, it was conducted on high principles and gave honest advice, and in the course of a decade or two it became a very prosperous concern and the largest agency of the kind in the world. Its relation to *Scientific American* was one of mutual helpfulness. When A.B. Wilson bought the model of his sewing machine (later the Wheeler and Wilson) to Munn & Company in 1849, it was written up for the *American.* In the same way, Thomas A. Edison got a good story on his new talking machine in 1877. The leading inventors of America were patrons of Munn & Company- Samuel F. B. Morse, Elias Howe, Captain James B. Eads, Captain John Ericsson, Dr. R. J. Gatling, Peter Cooper Hewitt, Thomas A. Edison. And even the obscure and unsuccessful inventions, of which the *Scientific American* published thousands (for every patron of Munn & Company got at least a few lines in the paper) were often interesting and sometimes significant in illustrating trends of experimentation.

The American featured these articles, and one of its most important departments was the weekly publication of the official list of patents, "with the claims annexed," received directly from the United States Patent Office; but the contents of the paper were not limited to matters about inventions. The publishers had enlarged the weekly issue to eight pages, and a variety of information of mechanical and scientific nature was presented.

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