Development of a WPI Innovation Gallery

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WPI

Development of a WPI Innovation Gallery

An Interactive Qualifying Project
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Abstract

Despite having pioneered dozens of significant technologies, WPI is severely underacknowledged among mid-sized technical institutions for its heritage of innovation. The creation of an exploratory virtual innovation showcase would not only showcase WPI's accomplishments, but also encourage a renewed spirit of innovation and commitment towards commercialization on campus and better communicate how WPI's project-based learning powers impactful and purpose driven research. Stakeholders in the broader campus community were interviewed and assessed current campus installations to analyze the feasibility of such a program. A clear list of strategic recommendations were established for the future development of an immersive virtual gallery.

Acknowledgements

This project would not have been possible without the support and guidance of many individuals and organizations. I would like to first thank my advisors, Dr. George Pins and Dr. Bogdan Vernescu, for their steadfast passion and commitment to the project and allowing me to have the opportunity to spearhead this campus initiative. They helped introduce and connect me with important and relevant individuals and their supportive weekly feedback was a large positive contributor to the outcome of this project.

I would like to especially thank Arthur Carlson, the university archivist, for all his efforts, enthusiasm, and input. His knowledge of institutional history and assistance in navigating archival collections was a tremendous help in jumpstarting the project and creating the foundation for future IQP groups.

I would additionally like to express my gratitude towards the WPI Board of Trustees. The cooperation of the members interviewed is sincerely appreciated, as well as the valuable insights they provided as significant stakeholders in the WPI community.

Finally, I would like to extend my thanks to Len Polizzotto and Curtis Carlson, who gave indispensable feedback on a number of iterations of my value proposition presentation.

Executive Summary

WPI students produce close to 50 invention disclosures and regularly license a number of patents every year, however, to prospective students, WPI remains severely underrecognized for its work in training students to innovate both during their time at the university and for years after. When WPI introduced The Plan, it singlehandedly pioneered project-based learning and yet has never received acknowledgment for being and remaining a leader as well as a source of innovative inspiration to other universities. This lack of recognition creates the need to better tell the compelling story of how WPI's project based learned allows the campus community to have impact by solving problems that have meaning for others. This need could be met by the implementation of a virtual innovation museum. Establishing a formal gallery program will not only help broaden appreciation of WPI's heritage of innovation, but it will also encourage a renewed institutional commitment to creating value and paint a more representative picture of WPI. Creating a more accurate online depiction of the university will also inspire future innovators, such as prospective high school students and faculty to join the WPI community. The implementation of an interactive and immersive exploratory website that showcases WPI's research contributions in an exciting manner will promote campus-wide intellectual engagement and propel WPI to once again be viewed as a leader in innovation.

Project Goal and Methodology

The goal of this project was to assess the feasibility of creating a new virtual galleries program at WPI that will connect and sustain efforts and programs that celebrate and share WPI's heritage of innovation. For this project, a vision was pioneered for the development of a gallery program to meet this demonstrated need and created a foundation from which future IQP groups can build a tangible product. The overarching goal of this gallery is to interactively showcase the societal impact of WPI's research contributions, while highlighting the underlying importance of value creation, entrepreneurship, and innovation.

A few of the significant parts of the project involved assessing the feasibility of sustaining a digital or physical gallery program and collecting research on historical inventions and interviewing stakeholders, peers, and other experts. Along with these, which specific archival materials are worthy of incorporation in the museum were identified and parallel to this endeavor, established the criteria that both the innovation and its respective developer must meet to merit inclusion. The research contributions were also classified from the founding of the institution up through the modern day according to impacts related to various categories, for example the four industrial revolutions and WPI thrusts of research. Finally,

templates were created for the profiles of the innovators, best practices outlined, and made recommendations made related to software programs and common resources for future IQP groups to follow.

A model of the objectives, with specific tasks shown in the white boxes, is presented in the figure below:
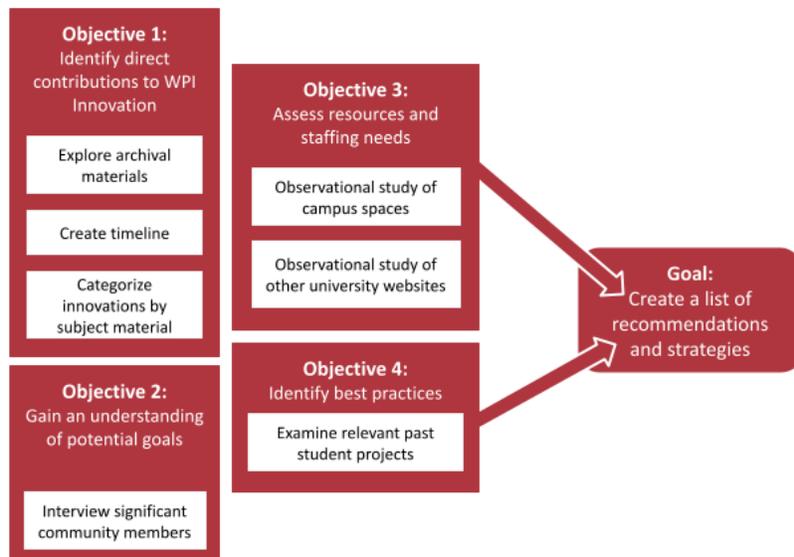
As illustrated by the figure, many of the preliminary objectives informed the final objective. With this project, efforts were particularly focused on objectives 3 and 4 as these were determined to be the most beneficial in creating a list of recommendations.

Findings

A considerable amount of the archival materials was found to not directly correlate with innovations that stemmed out of the university and thus were disregarded. Should this project in future terms expand in scope or want to revisit some of the material previously researched, it could still be a worthwhile endeavor to more thoroughly dig through the archives to see if anything was missed in the first cursory pass. Similarly, a lot of archival collections were focused on significant individuals in the WPI community, yet ones without a direct innovative contribution to society. As far as the collections that were diligently paged through are concerned, the primary goal when exploring the archival materials was to note anything of significance that should at some point be requested for digitization and in general find what information is researchable. Overall, there was not a lot of particularly relevant artifacts, as the collections detailed below primarily consisted of journals, diaries, and administrative papers. A

substantial cost would be required to transcribe what is conveyed by many of these documents, documents that are largely unrelated to an innovation and would have little added benefit if included in the gallery. The majority of notable findings were prototypes and design sketches, which overall would not require much external vendor support to digitize and whose inclusion would have a substantial effect on conveying the impact and background of varying innovative contributions. The archival card catalog was also found to be a more hidden gateway to useful and more engaging information, such as alumni's affiliation to various campus clubs and organizations and past yearbook photos, which could be used to promote student relatability on the developed site.

When analyzing innovation and other commemorative installations at other universities, Spotlight at Stanford best models what WPI should strive for with an initial implementation. The software provides any member of the broader campus community the opportunity to request an exhibit and contribute content, a feature that would be something especially beneficial to incorporate a modified version of into a WPI platform, as it provides a straightforward way for the community to contribute any knowledge, resources, and information they have to the project.

Conclusions and Recommendations

Concerning the eventual development of this software platform, a strong emphasis should be placed on end-user satisfaction, once initial functionality is attained, as it is arguably the most necessary element to launching a successful initiative. Feedback from remains a valuable aspect and it is important to address their needs and ideas, however, what excites students is what should be prioritized with development. For this, future groups should consider sending out a series of surveys or questionnaires to gather large amounts of student input.

A key detail for future groups to remember when deriving a tangible product for this concept is the overarching goals of highlighting value creation, entrepreneurship, and innovation. WPI aims to teach students to have an innovative mindset and develop this mindset to solve important problems and this museum should help achieve this goal. When looking at the scope of the project, it is important to restrict it to notable alumni with close ties to WPI and to otherwise keep the frame of innovations linked to students during their time at WPI. It is also important for developers to be consistent in the creation of their database, as well as consistent with the information being collected. The inclusion of campus involvement and club/organization affiliations is to help augment relatability of students to historical innovators.

It is a very difficult undertaking to directly motivate or inspire students and one viable workaround to this is to focus on relatability and the inspiration will follow.

In some location on the developed website, there should be a resources page for students to help clearly establish what tools students have access to and how to take advantage of them. Some of the categories of resources to be included in this section are makerspaces, advisors, events and networking opportunities, skills workshops, project funds/fellowships, relevant student clubs, collaborative spaces, available projects to join, and legal advice.

Finally, the importance of this initiative cannot be underscored enough and to stress this, this website should ideally be the heart of the wpi.edu domain or otherwise prominently displayed on the landing page. Having this featured in WPI's research magazine would be one step to promoting this, alongside presentations to stakeholders in the university explaining why this initiative is so critical to the future of the institution. Depending on the number of financial resources that can be designated towards this effort, perhaps eventually a corresponding physical establishment could be built to compliment the website, however, the future is digital and virtual development should remain the priority.

Authorship

       This document was written by Renee Sawka, with critical review and significant feedback contributed by project advisors Dr. Bogdan Vernescu and Dr. George Pins. This document provides specific acknowledgment where the published work of others was consulted. Additionally, references are clearly identified for all sources of information, such as quotations, figures, and other visuals.

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Chapter 1: Introduction

Initially founded with the intention of showcasing collections of historical artifacts, museums have since transformed into active community establishments that foster discussion and appreciation of shared heritages, using the achievements of the past to educate and inspire future generations. In the traditional sense, museums refer to physical institutions that host a carefully curated array of artifacts of historical, scientific, artistic, or cultural significance. However, while these walkthrough exhibitions serve as tangible links to the past, their virtual counterparts can provide an equal if not more immersive learning environment. As museums are widely being transformed from spaces of observation to spaces of participation, web-based displays are becoming an increasingly ideal medium for promoting such societal engagement. The interactive and non-linear nature of virtual museums allows users to pursue their specific interests related to the collections, while the curation of materials still shapes their interpretation with the relevant historical and cultural context. Alongside their integral role in enriching the learning of visitors, virtual museums additionally offer greater accessibility, providing unparalleled and constant access to information without the challenges that maintaining or visiting a physical institution otherwise presents. One of these issues related to creating concrete structures is procuring the necessary real estate, which proves to be difficult in densely populated urban areas, where available land is rare and expensive.

For these reasons, virtual museums have become a top choice, particularly for colleges that experience a shortage of expandable property while simultaneously possessing exhibitions worthy of display. Worcester Polytechnic Institute is one such university, home to a rich and long history of notable innovative achievements yet lacking physical infrastructure celebrating these technical solutions. While numerous and varied isolated campus locations, such as the Hall of Luminaries and the Gladwin Galleries, as well as some online resources, such as Digital WPI and WPI History, highlight impactful technological discoveries, there has never been a concerted effort to develop either a centralized physical or digital archive. Prior attempts to chronicle WPI's heritage of innovation include student projects, publications, and university celebrations for both departmental and institutional anniversaries. Additionally, there is a limited collection of archival information related to student, alumni, and faculty innovation, but much of the research for the individuals and their contributions to be showcased has not previously been carried out or brought together as a unified experience. The importance of sharing knowledge and academic discoveries, whether to a physical or a remote audience, is greatly underappreciated and a museum to this effect could profoundly enhance the WPI experience as well as benefit the broader scholastic community.

For this project, a vision was pioneered for the development of a gallery program to meet this demonstrated need and created a foundation from which future IQP groups can build a tangible product. The overarching goal of this gallery is to interactively showcase the societal impact of WPI's research contributions, while highlighting the underlying importance of value creation, entrepreneurship, and innovation. A few of the significant parts of the project involved assessing the feasibility of creating and sustaining a digital and physical gallery program and collecting research on historical inventions and interviewing stakeholders, peers, and other experts. Along with these, which specific archival materials are worthy of incorporation in the museum were identified and parallel to this endeavor, established the criteria that both the innovation and its respective developer must meet to merit inclusion. The research contributions were also classified from the founding of the institution up through the modern day according to impacts related to various categories, for example the four industrial revolutions and WPI thrusts of research. Finally, templates were created for the profiles of the innovators, best practices outlined, and made recommendations made related to software programs and common resources for future IQP groups to follow.

The eventual establishment of a virtual gallery following the guidelines laid out by this project will place a stronger emphasis on encouraging innovative development, serving as inspiration to both current and prospective students and faculty as well as connecting with existing physical displays scattered around campus. The museum will also further education, helping the community recognize the achievements of those who came before, and will be developed with the hope that the research behind it is a step towards improved and increased innovation stemming out of the institution.

Chapter 2: Background

In order to develop a complete collection of innovations that spans the University's history, it is important to identify what information is currently known with regards to such innovations. This chapter will review and evaluate past efforts to catalogue student, faculty, and alumni achievements. It will also assess the potential added value of various categorization methods that can be applied to my preliminary list of contributions to include. This project will survey and analyze the means that other institutions have used to create similar physical and virtual spaces dedicated to institutional history. This will involve an appraisal of the necessary resources, potential staffing needs, as well as a discussion about the significance of active engagement.

2.1 Defining Innovation

Innovation refers to the transformation of a concept into a tangible and practical reality – new products, processes, or ideas that have become established in the marketplace (OECD/Eurostat 2005). Innovation tends to adopt a broad, all-inclusive definition, however, within the context of this project, the scope of innovation needs to be parameterized, more clearly outlining the criteria that an achievement must meet to warrant inclusion in a university's gallery. An underlying philosophy that was used to help determine the guiding principles of these contributions is that of value creation. Primarily focusing on the four key principles of value creation: need, approach, cost/benefit, and competition – much of the evaluation of whether a contribution was significant enough for inclusion related to derived societal benefit. A substantial number of contemporary innovations from WPI are protected as objects of intellectual property, yet outside of the safeguards provided by the patent and the potential for and promise of future development, many patented WPI innovations have yet to be licensed or manufactured. For this reason, WPI innovations that either fail to meet a stronger measure of success or are too recent to have had a verifiable impact on society should be kept separate from those with a widely acknowledged influence. These more recent innovations are still significant in their own right and warrant inclusion in a distinct 'continuity' section where spectators can see up-and-coming research contributions stemming from WPI faculty, students, and alumni. The discussions that took place to allocate different innovations to each of these two categories of exhibitions relate to the cardinal goal of the showcase, which is to teach students to adopt/develop the innovative mindset needed to solve important problems.

2.2 Methods of Categorizing Innovation Content

While a large and significant aspect of creating a showcase revolves around the selection of individual items and development of historical narratives, an equally substantial though oftentimes underappreciated characteristic of a museum is the actual curation of the information. Despite the sometimes-subtler implementation, nearly all museum exhibitions hinge on dynamic themes, interwoven with a simple chronological system such as a timeline. By focusing on and grouping elements around certain unifying ideas and motifs, exhibitions allow a broader story to be told through the connections between them.

At the most general level the Oslo Manual, the internationally recognized reference guide for innovation statistics, splits innovations into four distinct categories. Product innovation encompasses goods and services, both new or substantially improved products with respect to technical specifications, functional characteristics, or intended uses (OECD/Eurostat, 2005). Process innovation refers to the introduction of a new or improved production or delivery method where an improved implementation would incorporate significant changes to software, equipment, or techniques (OECD/Eurostat, 2005). Marketing innovation is defined by the Oslo manual as the application of novel marketing methods related to product design, packaging, placement, distribution, pricing, and promotion (OECD/Eurostat, 2005). Finally, organizational innovation is methodology aimed at increasing company performance through changes to a firm's business practices, external relations, or general workplace structure (OECD/Eurostat, 2005). Marketing and organizational innovation remain important classifications, however, the scope of innovations for this project is more heavily focused on product and process innovations, due to their more direct and tangible impact on society. Therefore, innovations selected for inclusion in the gallery were ones that passed this initial categorization and fell strictly into either of those two classifications.

As far as classifying based on actual subject material is concerned, two sets of grouping were discussed as the initial themes to assign innovations to. WPI has a very rich history of innovation that spans back to the institution's founding in 1865 and the tail end of the first industrial revolution and therefore, innovations can logically be distinguished according to which of the four industrial revolutions they were developed during. While there is some discrepancy regarding what the four types of revolutions are, the innovations gallery will be following the outline published by the WPI provost who defines them as the following:
1. Mechanical Engineering and Metallurgy
2. Age of Electrical and Automation
3. Information Age

4. 'Smart World', the Convergence of Stem Disciplines

As a university, WPI has also established research communities that have made significant contributions to the field in four interdisciplinary areas (WPI, 2022c). These areas align with relative similarity to the industrial revolutions and consequently can be used as a parallel categorization. The first of these thrust areas of research is Smart World, which encompasses developments in robotics, data science, bioinformatics, cybersecurity, and other related disciplines (WPI, 2022e). Materials Reimagined focuses on new materials systems, working with water, energy, nanomaterials, biomaterials, and additive manufacturing (WPI, 2022d). BioPoint is the thrust area of research that looks to advance innovation in the bio-disciplines: bioengineering, biomedical engineering, and life sciences in general (WPI, 2022a). Finally, Global Initiatives comprises WPI's research efforts pertaining to the major social, environmental, and governmental challenges abroad WPI, 2022b). While these categories mostly cleanly partition innovations, there is innately some overlap due to the nature of transdisciplinary research, leading some innovations in the gallery to possibly belong to two groups.

Beyond the grouping methods described above, it was also determined that to strengthen the ability for viewers to relate to the gallery content, it would also be beneficial to implement some color-coding system linked to characteristics of the innovators themselves. While a large deal of information related to the innovators involvement on campus will be placed in their biographical section, tags should be added along the timeline citing whether the innovation came from a student, alumni, or faculty and potentially any other tags that enhance the viewing experience.

2.3 Innovation Exhibitions Located Around Campus

Although there remains no physical or digital archive related to institutional innovation, a need that will ideally be met by the eventual development of this innovation gallery program, there are several exhibitions highlighting specific accomplishments scattered around various campus buildings. The inherent issues with these are that none are comprehensive with regards to either their respective department or the greater institution, they are typically in low visibility areas, and their static and commemorative nature deters engagement from the student body and other passersby.

Hall of Luminaries

Established in 2017, the Hall of Luminaries is arguably the only display on campus that comes close to the goal of a centralized archive showcasing research contributions from

members of the WPI community. Each individual or 'luminary' celebrated in this exhibit is one who has been recognized for their significant scientific accomplishments as well as having inspired others with their work. This installation is located on the top floor of the Campus Center, a favorite study spot of handfuls of students, possibly because this location is also home to very little foot traffic. The integration of an interactive wheel incites public curiosity in the information displayed, which helps offset the slightly more remote setting.

Figure 1: WPI Interactive Wheel of Luminaries

The configuration of the Hall of Luminaries reinforces the concept that hands-on elements, ones that call for direct public engagement, leave viewers with a more memorable experience and have the potential to encourage more aspiration among the university's population.

Figure 2: The Campus Center Hall of Luminaries

The WPI Hall of Luminaries inducts individuals whose professional achievements have had exceptional and lasting impacts on society, however, not all inductees have contributions related directly to innovation. As a result of this, the eventual innovation gallery will only include a subset of the Luminaries and the discussion below giving brief historical highlights regarding the significant of each will help establish guidelines related to selection.

2017 Inductees
- George I. Alden was an innovator in many regards, inventing the first hydraulic elevator alongside Milton Higgins as well as a dynamometer for measuring the power of machinery. Alden also helped found the Norton Emery Wheel Company, an industry leader in the development of new abrasives. (Foote, 2017)

- Stephen Salisbury II. was a founder of WPI and as the first president of WPI's board of trustees, was primarily and strictly involved in the administration of the institution as opposed to research driven contributions. (Foote, 2017)
- Ichabod Washburn was another founder of WPI as well as the owner world's largest wire factory. In collaboration with John Boynton, Washburn helped develop the university philosophy of "theory and practice" by emphasizing the importance of vocational skills. (Foote, 2017)
- John Boynton, as stated above, helped revolutionize practical education, in addition to being a tinware manufacturer. (Foote, 2017)
- William Grogan was an incredibly notable individual in WPI's history, as he is responsible for innovating and implementing the WPI Plan, a groundbreaking approach to academic instruction. (Foote, 2017)
- Curtis Carlson is most widely acknowledged for his work in developing high-definition television and Siri for the iPhone 4. Carlson is also a significant figure in the WPI community for his development of innovation best practices. (Foote, 2017)
- Judith Nitsch is the founder of Nitsch Engineering and has carried out significant work in developing environmentally sustainable facilities at WPI. (Foote, 2017)
- David Norton created the Balanced Scorecard, which is an extensively used system for strategic planning and management of commercial businesses, legislative bodies, and other organizations. (Foote, 2017)
- Richard T. Whitcomb was a pioneer in the field of aerodynamics, conceptualizing transformative aircrafts that significantly improved the efficiencies of previous designs. He is also credited with developing the Area Rule and inventing the Supercritical Wing. (WPI, 2019)
- Robert Goddard is well revered as the father of modern rocketry and is known for his work with liquid fueled and multi-stage rockets. (Foote, 2017)
- Dean Kamen is a certified innovator, responsible for inventions such as the AutoSyringe, Segway, iBOT mobility system, and the HomeChoice portable dialysis system. (Foote, 2017)

2019 Inductees
- Joseph Adams was the designer and builder behind technical engineering and construction management projects for water and natural resources, which is an achievement largely unrelated to WPI. (WPI, 2019)
- Robert H. Beckett invented an analog and digital gravimetric feeder that allows more precise blending of solid materials for product formulations. (WPI, 2019)

- Harold Black was a remarkable engineer, credited with the invention of one of the chief electrical engineering concepts – that of negative feedback, and with that he also invented the negative feedback amplifier. (WPI, 2019)
- George Cowan was a key participant in the Manhattan Project and alongside his work in nuclear chemistry, helped found the Santa Fe Institute, a center of transdisciplinary research. (WPI, 2019)
- George Cowan was a significant innovator, best known for inventing the water fog nozzle and is responsible for many other nozzle and valve technology developments.
- Scott Harris is the creator of many CAD-driven design tools, such as SolidWorks, and manages several other entrepreneurial ventures. (WPI, 2019)
- Milton Higgins was the first superintendent of the Washburn Shops, but while his work mainly revolved around creating a talented workforce, he is also the co-inventor of the first hydraulic elevator. (WPI, 2019)
- Debora Jackson is a trailblazer, not in innovation, but rather representation and academia. (WPI, 2019)
- Charles O. Thompson was known for his role as a professor in chemistry and the first principal of WPI, then known as the Worcester Country Free Institute of Industrial Science. (WPI, 2019)
- Emory Washburn was an important political figure, holding the title of Twenty-third Massachusetts Governor. (WPI, 2019)

Apollo Lunar Model Leg Prototype

Donated to the campus archives in 1992 and standing just under six feet tall is a prototype of one of the four primary struts, or legs, that Alan Glazer outfitted all six Apollo lunar landing missions with. A member of the class of 1947, Alan Glazer majored in mechanical engineering before founding his own company Honematic Machine Corporation nearly a decade later (Carlson, 2019). Made from a lightweight aluminum alloy, these legs served to cushion the landing, maintain stability, and support the descent of Apollo 11's Eagle module which landed on the moon in 1969 (Carlson, 2019).

Figure 3: Apollo Module Leg Prototype (Glazer, 1966)

While this innovation is arguably one of the more significant ones to come out of a WPI alumnus in the field of aerospace engineering, it is one that appears vastly under advertised and undercelebrated by the university. The prototype itself is on display in the corner of the Fellman Dickens Reading Room, a place that is accessible by appointment only and likely one that a large subset of the campus population will never need to access for research nor seek out for other reasons. For this reason, it is recommended that a custom glass display case is constructed for protection purposes and the prototype relocated to be displayed more prominently on campus, such as in Higgins Laboratories, the resident home of the aerospace engineering department. With this modification, not only will Glazer's contribution be celebrated in the eventual virtual innovation gallery, but also in a more visible setting and one that can be cited on campus admissions tours and promote interest in the university.

Atwater Kent Radios

Atwater Kent was a very significant inventor in the early 20th century, known for manufacturing radios and patenting the modern automobile ignition coil (Williams, 2020). Similarly tucked away in the basement of the library, lining a shelf in the Dickens Reading Room are many of Atwater Kent's early radio models. Above Model 55, a radio manufactured in 1929 (Williams, 2020), is Kent's patent pending detection amplifier. These innovations are surely of interest to prospective electrical engineering and other mechanical disciplines students and should be housed in a more prominent campus location.

Figure 4: Dickens' Reading Room Models of Atwater Kent's Radios

Figure 5: Atwater Kent Model 55 Radio

Profiles in Innovation

Prominently displayed on the bottom floor of the library, the Profiles in Innovation exhibition recognizes two of the most highly decorated WPI alumni, Robert Goddard and Richard Whitcomb, for their contributions to technology. Theo Brown, an inventor known for his contributions to John Deere, Harold Black, the inventor of negative feedback, and Robert Harvey, the inventor of one of the first artificial hearts Jarvik-7, are also highlighted for their achievements, but in a more subtle manner (WPI, 2019). Alongside biographical descriptions, the display cases house some of the individuals' personal affects as well as models of their technologies (Danemayer, 2012). While the website of the developer of this exhibition refers to additional changing exhibits on more current subjects, it appears that such cases have yet to be added to the installation. The Gladwin Gallery, a neighboring hallway only accessible by special keycard privileges outside archive operating hours, similarly advertises rotating historical exhibits, suggesting that these are the displays referenced. The physical separation of the two connected archival exhibits, coupled with the Gladwin Gallery's focus on displaying prominent artwork, contributes to the feeling of inaccessibility regarding innovation in a centralized capacity at WPI. WPI's Gladwin Gallery, Profiles in Innovation, and related exhibitions are undoubtably the strongest foundation that could be expanded into a concrete, walkthrough celebration of institutional innovation, however their structure innately lends itself to a monotonous nature. While honoring past and present accomplishments is not an insignificant

feat, a physical manifestation that encapsulates the university's culture of innovation and passion for solving global problems should be exploratory and interactive in nature, as opposed to archival and commemorative.

Figure 6: Profiles in Innovation Exhibition Cases (Danemayer, 2012)

Fire Protection Engineering Spotlights

Adorning the walls of the Gladwin Gallery are several framed posters spotlighting members of the WPI community who have had a significant impact on the field of fire protection engineering. Duane Pearsall for inventing the first smoke detector, Howard Freeman for inventing the water-fog nozzle, George Rockwood for his sprinkler system company, and Howard Emmons, Dougal Drysdale, Robert Fitzgerald, David Lucht, Edward Watkins, Henry Phillips for their pioneering research, are those heralded for their contributions. In contrast to the other exhibitions scattered around campus, however, this one feels more forced and acts as a space filler. Each poster has a couple paragraphs of text for each innovator, lending the exhibition to effectively be a wall of text that few passersby will likely take the time to read and fully appreciate. While the display is perhaps not the most beneficial use of real estate, the research conducted to compose the descriptions could be a very valuable resource to reference in the creation of a more formally organized innovation gallery.

Figure 7: Framed Spotlights for Engineering Innovators in the Fire Protection Industry

2.4 Online Archival Information and Resources Related to Innovation

As the most accessible asset of the university, the WPI website as well as all its linked digital content is arguably the one that carries the greatest significance and has the most power to influence public perception of the institution. Maintained using the Drupal content management system and regulated by standards for content and visual appearance, the wpi.edu domain encompasses all the online repositories and digital archives related to innovation at the university, yet in a very scattered and not intuitively celebratory fashion. Each of the following sections will evaluate the usefulness and digital structure of different resources encompassed by the domain for potential use in the implementation of an innovation museum.

150 Years of WPI

With a strikingly engaging layout, WPI's 150 Year anniversary website allows visitors a very interactive tour through the history of the university (WPI, 2015). A timeline spanning the width of the page allows viewers to click through the years that campus saw significant developments and read about all the pieces that came together to create the university as it is known today.

Figure 8: Celebratory Website for WPI's 150th Anniversary (WPI, 2015)

While the majority of the information published and celebrated on this site can also be found in other campus resources, it is nevertheless a useful and entertaining account of innovative history at WPI. Visitors to the site can also interact with the sesquicentennial logo, exploring and learning about the architectural cornerstones of campus that are represented. The design of this website could be modified into an ideal implementation for a digital

innovation gallery, similarly, using a timeline to provide structure. Each year tab would contain the corresponding innovations with all their respective biographical content and interactive elements embedded within the section.

Digital WPI

Created as an open access digital showcase repository, Digital WPI primarily houses academic projects, undergraduate IQP and MQP reports, graduate theses and dissertations, and faculty research. Digital WPI enhances the global accessibility of WPI research contributions, as well as contributes to the archival efforts of the university by digitally preserving collections of historical images, student organizations and clubs, and university publications (WPI, 2018b).
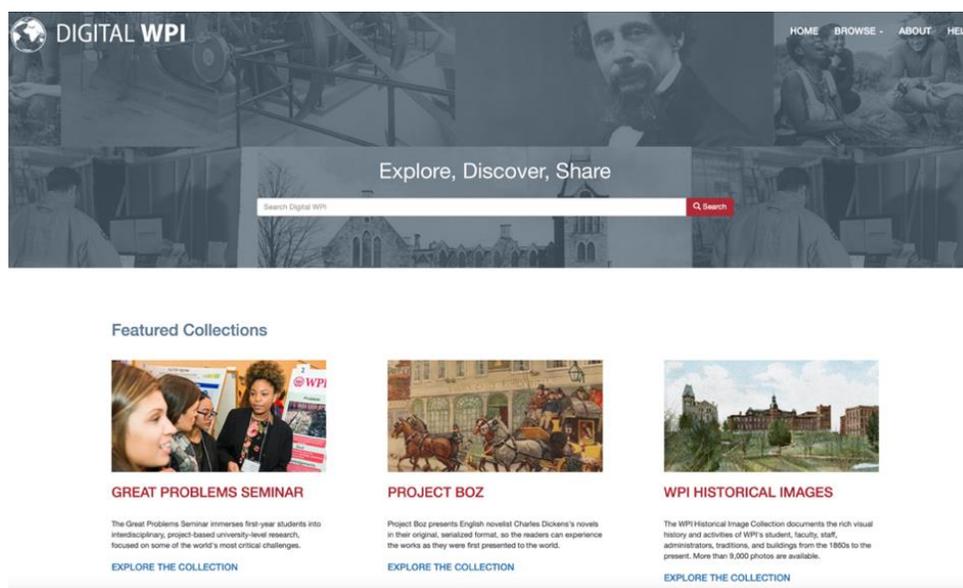
Figure 9: Digital WPI Homepage (WPI, 2018b)

Logically, it could make sense to relocate these archival collections to the university archives website, since they are more closely related to and overlap largely with the content there, or to even consider merging the two databases into one historical conglomerate. Of the Digital WPI Collections, the only particularly relevant one as far as institutional innovation is concerned is the university publications collection. This collection contains yearbooks, alumni journals, WPI Journals, campus newspapers and magazines, all of which could provide useful biographical information about the innovators to be featured in a gallery program. Some of these resources can also be found in physical format in the Fellman Dickens Reading Room. Beyond the actual content of the website, if this structure were to be used or incorporated to

create the virtual innovations program, it would likely need a completed digital overhaul rather than a couple minor adaptations, due to its logistic-oriented nature.
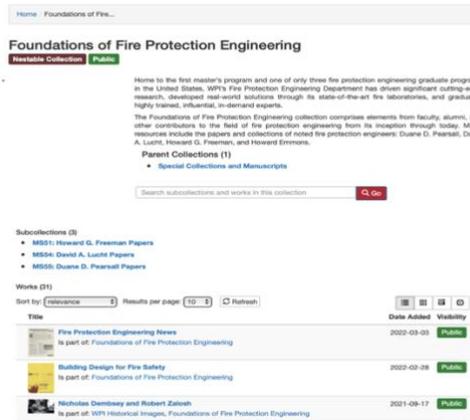
Figure 10: Digital WPI Foundations of Fire Protection Engineering Exhibit (WPI, 2018b)

Since Digital WPI is designated as a repository, it is very metadata driven, whereas the intentions behind the innovation gallery are participation focused, while still possessing all the source and datalike information.

University Archives

The WPI ArchivesSpace website hosts a multitude of inventories related to the manuscript collections and university archives that are physically housed in the WPI Archives & Special Collections storage rooms in the library. The University Archives repository provides information mostly related to presidential records, the founding of WPI, and the implementation of the WPI Plan. The Manuscript Collections repository contains information and artifacts related to specific distinguished individuals of the WPI community, a subset of whom are notable innovators. (WPI, 2022f)
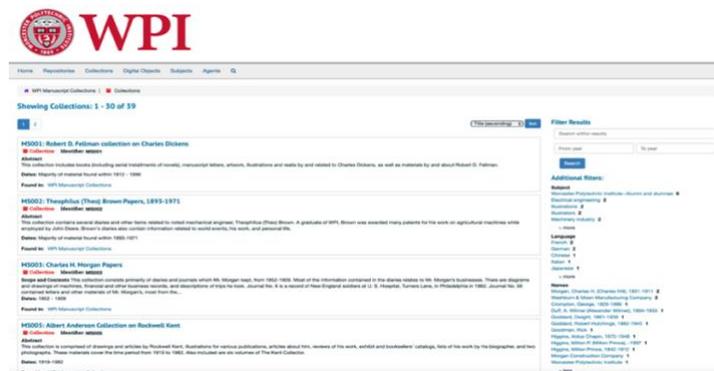
Figure 11: WPI ArchivesSpace Manuscript Collection Guide (WPI, 2022f)

Inside each collection is an overview of the scope and contents of the archival materials as well as a detailed inventory to assist the browsing of collections.

2.5 Options for Development and Appraisal of Resource and Staffing Needs

One of the more important decisions to establish in the early stages of planning is what medium the innovations gallery will take on. Based on the configurations of current exhibits and an assessment of open campus areas, it appears that space is a strong limiting factor to the development of a comprehensive physical gallery. While elements could certainly take shape in a tangible form, leading to a partially physical implementation, it would be significantly better if the gallery was consolidated all in one online framework as opposed to having multiple distinct aspects that need to be integrated with one another. Should a physical showcase become increasingly feasible in future years, the resources and staffing needs for a museum of that nature will vary slightly from those of a virtual museum. Outside of the initial development and construction of the gallery, facilities personnel will be required on a somewhat regular basis to ensure the upkeep of the display. In a similar fashion for showcases that take on a virtual form, IT personnel would be required to handle troubleshooting, overall website maintenance, and security certificate renewals, alongside the other responsibilities native to a web application. Assessing the needs of both methods of development suggests that the resource requirements post-establishment are significantly greater for online mediums. However, online applications are also substantially more feasible and scalable in addition to offering greater accessibility and catering more to the interests of younger generations.

2.6 Promoting Public Engagement with Archival Material

Arguably, the most difficult challenge encountered when presenting archival material, either in a physical or digital forum, is how to prompt active involvement from visitors. With any exhibition, one of the chief objectives of curation is to invite people to become cultural participants with the material, rather than passive consumers of the information. Infographics, animations, and other 'clickable' items are features that help transform web technologies into multi-directional content experiences and users maintain focused attention.

Nina Simon's book entitled *The Participatory Museum* is a first-class publication detailing how to practically create these engaging and community-centered cultural institutions and is a resource that can be utilized by WPI in the creation of the university's innovation

gallery. One of the founding ideals of Simon's work is the five stages of interface between an institution and its visitors, where the early stages provide opportunities for intellectual inquiry and the later ones facilitate enriched community interactions (Simon, 2011).

STAGE 5	Individuals Engage with Each Other Socially
STAGE 4	Individual Interactions are Networked for Social Use
STAGE 3	Individual Interactions are Networked in Aggregate
STAGE 2	Individual Interacts with Content
STAGE 1	Individual Consumes Content
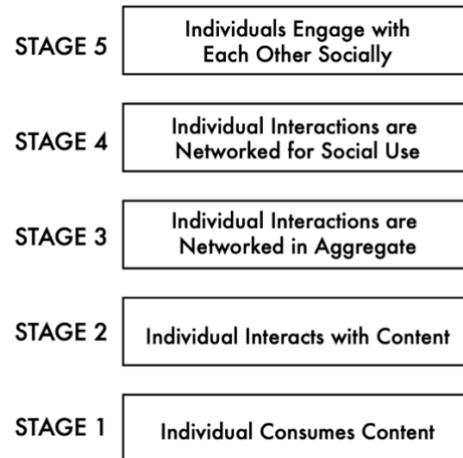
Figure 12: Nina Simon's Evolution of the Visitor Experience (Simon, 2011)

Throughout the novel, there are many strategies and recommendations of ways to successfully incorporate and apply the various principles of participation. In following these guidelines, an exploratory presentation of WPI's various innovations should emphasize the tools that were used in the process, helping to highlight the shared maker mindset, and enabling visitors to step into a sense of comradery with the decorated innovators by better understanding how various ideas were transformed into reality.

Chapter 3: Methodology

The goal of this project was to assess the feasibility of creating a new virtual galleries program at WPI that will connect and sustain efforts and programs that celebrate and share WPI's heritage of innovation. This goal was approached by way of these main objectives:

- Identify potential individuals or groups, along with ideas, inventions, and technologies that have made direct contributions to or highlight WPI Innovation.
- Discover and categorize a preliminary list of WPI's contributions to areas of the Four Industrial Revolution.
- Better understand potential goals, themes, audiences, opportunities, technology, and strategies for a WPI Heritage of Innovation Project.
- Assess resources and staffing needs.
- Identify common resources, best practices, and technology used and recommended in appropriate settings.
- Create a prioritized list of recommendations for strategies to proceed with a digital and/or physical Gallery of Innovations (Projects with Impact; PWI)

To accomplish these objectives, a set of tasks to accomplish were identified within the fourteen-week period of the project. These tasks are highlighted in the white boxes within each objective in Figure 3.1. A Gantt chart showing the planned timeline of task completion is in Appendix A: Project Schedule.
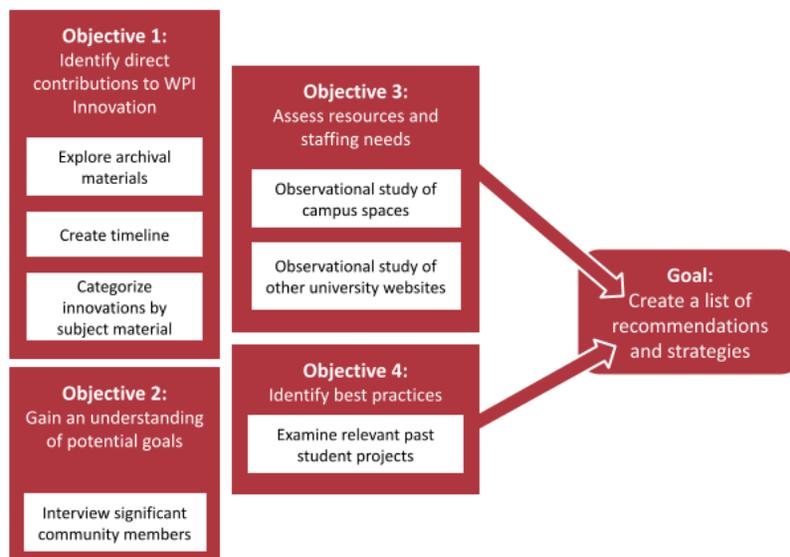
Figure 13: Flowchart of Project Objectives and Tasks

As illustrated by the figure, many of the preliminary objectives informed the final objective. With this project, efforts were particularly focused on objective 3 and 4 as these were determined to be the most beneficial in creating a list of recommendations. In the following subsections of this chapter, the approach and implementation employed to achieve each objective will be detailed.

3.1 Identify Direct Contributions to WPI Innovation

The first objective was to investigate what is already known regarding innovations that have been developed by the WPI community. To do this, a preliminary list of significant individuals that are closely linked with WPI was created and for each individual created an initial list of significant inventions that are credited to them, based on information that was readily found online as well as in the archives. Some information and potentially notable names were contributed towards this effort by interviewees Andrew Palumbo and Todd Keiller, the Vice President of Enrollment Management and Director of Intellectual Property and Innovation, respectively. One of the past advertisements used by the admissions department was the poster found in figure 14, which links well known and widely celebrated commonplace inventions and companies to WPI alumni.

Figure 14: Formerly Used Innovation Themed Marketing Pamphlet

The Office of Technology Commercialization also shared a list of members in the WPI Chapter of the National Academy of Inventors, shown in figures 15 and 16. This list will be beneficial in identifying significant innovators in more recent years, while the efforts and research described below were more focused on the earlier years of WPI's history.

Members

Emmanuel Agu	John Madura
Diran Apelian	Drew Martino
Torbjorn Bergstrom	Makhlouf Makhlouf
Cameron Betts	John McNeill
Kristen Billiar	William Michalson
Christopher Brown	Cagdas Onal
Terri Camesano	John Orr
Heather Cirka	Selim Ozel
Edward (Ted) Clancy	Raymond Page
Edward Clarke	Peder Pedersen
Kevin G. Cornwell	George D. Pins
David Cyganski	Marko Popovic
Tanja Dominko	Fioleda Prifti
Reginald James Duckworth	Reeta Rao
Gregory Fischer	Marsha Rolle
Cosme Furlong	Michael Sao Pedro
Glenn R. Gaudette	Jessica Shelsky
Janice Gobert	Xiaochuan Shi
Neil Heffernan *	Richard Sisson
Allen Hoffman	Saivimal Sridar *
Mayer Humi	Dalin Tang
Christopher Lambert	Yan Wang
Reinhold Ludwig	Pamela Weathers
Yi Hua Ma	Jamal Yagoobi *

Figure 15: List of Members in the WPI Chapter of the National Academy of Inventors

Honorary Members

Joseph Abinader	Ari Giaya	Rebecca Miles *	Harrison Roy
Todd Alexander	Dennis Giaya	Alexandra Miller	Matthew Ryder
Nathan Alvord	Scott Gowing	Shannon Moffat *	Montira Satienpoch
John Arnold	Parker Grant *	Michael Morisseau	Elizabeth Schofield
Casey Arpin	Jacob Grealis	Michael Morlock	Robert Sherburne
Bryant Babel	Karin Greene	Kathleen Morse	Nicole Sherlock
Azita Bakhtyari *	Michael Griffin	Eric Motler *	Ayushka Shrestha *
Kaitlin Beach	Lauren Guertin *	Jack Murphy	Reed Standley
Sarah Bergeron *	Lubna Hassan	David Nickerson	Mark Strauss
Sathwik Bharadwaj *	Nicholas Hassan	Kyla Nichols	Daniel Sturman
Bradford Bjorklund	Madison Healey *	Joshua O'Connor	Joseph Switzer
Jack Blanchard	Garth Hull *	Kendra O'Malley *	Craig Teed
Christina Bottom	Mary Kandaras *	Connor O'Neill *	Leslie Tepanecatl
MacKenzie Brandes	Ravneet Kaur *	Fiona Ogren	Timothy Tetreault *
Colin Buckley *	Gerald Kersus	Carlos Ordonez	Christopher Tolisano
Michael Buonomo	Carolyn Keyes	Deborah Oyewole *	Ermal Toto
Kyra Burnett	Anna Kjelgaard	Allison Paquin	Connor Tower
Anthony Capuano	Brooke Klepper	Alexandre Pauwels	Panyawat Tukaew
Christopher J. Chagnon *	Camden Knoff	Marissa Pereira *	Edward Van Atten
Sarah Chamberlain	Dennis Kole	Jonathan Perry	Caleigh Waskowicz
Harry Chartoff	Jocelyn Kurtze	Nhi Van Phan *	Zachary Weiland *
Ethan Coeytaux	Ryan La Marche *	Saraj Pirasmepulkul	Yonatan Weiner *
Costi Alicia *	Ross Lagoy	Nicholas Potvin	Brandon Werner *
Cameron Crook	Brandon Lam	Nicole Quintal	Hugh Whelan
Zachary Culp	Albert Languet	Shadi Ramadan	Alexandra Wolfe
Anny Cunha	Josephine Leingang	Zachary Richards	Nicholas Workman
Steven D'Agostino	Matthew Lesonsky	Alex Riley	Shanshan Xie
Anthony D'Amico	Katie Flynn Livingston	Emily Robbins	Tan Zhang
Thomas Dagostino	Taylor Llodra		
Jennifer Day	Lindsay Lozeau	* 2019 New Members	
Raymond DiMestico	Ashley Lutz *		
Joshua Donovan	Swarnadeep Majumder	### Licenses	
Michael Doyle	Pete Manca		
Julia A. Dunn *	Tyler Marshall	Tanja Dominko, Histogen, Inc.	
Raymond Dunn	Benjamin Mart *	Ray Page, Histogen, Inc.	
Richard Eberheim	Christopher Massar		
Peter Fenner	Emily Matsco	Gregory Fischer, AiM Medical Robotics, Inc.	
Brianna Fogal	Abigail McAdams *	Neil Heffernan, SAAL	
Zoey Foley *	Kinsey McNamara *		
Steven Franca Jr.	Shivam Mehta	Marko Popovic, Lockheed Martin & Toyota	
Mark Freitas	Connor McGrath		
Lucy Garvey	Joseph Miceli	### Hall of Fame	
Joshua Gershlak	Madison Michaud *	Neil Heffernan	

* 2019 New Members

Figure 16: List of Honorary Members in WPI's NAI Chapter

Explore Archival Materials

For this objective, the collections housed in the WPI archives were surveyed and analyzed in addition to the online collection guides, which were browsed for any information that could later be useful. Useful materials were defined as those that contained biographical information that could be included in a profile section in the virtual museum. Other useful materials were diagrams, drawings, or other visuals that could be incorporated into some graphic and potentially interactive element for the website. The results and findings of this exploration can be found in section 4.1.

Create a Timeline

From the information collected in the archives, both the digital and physical resources, an initial timeline was created with the preliminary list of names of significant innovators attached to the year of earliest relevance for the individual. For alumni, this year is the one in which they received their first degree from WPI. For non-alumni faculty, staff, and administration, the year associated with them on the timeline is the year they began working or teaching at WPI. Another timeline should be constructed, chronicling the sequence of patents/production for the innovations themselves to be hosted on the developed website. It was determined, however, that to promote all-inclusive research, that can then later be cut based on relevance, the foundational timeline should encompass all relevant years respective to a given individual. This preliminary timeline of innovators can be found in Appendix B.

Categorize WPI Innovations

Along with delivering a list of recommendations and strategies for developing a WPI innovation gallery program, one of the deliverables created for this project is a document with ongoing research related to each of the innovators that was identified. Within this document, keywords have been added related to which field of research their respective inventions fall under, as well as which thematic industrial revolution they belong to, with both categorizations following the descriptions found in section 2.2.

3.2 Gain an Understanding of Potential Goals, Themes, and Strategies

In order to better qualify the goals, opportunities, audiences, and themes behind a virtual implementation of a WPI galleries program, it was important to understand the perspective of individuals in the campus and their level of familiarity with the idea. Data was gathered by contacting and interviewing people of interest identified by the advisors during weekly meetings, following the protocols outlined in Appendix D.

Interview Significant Community Members

The majority of stakeholders identified as valuable candidates for interviews were members of the WPI Trustees. As alumni and individuals with the power to influence the direction of the university, the trustees provided indispensable insight into the feasibility of this project as well as suggestions for execution. Questions were focused around whether the atmosphere of WPI promotes innovation and how it has changed over time to accommodate this need and incorporate concepts of entrepreneurship into everyday coursework. This interview process greatly informed the recommendations were made and will be useful for future developers to reference as the individuals interviewed have a great understanding of how WPI has transformed over time and what direction it is headed in the future. Additionally, some of the interviewees are ones to be featured in the final project and the discussions had with them relate to their innovative process and significant developments, creating a useful foundation of information to build off of. Paraphrased summaries of the conversations that were had can be found in Appendix E.

Present a Value Proposition

Using WPI's Value-Creation Guidebook, created as part of the Innovation for Impact program, an NABC Value Proposition was created and presented to pitch the end-user need for an innovation gallery program as well as address the approach, benefits/costs, and competition behind this venture. This NABC was then iteratively presented to the advisors alongside Distinguished Executives in Residence Curtis Carlson and Leonard Polizzotto, the pioneers behind the Value Creation Initiative at WPI, incorporating feedback between each respective presentation session. The slide deck for the value proposition can be found in Appendix C.

3.3 Assess Resources and Staffing Needs

One of the most important constraints of establishing an exploratory and interactive virtual museum or other implementation of a WPI innovation gallery program is the assets available for development. Different implementations, even when confined to looking at either a physical or an online development, require varying degrees of staffing and resources. To better understand what assets would be needed to execute the recommendations made, observational studies were completed of both WPI's and other universities' installations to serve as a baseline for comparison.

Observational Study of Campus Spaces

Included in the syllabus for this project was a list of exhibitions on campus to look at for research and design considerations and inspiration. Using this list as a guide as well as touring campus to find other niched installations, an initial assessment of each was made, including some recommendations for how they could be improved upon. The assessments of each location can be found in section 2.3.

Observational Study of Other University Websites

A large component of this project involved benchmarking WPI's infrastructure against that of other similar and potentially competitive universities, as far as the applicant pool overlap is concerned. While physical installations on other campuses were not able to be evaluated in person due to travel logistics, online versions of these sites were analyzed in addition to natively virtual applications. These assessments can be found in section 4.2.

3.4 Identify Best Practices

In order to roughly outline the most effective plan for future groups to follow to address the demonstrated need of this project, work by other students related to digital culture and historical applications were examined. Alongside this, general recommendations were assembled based on a high-level overview of the work that remains to be done.

Examine Relevant Past Student Projects

The majority of student projects, whether IQP, MQP, or ISP, were not directly relevant to this project and so very few technology and software recommendations could be pulled. One IQP worked to develop the Global Contributor System for WPI's Weiss Jazz History Database, which is arguably a similar venture to an innovation gallery program and can be mimicked in some regards with respect to technical components (Varella & Matticoli, 2020). In eventually developing the technical implementation of a virtual gallery program, future IQP groups should consult the process that authors Matticoli and Varella employed. Professor Charles Roberts from the Computer Science Department proved to be an invaluable resource to that project and could likely provide similar insight into a range of viable solutions for this venture and help influence design decisions based on his expertise and assessment of long-term feasibility.

Recommendations for Continuing My Work

The next critical step with this project is to recruit capable and motivated students to help materialize this working concept into a veritable implementation, ideally within the next couple of years. A large component of the next group's work will be related to the development of metadata schemas for the database that will house all the data found on the site. Coupled this will be the creation of templates for each innovator profile to ensure a subtle and overarching consistent feel and aesthetic, with some differentiation between pages depending on the respective materials and elements. One of the few final things before undergoing software development will be to survey the target audience for feedback and experts for evaluation of various prospective technologies.

Chapter 4: Findings

In this chapter will be a discussion of some of the key findings from the data gathered from research, archival exploration, community interviews, and observational studies. From the interviews, transcribed in Appendix E, it was discovered that WPI never strongly emphasized the importance of intellectual property nor widely encouraged student development until recent years. This is one of the main overarching ideals that stakeholders hope the museum will help influence and was a guiding aspect when conducting research. The data researched and detailed below alongside the analysis and discussion helped inform the recommendations in Chapter 5.

4.1 Assessment of Related Physical Archival Materials

Located on the bottom floor of WPI's George C. Gordan Library are the Archives and Special Collections, which house physical collections of manuscripts, academic and administrative records, as well as alumni files and other memorabilia. These collections chronicle a lot of the history of the university and were surveyed for relevant and important information that is not be easily able to be found online.

Analysis of the Collections Assessed

A considerable amount of the archival materials was found to relate to Worcester-based manufacturing companies from the nineteenth and early twentieth centuries such as The Morgan Construction Company. While these companies were noteworthy, contributing significantly to the development of Worcester and establishing it as a leading industrial city, they are not directly correlated with innovations that stemmed out of the university and thus were disregarded. Should this project in future terms expand in scope or want to revisit some of the material previously researched, it could still be a worthwhile endeavor to more thoroughly dig through the archives to see if anything was missed in the first cursory pass.

Similarly, a lot of archival collections were focused on significant individuals in the WPI community, yet ones without a direct innovative contribution to society. Based on an initial assessment of the subject material found in the collection guide abstracts, the following Manuscript (MS) Collections were determined to likely not have materials that would add substantial value to the project and were therefore passed over:
- MS001: Robert D. Fellman Collection on Charles Dickens
- MS006: Howard Emmons Collection
- MS008: Woodbury and Company Collection

- MS017: WPI Video Game Collection
- MS020: Crompton and Knowles Loom Works Collection
- MS023: Mark Eldredge Papers
- MS024: Arthur C. Comins Collection of Gompei Kuwada Correspondence
- MS040: Society of Professional Communicators Collection
- MS043: Roys Family Collection
- MS061: Betty Hoskins Papers
- MS062: A. Frederick Griffin Collection
- MS077: Morgan Construction Company Records
- MS103: Fred Guida Audio/Visual Collection on Charles Dickens

While art and innovation are closely related and art can be regarded as innovative, it does not take on the same meaning as innovation does with respect to science at WPI. This project focuses on innovation as it relates to STEM disciplines and so artistic works and their creators were determined to not meet the criteria for inclusion in the initial design of the virtual gallery program. Therefore, the following archives were not considered based on the scope of the project, but could be reevaluated later if the definition of innovation as outlined in section 2.x was expanded:
- MS005: Albert Anderson Collection on Rockwell Kent
- MS048: Bernard Brenner Collection

In the process of identifying a preliminary list of individuals, ideas, inventions, and technologies for the museum, several names arose on whom more thorough research would need to be carried out to evaluate the scale of their contributions and see if they are on the same level as those deemed worthy of inclusion. Collections that fall under this category and are certainly worth looking through at a future time are:
- MS018: Rick Goodman Collection
  Rick Goodman is a video game designer, and this collection contains various game design documents, which could potentially include innovations in game design strategies, design, etc.
- MS030: Leslie J. Hooper Papers
  Leslie Hooper received an honorary doctorate degree in engineering from WPI and helped to develop the Navy's Underwater and Sound Laboratory. This collection may contain information related to his work with the Navy or innovations he could be credited with.
- MS037: Frederick Anderson Papers

Frederick Anderson was a mechanical engineering professor at WPI and this collection may detail any significant research contributions of his from his work in stress analysis and material testing.

- MS041: Alexander Wilmer Duff Collection

    Alexander Wilmer Duff received an honorary Degree of Science from WPI and published the leading textbook in physics in the early 1900s. This collection may contain information related to any of Duff's significant research contributions.

- MS044: Leroy Norman Reeve Collection

    Leeroy Norman Reeve designed the Conowingo Dam and hydroelectric power plant on the Susquehanna River in Maryland. Examining this collection could be beneficial in determining if any of his innovations in the field of civil engineering can be credited specifically to him, as opposed to his corporate employer.

- MS002: Theophilus (Theo) Brown Papers, 1893-1971

    Theo Brown made a lot of significant design and patent contributions to John Deere, with this collection containing his personal diaries which detail a lot of these developments.

As far as the collections that were diligently paged through are concerned, the primary goal when exploring the archival materials was to note anything of significance that should at some point be requested for digitization and in general find what information is researchable. Overall, there was not a lot of particularly relevant artifacts, as the collections detailed below primarily consisted of journals, diaries, and administrative papers. A substantial cost would be required to transcribe what is conveyed by many of these documents, documents that are largely unrelated to an innovation and would have little added benefit if included in the gallery. The majority of notable findings were prototypes and design sketches, which overall would not require much external vendor support to digitize and whose inclusion would have a substantial effect on conveying the impact and background of varying innovative contributions. The sections below showcase figures of useful discoveries that are of high interest for official digitization and provides a list of other useful information found that can be further researched.

Card Catalog

Located in the cabinet in the Fellman Dickens Reading Room is a physical card catalog that indexes all references in the WPI Journals, Tech News, and other sources to respective individuals of significance in the WPI community as well as references to other notable campus entities. While the virtual gallery program will largely and logically be centered around the manifest research contributions, a comprehensive search through the card references of each of the highlighted innovators should be completed to see if there is any biographical

information, photographs, or other interesting documents that merit inclusion in the respective exhibits.
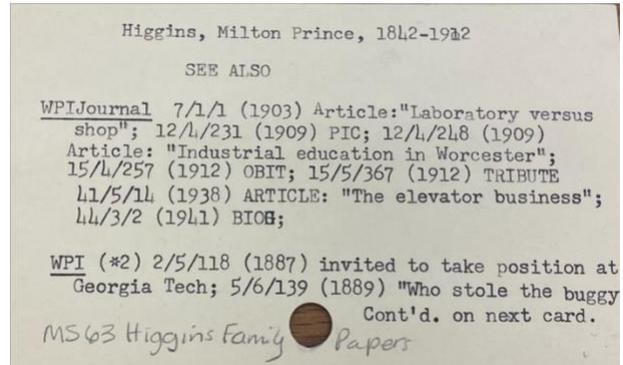
Figure 17 (left): WPI's Card Catalog System
Figure 18 (right): One of the Milton Prince Higgins Cards in the Archive Catalog

Few collections had materials that would be particularly engaging in a digital format; the majority of relevant collections contained little to no illustrations or photographs, however, the biographical and technical information could have some merit, pending further evaluation.

MS003: Charles H. Morgan Papers

This collection contains primarily diaries and journals with recollections of Morgan's businesses, transactions, and travels. Some of the journals contain sketches of machines and the most significant drawings are identified in the images below.
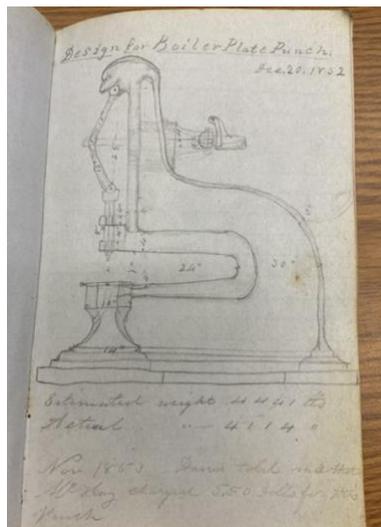

*Figure 19: Sketch design for boiler plate punch (Morgan, 1852-1854)*
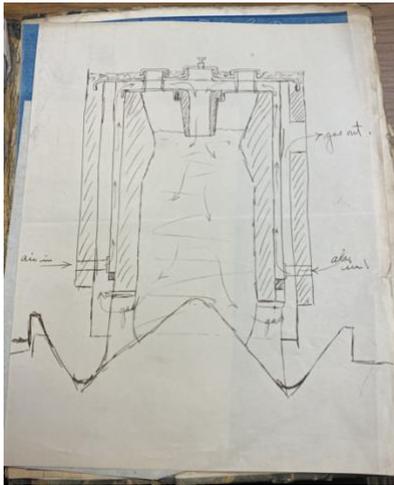
*Figure 20: Sketch for gas producer (Morgan, 1859-1868)*
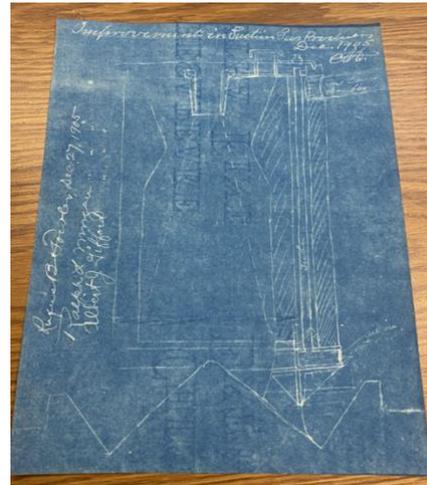
Figure 21: Blueprint for gas producer (Morgan, 1859-1868)

The journals in box four of the collection contained numerous other diagrams that may have been initial sketches for technologies Morgan later went on to patent, however, someone with knowledge in the field would need to examine them before they are confirmed as significant.

MS09: Harold S. Black

This collection contains hundreds of detailed handwritten notes, formula sheets, diagrams, and presentations about Black's research on feedback theory. Alongside a multitude of research documents from his work at Bell Labs, technical papers, and patent documents, the collection contains some personal correspondence with family, mostly related to business and estate.
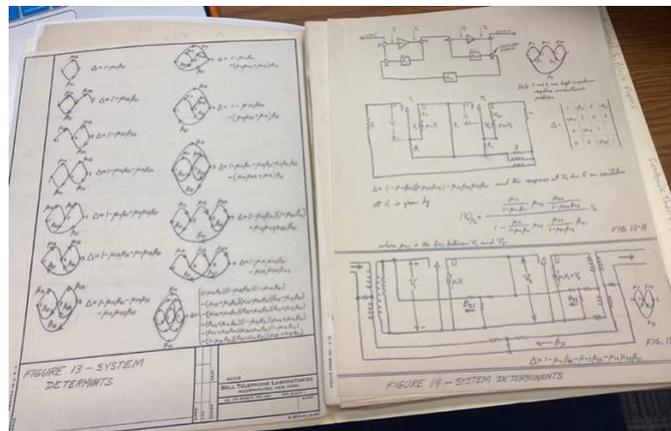

Figure 21: Black's Notes on Feedback Theory: μβ Stability Examples (Black, 1898-1993)
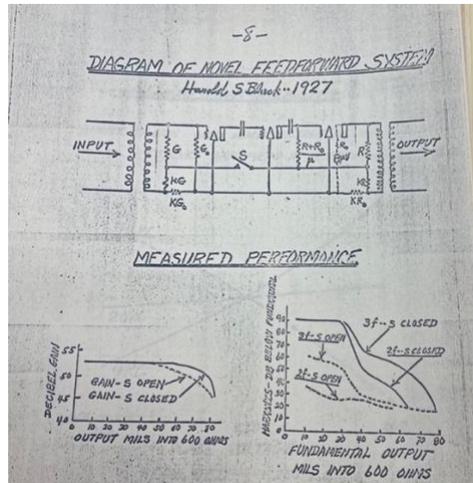
Figure 22: Black's Design for a Feedforward System (Black, 1898-1993)

MS014: Robert and Esther Goddard Collection

This collection contains a lot of background biographical information that could be useful in creating an innovator profile. Box one holds all of this information as well as a list of chief accomplishments and a complete list of attributed patents. Box two contains a lot of photographs of the mechanical equipment used during the assembly of the rockets, which might be worth using to highlight the standards of technology at the time. Boxes three and four contain notes of a broad spectrum of engineering concepts, which would not serve an outrightly notable purpose.

MS049: Dwight Goddard Papers

This collection houses a lot of genealogical information related to Goddard, as well as a detailed timeline of his life and career. The most significant pieces of information in this collection are drawings and figures found in his engineering notebook in folder one.
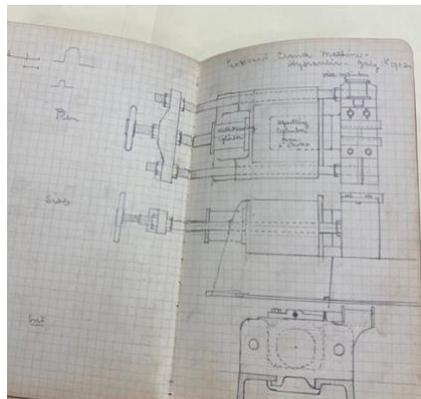
Figure 23: Goddard's Proposed Hydraulic Crank Machine (Goddard, 1902-1907)

Figure 24: Patents for Binding Cranks (Goddard, 1902-1907)
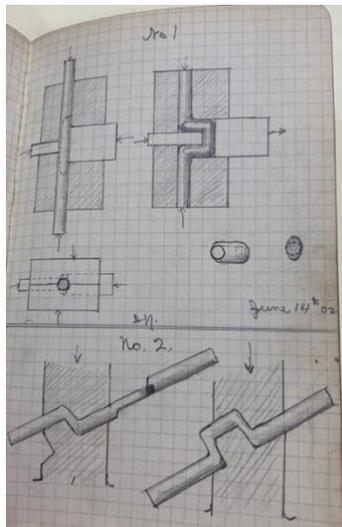
Figure 25: Miscellaneous Crank Sketch (Goddard, 1902-1907)
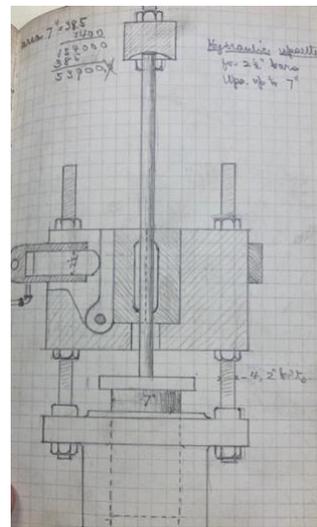
Figure 26: Hydraulic Equipment (Goddard, 1902-1907)
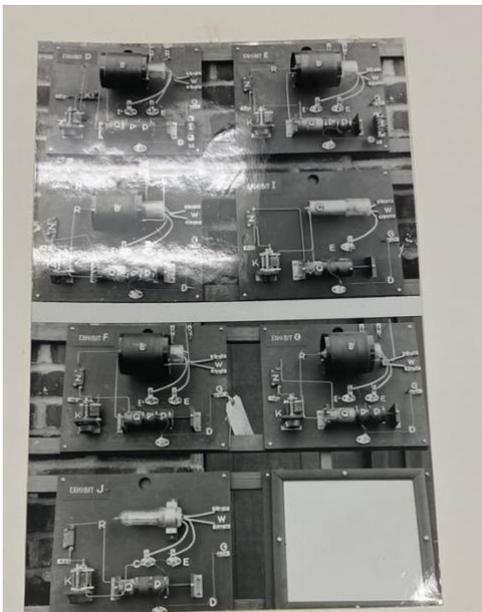
Figure 27: Bread Board Oscillators from Patent Application (Goddard, 1902-1907)
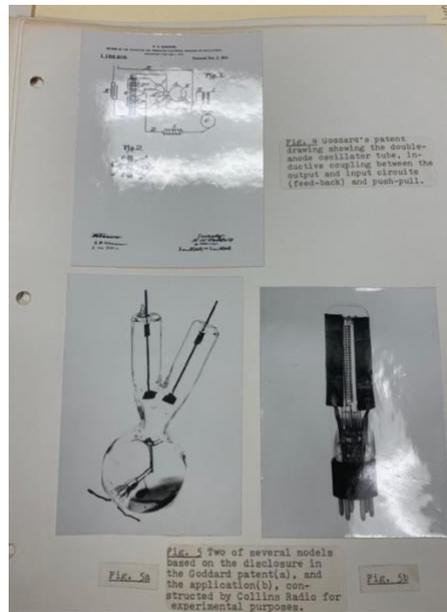
Figure 28: Oscillator Patent Drawing and Models Based on Them (Goddard, 1902-1907)

MS053: Higgins Family Papers

This collection encompasses the majority of the Higgins family's history as well as all of the historical ties connecting them to WPI. As far as a virtual innovation gallery is concerned, the most interesting documents are technical designs submitted for patent applications.
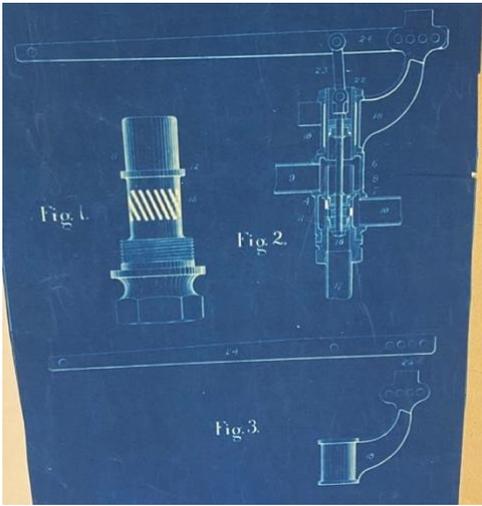
Figure 30: Patent Application Blueprint for Balanced Valve (Higgins, 1888)
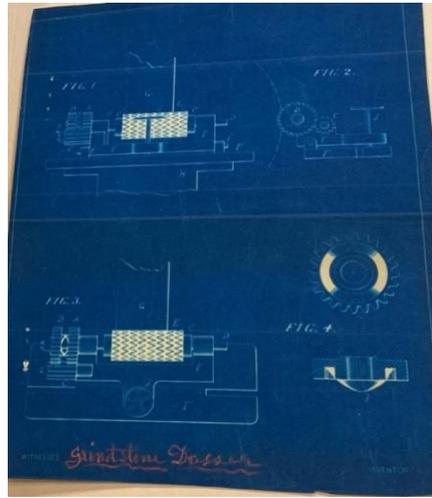
Figure 31: Specifications for Grindstone Dressing Machine (Higgins 1888-1890)
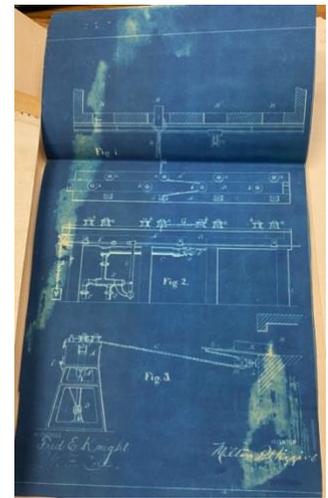
Figure 29: Original Specifications for Hydraulic Puller (Higgins, 1890)
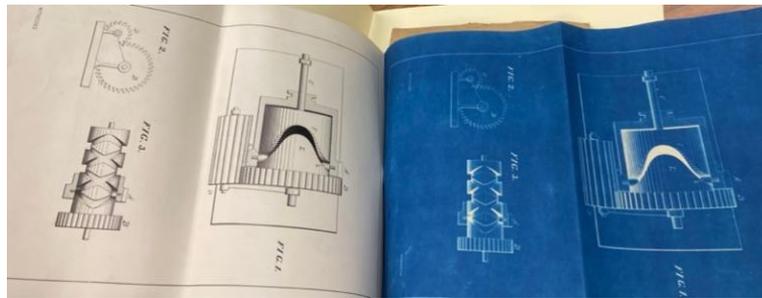
Figure 32: Diagrams for Patent Applications (Higgins)
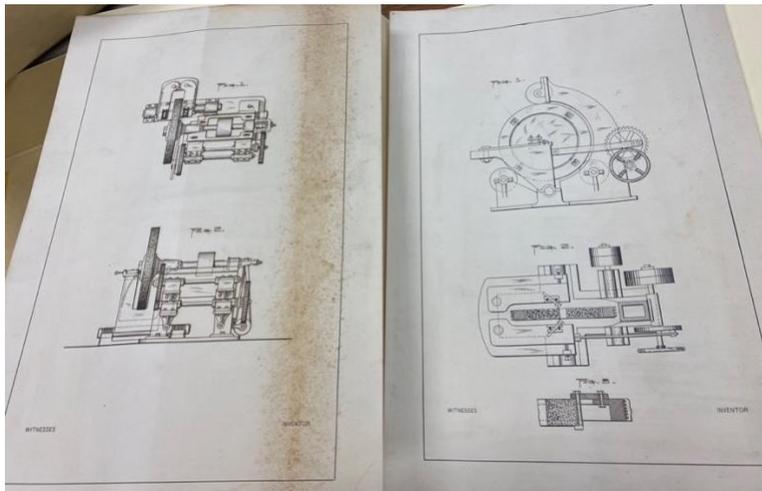
Figure 33: Diagrams for Potential Patent Applications (Higgins)

MS068: Edward N. Clark Papers

This collection contains descriptions of Clark's twelve inventions, which are all formatted mostly as announcements to the Patent Law Department of his company Sylvania Electric Products.
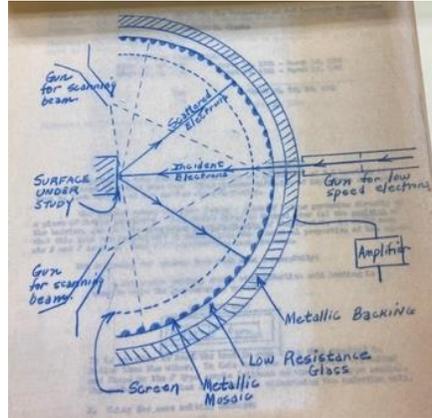
Figure 34: Study of Surfaces by Means of Slow Speed Electron Diffraction (Clarke, 1954)

University Archives Collection 67.01: Washburn Shops

This collection documents the history of Washburn Shops, housing financial reports and advertisements along with catalogs and brochures of the shop's products. One of the significant inventions described in this collection is found in the report of the shop committee and details the development of a new variable speed sensitive drill press. The drill press had several patents pending, which might be able to be attributed to the shop's founders Ichabod Washburn's and/or John Boynton's section of the online innovation gallery, contingent on further research into the development of the press.

Figure 35: Sketch for Washburn Shop Drill Press (Washburn, 1907-1908)

Finally, there were several collections linked with individuals who had been identified as significant innovators that either did not have anything especially substantial to note or whose contents were in protected display cases and may or may not be later evaluated and determined to have significance:

- MS051: Howard Freeman Papers

    Howard Freeman revolutionized the fire protection industry, particularly through his invention of the water-fog nozzle for sprinkler systems.

- MS054: David Lucht Papers

    David Lucht has had a remarkable impact on the development of fire safety studies and helped innovate a graduate curriculum program for fire protection engineering at WPI, the first in the country.

- MS055: The Duane D. Persall papers

    Duane Persall invented the first battery operated smoke detector for residential use.

- MS060: James Forrest Howe Papers

    James Howe developed a method of prestressing wire ropes for suspension bridges as well as a new innovative and accurate method for measuring these ropes and cables.

- MS067: Alan Glazer Collection

    Alan Glazer developed the legs for the Apollo lunar modules.

4.2 Evaluation of Other Institutions' Celebratory Exhibitions

Promoting and celebrating student success and the accomplishments of a campus community is not only an effective admissions marketing strategy but also a primary driver behind student motivation and the development of an encouraging and innovative culture. Outside of commencement awards and publication of student theses, one of the many ways universities can call attention to these significant achievements is through commemorative expositions. In order to compile a list of best practices for WPI to follow when looking to implement this concept in a way that aligns with university ideals, colleges and other institutions with established museums were used as a benchmark. Viewed from the lens of a current student, recommendations were proposed based on what elements are anticipated to encourage excitement among the student body. Many of the suggestions related to which universities should be explored came from recommendations from interviews, detailed in Appendix E.

Spotlight at Stanford

Spotlight at Stanford is an open-source collaborative archive application that was developed by the university with the goal of helping cultural heritage organizations easily organize digital content and create virtual exhibits (Stanford University, 2021). Any member of the broader Stanford community has the opportunity to request to create an exhibit and this software feature would be something especially beneficial to incorporate a modified version of into a WPI platform, as it provides a straightforward way for the community to contribute any knowledge, resources, and information they have to the project. As a whole, the Spotlight software enables the creation of aesthetically interesting sites that host collections of information. Stanford University primarily uses the platform for instructional aide, to act as a companion to their physical on campus exhibitions, to increase availability of scholarly materials, and to provide a narrative context around given artifacts (Stanford Library, 2022).
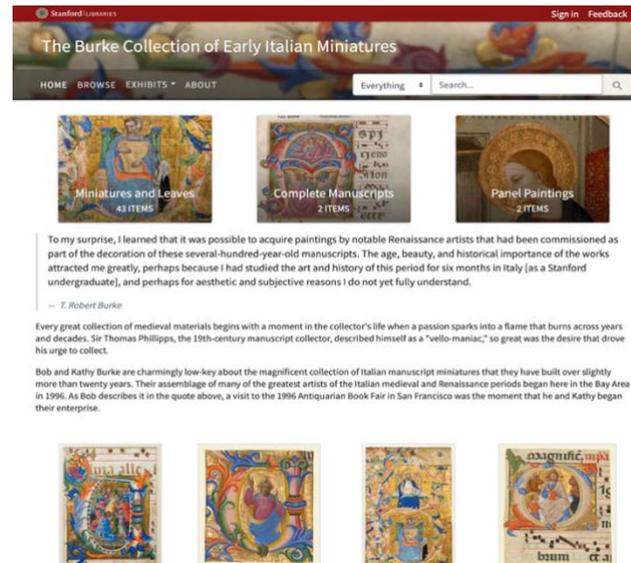
Figure 36: Stanford Exhibition of Notable Renaissance Artwork (Albritton, 2017)

There are many different built-in features that exhibitors can take advantage of when conceptualizing how to display the content they select from their repositories. Most of the content Spotlight at Stanford has published is image-based and although the platform can easily support file-based content, it recommends including graphics and emphasizes the importance of visually interesting exhibits. The platform also supports full text search and uses advanced indexing methods, allowing visitors to easily explore exhibits by themes and other groupings and view metadata within the context of the exhibit (Stanford Library, 2022).

Figure 37: Reference Manual for Making Spotlight Exhibitions (Aster, 2022)

Overall, Spotlight at Stanford has a very interesting and aesthetic organization, and not only include exhibits related to science but also art, which is one way of being more inclusive with an institution's celebratory project. A very similar format could be beneficially implemented in a WPI gallery, but perhaps with more cohesive ties between the exhibits on the homepage, instead of how Stanford has them as isolated and distinct categories.
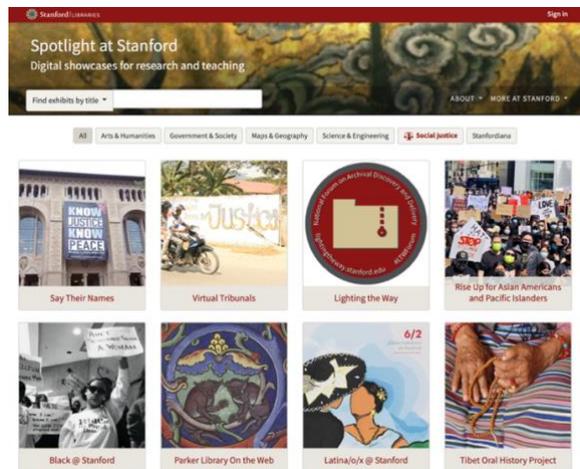
Figure 38: Spotlight at Stanford Homepage (Stanford University, 2021)

Inside a given collection, maintaining an easily navigable structure is of utmost importance, followed by striking a desirable balance between informative text content and interactive visual content. A large number of the Stanford exhibits vary drastically in how each individual exhibit can be navigated and have their information structured in an overwhelming manner, both factors which only serve as a moderate deterrent to visitors. Additionally, some exhibitions lack contrast between text and graphic elements.

Figure 39: Stanford Chinese Railroad Workers Project Exhibition (Chang, 2020)

Jazz History Database at WPI

The Weiss International Jazz History Database is an online archival repository established with a focus on using primary sources to preserve the legacy of and multimedia to present multi-faceted profiles for acclaimed jazz musicians (Curran, 2018).

Figure 40: The New England Jazz Hall of Fame (WPI, 2017)

Documenting the stories of many significant figures in the history of jazz, the database emphasizes a user-friendly nature as well as many avenues of selectable navigation. The database itself also lends itself to being a global contributor project, empowering international correspondents to donate content and knowledge to the museum, expanding the history beyond the initial New England scope (Varella & Matticoli, 2020).
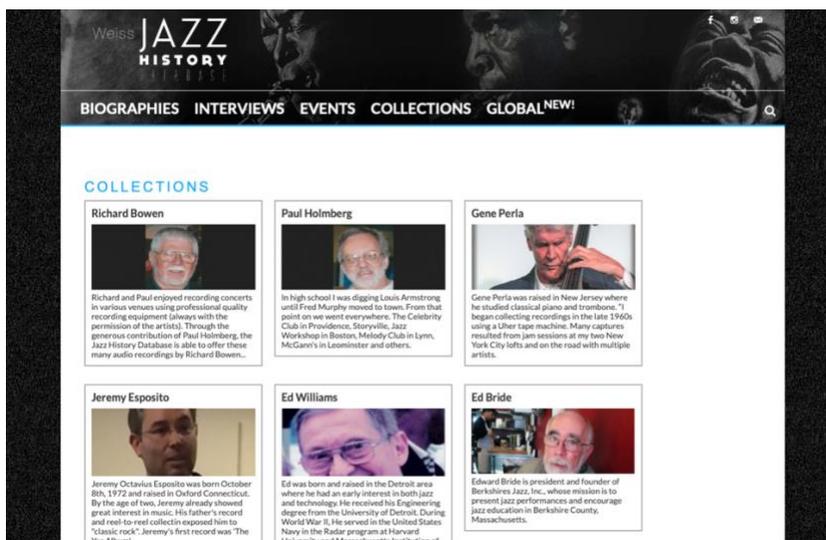
Figure 41: Jazz History Database Collection Guide (WPI, 2018a)

In a broad sense, the software technologies utilized on the backend could be conducive to modification for the purpose of developing an innovation gallery. One major aspect that would need transformation is within each individual collection, and likely throughout the site as well, there would need to be support for 3-dimensional models and similar technologies that are instrumental in creating an immersive, curiosity prompted experience.

Drexel Digital Museum Project

The Drexel Digital Museum Project is a collaboration among a select handful of other research universities and costume organizations whose focus is the creation and distribution of media intended for displaying pieces of historical fashion. One of the most notable aspects the gallery has to offer is its own proprietary 3D interactive media, dubbed OBJECTVR (Martin, 2019). This software allows viewers to the site to actively engage in the exhibition by allowing them to fully rotate and zoom in on each installation. This technology, with its ability to animate and virtually distribute images to other collections, also helps preserve these historical garments, which otherwise risk degradation and stress from being on display (King, 2019). Creating or licensing a similar technology to showcase physical WPI technologies would be a

very interesting concept to look into as this form of interactive media is very engaging to students.
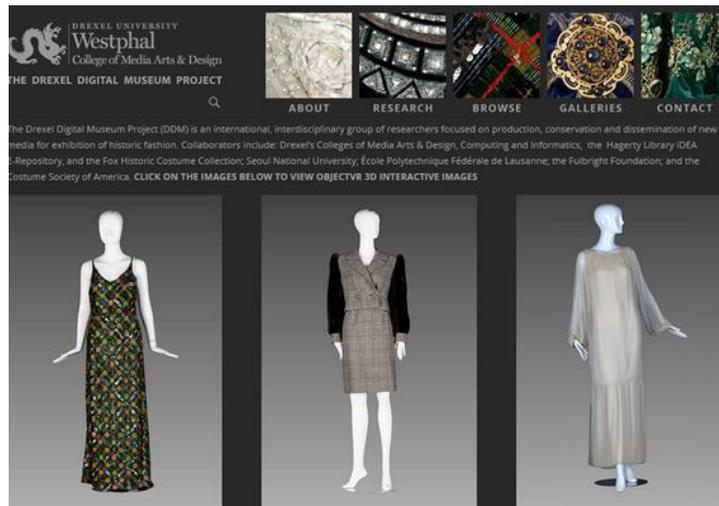
Figure 42: The Drexel Digital Museum Project Homepage (King, 2019)

The OBJECTVR technology displays the garments with incredible resolution, with viewers able to zoom in enough to discern individual stitches, yet because of this, the media box sometimes takes a handful of seconds to fully load. While the loading progress bar does not entirely hamper the user experience, it does suggest that there may either be a better way to host this media or room for performance-optimization on the backend of the website development. A more positively notable aspect that the design team highlighted was the comprehensive metadata descriptions, adhering to archiving standards, attached to each media element for ease of dissemination and conservation. Other software that was credited in development was GigaPan, which can be utilized to make panoramas of a space and Quick Time Virtual Reality movies, which were eventually repurposed as MP4s after QuickTime became legacy software (Martin, 2019). As far as a WPI innovations gallery is concerned, GigaPan would not be very applicable since there is no physical space that is looking to be digitized.

Figure 43: Implementation of ObjectVR technology (Martin, 2019).
(left) *Natively Digital Platform*   (right) *Physical Installation in Gallery*

The MIT Museum

Inviting visitors to view and participate in a multitude of exhibitions, galleries, demonstrations, and workshops, the MIT Museum works to engage a large community in ongoing research and innovation within the context of the university.

Figure 44: Exterior of the MIT Museum at its Former Mass Ave Location (MIT, 2019)

Housing thousands of artifacts, books, and technical archives that are significant to the history of the university, the museum provides wide access to the institute's historical collections in both physical and virtual forms (MIT, 2019). The museum is currently under renovation, with ambitious plans for the layout to reflect the spirit of innovation of the students. The MIT Museum is the physical embodiment of what WPI should try to achieve through a virtual implementation, capturing the societal impact of its respective research and scientific innovations to the same effect and ideally with a similar level of public engagement.

Figure 45: Artist Rendering for Renovated MIT Museum at Kendall Square (Shulman, 2018)

While the largest and primary focus of the museum is the physical implementation, MIT has also worked to develop an online counterpart to house the collections in a digital format. The

style of the collections database very closely resembles that of WPI's archival repositories, therefore leading it to not be an ideal model for an innovations gallery.
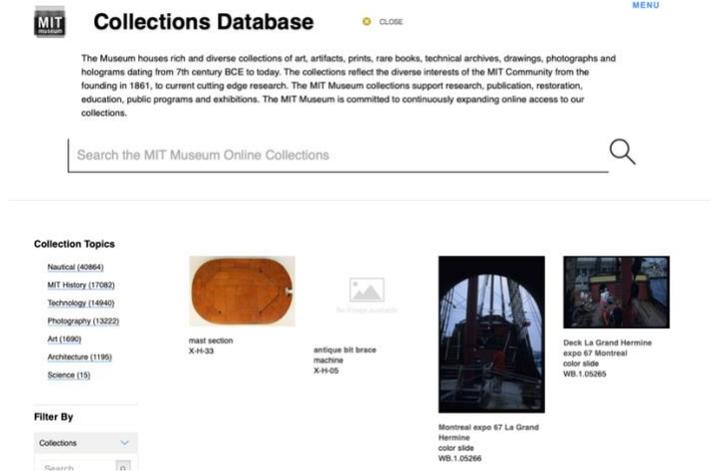
Figure 46: Beta Version of MIT's New Online Collections Portal (MIT, 2022a)

The Martin Trust Center for MIT Entrepreneurship

An integral part of the Sloan School of Management, the MIT Entrepreneurship Center is driven by the mission of commercializing student technologies, providing courses, grants, mentorship, and other resources to students (MIT, 2022b). As a whole, this initiative-aimed program is not the most imitable or applicable installation with regard to a WPI innovation gallery. Should the development of a WPI innovation museum prompt significant acceleration of ventures at the university, however, this center would serve as an outstanding model for resource allocation and student support offerings. The guiding principles outlined by the Martin Trust Center, as well as the structure and opportunities they provide students with is a paragon of enterprise, worth noting in the event WPI should be able to replicate any aspect of it in future years.
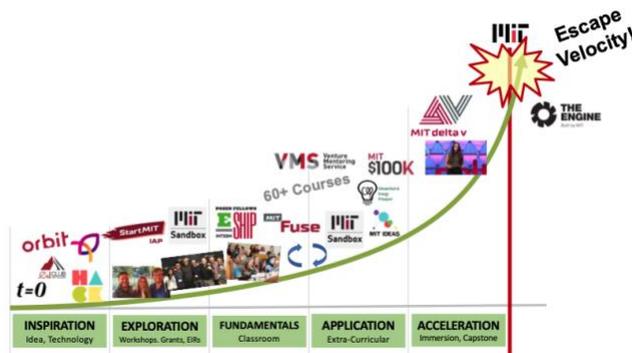
Figure 47: MIT's Structured Path to Entrepreneurship (MIT, 2022b)

Chapter 5: Conclusions & Recommendations

The goal of my project was to help assess the feasibility of creating a program to highlight WPI's nature of innovation with the overarching ideal of inspiring a renewed commitment to solving problems with impact across the campus community. Through my background research, conversations with community members, and resource surveys, numerous recommendations were proposed as to how a centralized gallery program could be implemented to showcase not only WPI's research contributions, but more broadly how WPI's design of project-based learning solves problems that have meaning for others. The following sections outline some of the methods and strategies that can be used or further researched for development.

5.1 Target Audience Evaluation

Functionality of a software platform is initially the most important aspect, however overall, end-user satisfaction is the most necessary element to implementing a successful tool. The idea of value creation and innovation feeds directly into this project, oftentimes technology is created and looks for applications which can result in creations that people do not want. One of the primary focuses of developing the infrastructure for this project should be on the customers. Feedback from stakeholders is in no way less valuable and it is still important to address their needs and ideas, however, what excites students is what should be prioritized with development. For this, future groups should consider sending out a series of surveys or questionnaires to gather large amounts of student input. One thing to note is that these widely distributed questionnaires may need IRB approval if they ask for personal information, but the librarians are a great resource and can help with the format of the survey. While it is certainly a concern that not every student will have a good working knowledge of what is feasible and their suggestions may introduce technical constraints, polling student opinions is necessary to ensure broad satisfaction.

5.2 Software Recommendations

The following technology and supporting system recommendations were made based on the need to have an initial viable working implementation. Future iterations and ones that scale to incorporate more advanced technology such as virtual and augmented reality software will require more research.

For the purposing of surveying individuals, Qualtrics, LibWizard, and Google Forms were identified as the three best candidates. LibWizard is likely the best option as it is more intuitive and scalable, and also has the capability of being available to people outside the WPI community if future researchers decide to expand the survey population. With the development of the Jazz History Database, the authors created a custom Python program to run various queries on a MySQL database holding the survey responses (Varella & Matticoli, 2020). This program could be leveraged and or modified to fit the needs of this project.

For the development of the actual museum, Muse.Place or other transformative software like Google Sketchup. Muse.Place gives developers the ability to overhaul websites and transform them into a walkthrough virtual gallery. This software would help create an interactive media platform that will augment visitor interactions using interpretive text, sounds, and animated visual displays. The only concern with these platforms is with mobile compatibility, which is an area that Professor Roberts may be able to advise. For a less technologically advanced implementation, Stanford University has their own exhibits documentation detailing how to create and leverage Spotlight, a tool that WPI has also started licensing in a few contexts (Aster, 2022).

5.3 Overall Implementation Details

A key detail for future groups to remember when deriving a tangible product for this concept is the overarching goals of highlighting value creation, entrepreneurship, and innovation. WPI aims to teach students to have an innovative mindset and develop this mindset to solve important problems and this museum should help achieve this goal. When looking at the scope of the project, it is important to restrict it to notable alumni with close ties to WPI and to otherwise keep the frame of innovations linked to students during their time at WPI. There are certainly many notable WPI alumni who have gone on to successful ventures, however, the critical idea is that the innovation should be closer linked to the university than the respective company, unless it is one founded by the alum. Maureen Maynard, the Associate Director of Alumni, Parent, and Affinity Engagement in the Advancement Department, is a good connection to have in alumni relations for both this as well as reaching out for oral interviews that could be included in the museum. The idea of struggles and success is a theme that could possibly be incorporated into a virtual development and stories of failures from the successful individuals being interviewed should be asked about.

It is also important for developers to be consistent in the creation of their database, as well as consistent with the information being collected. Name, biography, inventions, photos, date of birth, significant patents, significant social connections, campus involvement, and

club/organization affiliations should be the initial metadata information fields for each innovator. The inclusion of campus involvement and club/organization affiliations is to help augment relatability of students to historical innovators. It is a very difficult undertaking to directly motivate or inspire students and one viable workaround to this is to focus on relatability and the inspiration will follow. For biographies Mike Dorsey was WPI's primary science writer for the past decade. As he has written a large amount about the luminaries, he may be a good person to contact for the biographical sections.

In some location on the developed website, there should be a resources page for students to help clearly establish what tools students have access to and how to take advantage of them. Some of the categories of resources to be included in this section are makerspaces, advisors, events and networking opportunities, skills workshops, project funds/fellowships, relevant student clubs, collaborative spaces, available projects to join, and legal advice.

Finally, the importance of this initiative cannot be underscored enough and to stress this, this website should ideally be the heart of the wpi.edu domain or otherwise prominently displayed on the landing page. Having this featured in WPI's research magazine would be one step to promoting this, alongside presentations to stakeholders in the university explaining why this initiative is so critical to the future of the institution. Depending on the number of financial resources that can be designated towards this effort, perhaps eventually a corresponding physical establishment could be built to compliment the website, however, the future is digital and virtual development should remain the priority.

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Appendix A: Project Schedule

TASK TITLE	START DATE	DUE DATE	January	February	March	April
Innovation Research						
Archive Exploration	01/18/22	02/18/22				
Stakeholder Interviews	01/26/22	04/04/22				
Timeline Creation	02/14/22	03/04/22				
Innovator Research	01/18/22	02/11/22				
Recommendations						
Software Best Practices	04/04/22	04/08/22				
Evaluation of Competition	03/14/22	04/01/22				
Evaluation of Current Initiatives	03/28/22	04/15/22				
Report Writing						
Introduction	01/18/22	01/28/22				
Background	01/24/22	02/23/22				
Methodology	03/14/22	04/08/22				
Findings	04/04/22	04/21/22				
Recommendations	04/04/22	04/21/22				
Misc.	04/25/22	04/29/22				
Value Proposition						
NABC Proposal	04/04/22	04/28/22				
Presentation	04/14/22	04/28/22				

Appendix B: Preliminary Timeline of Innovators

As a note, the majority of the innovators in this timeline are more historic and more research would need to be done to find inspiring modern day student contributions and inventions.

1865	Ichabod Washburn		1940	Howard Freeman
	John Boynton		1943	Richard Whitcomb
	Charles H. Morgan		1945	Carl Clark
1868	George Alden		1946	William R. Grogan
	Milton Higgins		1955	Milton P. Higgins II
1881	Elwood Hanes		1956	Robert Diamond
	Dwight Goddard		1962	David Norton
1882	Charles Corydon Hall		1965	Edward N. Clark
1888	Kotaro Shimomura		1967	Curtis Carlson
1893	Aldus Higgins		1970	Robert Harvey
1895	Atwater Kent		1973	Dean Kamen
1896	Robert Sanford Riley		1975	Judith Nitsch
	Leon Alford		1978	David Lucht
1899	James Forest Howe		1979	Duane Pearsall
1901	Theo Brown		1987	Emilio Sacristan Rock
1908	Robert Goddard		1989	Christopher Brown
1920	George Fuller		1990	Diran Apelian
	Burton Marsh		2010	Yan Wang
1921	Harold S. Black		2012	V.J. Manzo

Individuals that were identified after preliminary research had concluded and would require further evaluation before inclusion in the timeline:

- Ronald Zarrella
- Peter Gosselin
- Jason Tuell
- Kathy Loftus
- Jennifer Gray
- Michael Dolan
- Claudio M. Gelman
- Lise W. Jorgensen
- Maria Elisa Carvajal
- Peter Travers

Appendix C: NABC Value Proposition

The NABC presentation follows the below Value Creation Guidebook Card, as created by Curtis Carlson and Len Polizzotto.

In 2019 alone, WPI students produced 70 new invention disclosures and licensed 20 patents and yet from the perspective of prospective students WPI remains severely underrecognized for its work in training students to innovate both during their time at the university and for years after.

With the introduction of the plan, WPI singlehandedly pioneered project-based learning and yet has never received acknowledgment for being and remaining a leader and source of innovative inspiration to other universities. This demonstrated need to better tell the compelling story of how WPI's project based learned allows students, alumni, and faculty to have impact by solving problems that have meaning for others is one that could be met by the implementation of a virtual innovation museum. Establishing a formal gallery program will not only help broaden appreciation of WPI's heritage of innovation, but it will also encourage a renewed institutional commitment to creating value and paint a more representative picture of WPI. The implementation of an interactive and immersive exploratory website that showcases WPI's research contributions in an exciting manner will promote campus-wide intellectual engagement and propel WPI to once again be viewed as a leader in innovation.

Approach

Goal

Create an immersive and engaging virtual/augmented reality innovation gallery

In creating a foundation for this I plan to:

- Identify and categorize a list of WPI inventions
- Discover relevant and significant archival materials for inclusion
- Interview stakeholders and experts in the field
- Survey other institutions' websites
- Evaluate existing spaces on WPI's campus dedicated to innovation
  - Gladwin Galleries
  - Hall of Luminaries

With the end goal of creating an interactive and exploratory virtual experience, I have worked to assess the feasibility of creating a galleries program at WPI and establish a foundation from which future project groups are then able to develop a tangible product. Towards this ultimate and eventual development, I have followed and plan to accomplish the list of tasks above, beginning with researching a preliminary list of potential individuals, ideas, inventions, and technologies that have made direct contributions to WPI innovation. I also have sought out feedback and input from stakeholders in this project, such as a handful of WPI trustees and university historians, to gain a better understanding of potential themes and strategies to prioritize. In order to then create my list of recommendations for strategies, I surveyed other universities with spaces dedicated to institutional history as well as places around WPI's own campus to assess resources, staffing needs, and to gain insight into what an eventual product would look like.

Benefits and Cost

Benefits

- Increase institutional awareness of innovation
- Increased visibility of WPI
- Stimulate intellectual curiosity
- Interactive relatability
- Establish a foundation for additional exhibitions

WPI vs RPI website audit

Traffic and Engagement

Traffic & Engagement Last Month

Total Visits	12M	14M
Last Month Change	4.75%	5.03%
Avg Visit Duration	00:06:31	00:07:55
Pages per Visit	5.40	7.32
Bounce Rate	42.71%	33.02%

SimilarWeb Website Ranking

- 302 csuchico.edu
- 303 ndus.edu
- 304 wpi.edu
- 305 hacc.edu
- 306 uri.edu
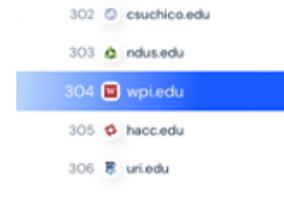
2020-2021 Admission Statistics
Worcester Polytechnic Institute

Legend: Applicants · Admitted · Enrolled · Acceptance Rates · Admission Yield

(Categories: Total, Men, Women)
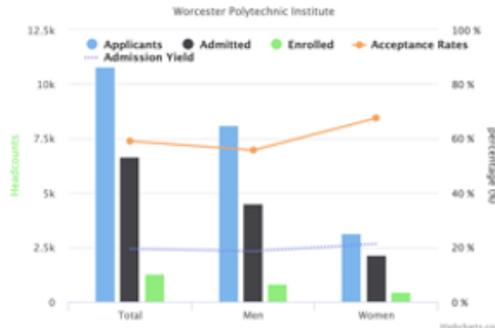
To an end-user, a virtual innovation museum will be a significant tool in educating community members as to what innovations WPI is credited with. A virtual gallery program would help increase relatability among the general student body population to some of the more significant and historical innovators and hopefully inspire students to be more entrepreneurially driven. When looking at the cost aspect of the project a large portion will be offset by recruiting and utilizing student and faculty talent to carry out development. Additionally, this natively online platform will have significantly less overhead than a physical exhibition, however, could have larger associated costs of around a couple thousand dollars if VR/AR technology is incorporated and related software is licensed. As this development will greatly improve WPI's reputation, it has the potential to increase the number of applicants by upwards of a couple thousand and increase yearly yield by a couple percent bringing it up from 23% closer to 30 and therefore drive down the acceptance rate from 49% closer to 40%. To address costs of continued site maintenance and website optimization, any necessary funds can be raised through the Trustees and other campus initiatives, as it has been determined that ensuring students graduate with entrepreneurial mindsets and learn to create value is a fiscally worthwhile undertaking.

Competition & Alternatives

- Spotlight at Stanford
https://exhibits.stanford.edu
- MIT Innovation Museum
https://mitmuseum.mit.edu
- Other digital/social media platforms

- Alternatives
  - Expansion of library's physical exhibition
  - Department specific exhibitions
  - Passivity/no action

As far as competition goes for this virtual installation, one of the largest ones is at a very broad level and consists of all other digital platforms competing for screen time and attention. In an online setting, end users are not viewing WPI in a vacuum and can more easily be distracted away. Other competition obviously includes innovation exhibitions by similar mid-sized technical universities. To address this competition, WPI could focus this virtual development through the lens of value creation forums and highlight how students are working on major societal problems every day, which is something few other universities are able to do.

Appendix

Value Factor Analysis

	Product or service		Virtual Innovation Museum				
	Target Market		Prospective students/faculty				
Quality Features	Market Importance	MIT Satisfaction	MIT Total	WPI Today Satisfaction	WPI Today Total	Our Idea Satisfaction	Our Idea Total
1	Interactivity	3	2	6	3	9	4	12
2	Educational value	4	4	16	4	16	5	20
3	Entertainment	5	3	15	2	10	5	25
Total			37		35		57
Convenience Factors	Market Importance	MIT Satisfaction	MIT Total	WPI Today Satisfaction	WPI Today Total	Our Idea Satisfaction	Our Idea Total
1	Easy navigation	5	3	15	2	10	5	25
2	Consistent acess	3	5	15	4	12	4	20
3	Quick loading	5	5	25	3	15	3	15
Total			55		37		60
Cost Components	Market Importance	MIT Satisfaction	MIT Total	WPI Today Satisfaction	WPI Today Total	Our Idea Satisfaction	Our Idea Total
1	Initial development	3	$$$	9	$$$$	12	$$$$	12
2	Maintenance	5	$$$	15	$$	10	$$$	15
3	Content Additions	4	$$	8	$$$	12	$$$	12
Total			32		34		39
Value = (Quality X Convenience/)Cost			64		38		88

I created a value factor analysis to look at how our idea compares to WPI's website today as well as MIT's, which was selected for comparison for obvious reasons. I broke the aspects of the website into different levels, looking at features and benefits for various components and determined that even if only some of the changes and suggestions were implemented, we could have a profound improvement over what we have today.

Action

Recruit talented and driven students to continue this work

The next critical step with this project is to recruit capable and motivated students to help materialize this working concept into a veritable implementation, ideally within the next couple of years.

Appendix D: Email and Interview Protocol

Sample Email

Written below is a sample of the information included in emails sent to stakeholders of the Innovation Gallery, requesting their availability for an interview regarding any insights they might have that could prove beneficial to the project. All stakeholders individually received an email providing the general background of the project, with a personalized section for each recipient specifying the area that they could lend their expertise to and an overview of the questions they would be asked.

Following a brief greeting and the naming of my IQP and advisors to establish the purpose of my contact, the emails were formatted using the following template:

> Here is a little more background information on the project:
>
> WPI has a long history of innovation, yet there remains a demonstrated need for the creation of a centralized (likely digital) gallery that showcases and celebrates the impact of WPI's research contributions and its heritage of innovation. My project is aimed towards surveying other institutions, gathering data on past and current projects as well as collecting input from stakeholders, peers, and other experts to build a template for the showcase. This will be completed with the goal that future IQP groups will then work towards creating a tangible product. While the ultimate decision of what this virtual museum will look like will be a larger institutional one, it will surely include details about significant recent innovations that have come from students and professors. As the Director of Intellectual Property and Innovation, you were identified by my advisors as the ideal person to interview for this information.
>
> While the ultimate decision of what this virtual museum will look like will be a larger institutional one, the <department> would likely be a significant stakeholder and I would be interested in learning what potential goals and themes such a museum could have that would align with the current <example> strategy of <department>. As the <position>, you were identified by <advisor/contact> as the ideal person to interview to hear your perspective on this.

I concluded the emails by posing the more individualized questions and highlighting shared availability in our Outlook calendars to schedule meetings.

Interview Protocol

I began each interview with a brief refresher of my project and a few introductory statements related to what information I hoped the interviewee could contribute. The specific content of

the interviews was largely catered to the individual and their relation to the project, as seen in the interview notes in Appendix E, but the questions below were some that were used to frame and guide the discussions.

Questions for Featured Innovators
- What inspired you to create <invention> and how did you evaluate a customer's need for it?
- How did you decide that <invention> was a worthwhile endeavor and feasible to pursue?
- (For Professors) How do you think your course material promotes student-driven innovation within and/or outside of the classroom setting?
- (For Students/Alumni) How do you think your course work promoted innovation within and/or outside of the classroom setting?
- (For Students/Alumni) Were any WPI resources specifically beneficial to you in the development of <invention>?
- What was your methodology when approaching the problem, how did you generate your solution?
- How do you envision the long-term impact of your work, what do you see <invention> moving towards in the future?

Questions for all Interviewees/Stakeholders
- Do you have anyone else in mind that you would recommend I speak with next?
- Regarding the eventual implementation of such a virtual innovations gallery, what are aspects you would like to see incorporated?

Appendix E: Transcripts of Interviews

As a note, the interviews that were conducted were not recorded. The transcriptions were instead composed from bulleted notes taken throughout the duration of the meetings.

Stakeholders

E.1 ANNA GOLD
Connection to Project: University Librarian

The museum should be a reflector/shaper of the technical, more specifically sociotechnical, evolution of innovations at WPI.

What is the nature of what we already have and where to find resources?

There are lots of resources scattered around campus that can be utilized and viewed for both research and design considerations. Within the Archives & Special Collections there is WPI Profiles in Innovation, which is fixed and tangible only, WPI History, a legacy website, the Gladwin Gallery, which has exhibits celebrating the 50th anniversary of Gordon Library as well as Women of WPI, and a Fire Protection Engineering Exhibition, located in Gateway. Additional locations that would be valuable to investigate are the Hall of Luminaries, WPI anniversary celebrational websites, and Digital Worcester. A couple notes are that there are no digital surrogates of the archives and Digital WPI only records back to the early 2000s and is mainly a vast collection of images, mostly historical ones of buildings, and includes old newspapers and yearbooks. Fire Protection Engineering has remarkable things related to innovation but only covers one idea/theme so make sure to cover breadth of topics along with depth. Arthur Carlson is very knowledgeable about the historical aspects of the archives and can speak on what was preserved and why it was meaningful. Past IQPs and MQPs may be helpful resources and/or cover other periods of time, but the documentation of other students' works is a work in progress, so it is not easy to find all student virtual exhibitions.

What scope would you recommend for the museum?

There are many different frames that the museum can be viewed through, and one design consideration would be to consider having an option for users to toggle between different perspectives. Exhibits include more than just the item, but also the curation of it as in the connection between things. A timeline is a powerful tool to link distinct kinds of things and that is something that could be incorporated regardless of the scope and whether you focus on contributions to the Four Industrial Revolutions, the significant innovators/people, the

innovations themselves. A good idea might be to create a network of stories centered around themes (i.e., student majors), which relates back to the idea of toggling between different perspectives. Another consideration could be treating the museum as a "Heritage Hall' type project, where the curation discusses the broader story than just the institutional impact. Part of curation involves learning how to build the narrative and add value so it could be a possibility with the museum to include counternarratives to paint the authentic and full story. Allie Fry is a good contact for this as she is doing work with digital exhibits and similar analysis.

E.2 ARTHUR CARLSON

Connection to Project: University Archivist and Assistant Director for Special Collections

Can you speak to the overall scope of the project?

A lot of the project revolves around discovering what to showcase, researching underserved areas, and the product involves contextualization. The majority of WPI history has been focused through the lens of self-service and marketing, with the most publicized knowledge related to individuals with namesake elements or those who have provided monetary support. This means that more thorough research will be necessary to find information on the other innovations, for example stainless steel and aluminum are related to two of the more undercelebrated ones. What is celebratory and can be used to attract potential students are important considerations and the project entails finding the biggest gaps and see which ones are most feasible and/or interesting to explore given the time.

How will my work connect to future projects?

The project will focus on highlighting methodology and establishing a foundation for future IQP groups to work off. Perhaps the way the project will be split up among groups is by focusing on different industrial revolutions. Mechanical engineering would be the easiest, it is things people see, in addition to being the first and most well established. Make sure to determine more precisely what to call the 3rd IR, as there is long standing debate between referring to it as communication versus transportation. Your project is setting the precedent for others, so making recommendations, evaluating what resources exist, identifying what we still need and where to look. The success of the project is not based on a physical deliverable, but rather what pathways are discovered that are viable for future groups to follow. Potential tasks include creating a template for the cataloging system, designing a collection guide to highlight what you have and make it easier to transmit your work to the next group, outlining the criteria for selecting people: listing what common questions will be asked, how to tie things broadly to WPI, determining the best types of software to be used, etc. The largest challenge is identifying what is important and doable, however, future groups can expand what they believe qualifies as such.

Can you speak to the challenge of making a virtual museum as opposed to a physical one?

One of the primary ones has to do with making the museum engaging through interactive elements. To cite one example, the Veterans' Museum in Alabama, although tangible, has touch screen questions that had 'what it like was…' soundbites. Digital WPI is one example of a potential structure for the museum, where any thematic tabs can be added and there can be different categories along with common types of exhibits. A good idea is to survey what is at RPI, what is at Duke, etc. and really look at places that have invested money into showcasing innovation and history. Spotlight @ Stanford is another good example that uses a tile layout.

What was accomplished by any past efforts with a similar objective?

Past efforts to catalogue innovations were not aimed at digital dissemination. You can critique such efforts and report that 'in my investigation found the archives had <x> collections available concerning innovation'. There is a WPI Wikipedia for research on the significant individuals and at one point there was a historical equipment survey sent out to the departments, but some of it might be solely academic. As far as the archives are concerned, they are intentionally overly neutral, with no judgement on the resource. 'Manuscripts' contain information about people that are more loosely affiliated with WPI and 'Collections' contain information about individuals directly connected with WPI, and there are some unprocessed ones that Amy can help with. The Morgan Construction and Crompton Library collections are recommended, and you can do a survey of the collection guides archives.wpi.edu to see what else of note comes up. *Seventy Years* and *Two Towers* might have useful biographical and historical information and the access to the card catalogue, references as volume/issue/number, will be granted for indexing the WPI Journals.

How would you say this virtual gallery could inspire people and drive them towards innovation?

As far as inspiring prospective and current students and faculty goes, it is more of a concern with how the context is presented. Listing class/graduation year is the primary way WPI can easily and subtly create relatability, albeit there can be the danger of oversaturation. Following someone's journey from student to innovator might be hard to do for the majority and is usually something reserved only for luminaries. Focus on relatability over inspiration which is a much more attainable goal as conscientious design decisions can accomplish this by creating a more subtle sense of belonging to the community.

Who are other significant people I should connect with for insight into this project?

Maureen Maynard in Alumni Relations is able to see what contacts remain engaged in the WPI community and would be willing to participate in an oral history. Amy Smid and Emily O'Brien from the library work with metadata schemas like Dublin core and can help create one

for each innovator profile. The schemas involve finding and clarifying the minimal acceptable amount of information for something to be useful and discoverable. Professor Kenneth Stafford in the Engineering Department could be useful to contact as he has a lot of aerospace and astrophysics information and might have knowledge about innovations in the field relevant to this project.

E.3 ANDREW PALUMBO

Connection to Project: Vice President of Enrollment Management

What are some of the general ideas related to using the gallery as an admissions tool?

For students looking at WPI and other schools that approach education differently than the standard curriculum, projects are something that stand out, but it is sometimes difficult for prospective students to understand specifically what an IQP is or why it matters. An important piece to admissions is the student narrative and how students thought about something and selected a project and what the value of their experience was. Depending on some of the implementation details, using a gallery could help with the ability of prospective students to paint a picture and envision themselves in the shoes of a WPI student. A virtual museum would be easily accessible, and the on-demand visitation aspect is ideal. Additionally, including elements/objects that can be manipulated makes the showcase very interactive and engaging.

How does the admissions department determine what content to distribute through emails, websites, and other online campaign tools?

Admissions starts by looking very broadly at first and purchasing names from places that collect student data, like College Board and other standardizing testing companies. After finding high achieving students, the focus is then pivoted towards getting the students to understand what is distinctive about WPI, for example the 7-week terms, non-punitive grading, and projects. The aim is to focus on a few things that WPI does well and see what resonates with students. As their senior year approaches, engagement is increased in terms of more connections and possibilities are made to give a more representation idea of who the professors and students are. To talk more specifically about the content distributed, it is centered around core themes: location, projects, collaboration, student voices, etc. Adding a lot more video components can generate a greater aspect of authenticity, and while specific implementation tactics do not change a whole lot from year to year, they are moving the focus towards diversifying stem

How does WPI dynamically strategize and benchmark against competing universities?

There are 5 benchmark schools based on size on application overlap: Case Western, RPI, Northeastern, Stevens. RIT. It is significantly more difficult to recruit with the digital realm, as

the competition extends beyond other colleges to include slick professional companies/social media. It turns into competing with an experience/for screen time with other services as the student is not thinking about WPI in a vacuum but rather as a general web experience

What are your thoughts on using this IQP specifically (not the gallery itself) as a tool for admissions?

Showcasing how a student is responsible for the work gives the source much more credibility and interest. Overall, it would create a less stiff and corporate aesthetic by cutting out the filter of sales and the additional level of authenticity would dramatically change expectations of prospective students

How does admissions approach marketing student narratives/soundbites?

When doing media interviews, it is key to try to find an engaging way to share 2-3 important things to get across. It is difficult to underscore the complexity of the methods, but for example including a short story of overcoming an obstacle. A short tidbit that people will remember is something to aim for and what the value to the person learning this, the "why it matters", is the biggest piece. The end takeaway related to the museum is that they could do this and/or this is something in their everyday life.

Who are other significant people I should connect with for insight into this project?

Sheila Georger is the Executive Director of University Marketing and can advise on creative aspects and best practices. Coaches and directors in Athletics might have tools for recruiting that could be helpful but also potentially too specific to sports. Any tour guides/Crimson Key can speak to which questions prospective students always ask.

E.4 TODD KEILLER
Connection to Project: Director of Intellectual Property and Innovation

With the background you have in intellectual property, can you speak broadly about the project and what innovations come to mind for inclusion?

Many startups have come out of patents that have been filed for WPI technology. Professor Christ Brown is responsible for many patents that have been licensed in sports engineering, where the original patent was an MQP. His work in developing a new injury-preventing athletic shoe sole is currently being tested at the Hospital for Special Surgery, a big orthopedic hospital in New York. If the testing results are positive, it is possible that New Balance, Nike, or another sporting company picks up those patents. Professor Greg Fischer is an NAI senior member who has several patents that have been licensed into AIM medical robotics and his research is targeted to be through FDA testing within 18 months. Professor Yan

Wang is a recent inductee into the National Academy of Inventors and currently spearheads two companies: Ascend Elements has 6 patents involved, $90M raised, and plans to open the first recycling plant in Georgia in August and AM batteries has 2 patents. His work with lithium-ion battery recycling was submitted to the Better World competition, which evaluates the most significant transfer of technology to better the world. Out of 65 entries it was chosen as the final 3 alongside UC Berkley and University of Minnesota. You can search on USPTO for Worcester Polytech and find all the patents licensed, 40% of them have women inventors, which is double the national average. There are a few companies related to computer science, such as Dmitry Korkin's VR company and Craig Shue's, though they are mostly dormant. Neil Heffernan has a very successful non-profit called ASSISTments, which merits inclusion in the gallery but might require a different categorization

Based on your current knowledge of the project, what selection criteria do you think there should be for individuals?

Licensing a patent is much more important than just owning one and should be a primary indicator. The Chapter of NAI lists everyone with a patent and everyone that has been licensed, only 1 or 2 have gotten royalties but that will change dramatically in the next few years.

Should the most recent Forbes 30 Under 30 2022 list professors be included?

Professor Bailey-Hytholt and Professor Islam do not have intellectual property at the moment, but they are individuals to keep an eye on for the future. A previous Forbes 30 Under 30 list maker, alumni Aaron Birt has two companies and WPI has licensed one of patents, so he is a candidate for inclusion.

What are the benefits/challenges of patenting technology as a WPI student?

The major challenge is when the technology is disclosed, it is at a very early stage and no company is really interested. This is known as the process of getting through 'the valley of death' and being able to move it along. This is why there are so many startups; WPI raises money and puts it towards the startup, allowing the individuals leading the efforts to prove the concepts to external investors and at that point the startup can either be bought by a company or like Ascend Elements build their own plants and sell their product themselves. A fair number of student inventions come from MQPs, since it is relatively cheap to file a provisional patent. The downside, however, is when students graduate, they tend to lose enthusiasm for the project, and generally drop those patents. Some patents have no faculty involved and WPI allows the students to own them completely, though the students pay for the cost. All WPI attorneys are alumni and so they help with organizing and purchasing. One example is a company known as ROADGNAR now Cyvl, which maps potholes. The City of Worcester has been piloting Cyvl's technology and is starting to get orders through the company. Cyvl is one of

the companies that WPI is invested in; there is a special commercialization fund that is used to assist students financially and a sum of that money has been put towards this endeavor.

What are some of the resources students have access to?

Though in need of updating, there are many listed on the innovation and entrepreneurship website. Outside of those, ICorps is a grant from the National Science Foundation that provides funds to go to conferences which train students in carrying out customer discovery: asking questions and gathering input on a particular idea. These conferences provide students with the opportunity to collect feedback from 30 customers over an 8-week period and nearly all students pivot from their original idea after receiving input. The question that then remains based on customer input is whether to file a patent. WPI funds a significant amount of prototyping and then if the students form a company, WPI will then invest in it and gain equity. As for other resources, lots of alumni mentors help with ICorps and help fund startups to get them off the ground.

How do you envision the implementation of a virtual innovation gallery?

I imagine little interviews and videos of the devices working, for example the shoes from Professor Brown that reduce ACL tears and redirect the force that goes up the leg. Videos can show the product functioning. As a note there might be privacy issues/situations that arise depending on how much innovators can or want to show. Marketing as done quite bit on this, and recent stories are in links on the innovation website.

Who are other significant people I should connect with for insight into this project?

Sarah Mahan is a licensing associate in the Office of Technology Commercialization and can point you to information related to licensed patented technology. Lynda Kelly is the Assistant Director of Intellectual Property and Innovation and can give you the complete list of all NAI members. Jillian Ferguson in Marketing Communications, Tanja Dominko in Biology & Biotechnology and Danielle Cote in Mechanical & Materials Engineering are also good points of reference.

E.5 ANDREW ABERDALE

Connection to Project: WPI Alumnus and former chair of the WPI Board of Trustees, original member of the WPI Tech Advisors Network, Chief Financial Officer of Professor Yan Wang's Company Ascend Elements

As one of the original members, can you speak a bit about your work with the Tech Advisors Network, either in general or specific ventures you have advised?

It was a group of four of us that originated the Tech Advisors Network with Dean Mark Rice – me, Mike Aspinwall, Jim Baum, and Henry Fitzgerald. It started very small and within just a few months with Todd Keiller and Sarah Mahan's help the Tech Advisors Network grew to standing room only. There was always a general session before we broke out into the teams and some of the projects I advised early on and were in some of the original meetings for were Bluestream and Battery Resourcers now Ascend Elements. Over the years, the Tech Advisors Network has changes and morphed and for a few years there it seemed to move away from commercialization focused and towards activity as opposed to results.

And further, with the Tech Advisors network, how do students become involved with TAN and after they are placed with an advisory board, what resources are they directed to, either WPI or external ones?

When I was heavily involved in it, there was an active screening process for both the mentee and mentors, or advisee and advisors organized by Todd and Sarah. Same thing with the screening process for the possible projects or enterprises that were presented in front of the Tech Advisors Network.

Moving onto something you are more recently familiarized with, the work of Professor Wang, can you speak about your role at Ascend Elements and your involvement with the innovations at the company?

My involvement with the company started with TAN, it went through the virtual incubator and raised a little bit of money in the first five years out of that and set up a pilot plant. I have always been close to the company and close to Professor Wang ever since I met him at TAN and close to Eric Gratz, who was the original CEO of the company. So, I have been close to the technology and close to the founders and was always a big fan of both. When I came back from one of my previous jobs/companies back into the area I reconnected with them and started helping them as a friend of the firm. They then brought me on part-time as a contractor consultant, as an interim CFO. During the COVID year we tried to raise money and it was very difficult to keep the company afloat and because the company was running low on cash, some of the trustees of WPI stepped up and invested in the company to try and keep it going. After making it through the difficult year of 2020, we raised $90 million in 2021 and the company is now worth $100 million. We are now in the middle of another fundraiser for $250 million and we have offers putting the company at a post-money valuation of $750 million, so ¾ of a billion dollars. We opened a Westborough pilot facility with stainless steel processing equipment, and we opened North America's largest lithium-ion battery recycling facility down in Georgia, with line number one coming online in July, line two in September, and three sometime in Q4 though due to supply chain issues that is always a moving target.

How do you envision the long-term impact of the work being done and what do you see Ascend Elements as a company moving towards in the future?

This is WPI's technology exclusively licensed to Ascend Elements. Ascend Elements is the commercialization of the technology, WPI has a battery lab and the more technology that comes out of it and can be licensed to a commercialization company, the better it is for WPI and the students. The more money that can be given back through licensing and royalty agreements, the lower tuition is, so there are a lot of good things and benefits that can happen for students. When looking globally, this is revolutionary technology, this technology will stop batteries from being thrown into landfills and multi-billion-dollar companies from smelting batteries, which you can only imagine how bad that is for the environment. This company delivers a 93% reduction in carbon dioxide emissions and reduces the cost of a battery by over 60%. So, this technology will change the way that lithium-ion batteries are handled, and it is very similar to the way lead-acid batteries are handled so it is a proven path that has worked in the past. At some point there might be a credit for exchanging batteries. This technology will also revolutionize the way these minerals are mined. Right now, child labor is ripping apart the Congo for cobalt and Argentina and Asia for nickel, manganese, and lithium but instead of mining the Earth, the minerals can instead be urban mined. This is the process where batteries are taken out of devices and vehicles and the materials are shredded down and dissolved in acid, which then allows the original elements to be coprecipitated out right back into a cathode again.

As an alumnus, would you say that the coursework and atmosphere of WPI promotes innovation and/or drove you to these more entrepreneurial ventures and if yes, how so?

I would say when I was there, WPI definitely drove you to be creative. So, with my IQP and my MQP we had to do something unique and WPI provided that type of atmosphere for creativity. Back when I was there, it did not emphasize how to commercialize ideas and so while it taught me to have confidence in my creativity, commercializing was absent in my time. From what I have seen though it has taken on a stronger focus since, but I do think it pales in comparison to what it could be. I am very proud of WPI, and it sounds like what you are working on is going to be very helpful here. You look at Northeastern and Northeastern has an innovation center in Burlington. When you compare the two, Northeastern is moving very fast on a lot of fronts and WPI is not moving fast.

Moving onto the hopeful eventual product of this collection of IQPs, some of the virtual museums that I am looking into are the MIT Innovation Museum and Spotlight at Stanford, how do you think a WPI virtual innovation museum would be beneficial to the institution and how do you imagine it would be utilized?

It will be a motivator to prospective students, motivator to students, and a motivator to faculty to do more work like this because the faculty benefit and generally own these companies or large parts of these companies. So, I think this will be very motivating to get these success stories out there.

Who else do you think would be key stakeholders in this project, whether they are outside investors or anyone else?

Certainly, the students, certainly the faculty and I think there could be an opportunity around companies. Some companies may want to sponsor this and give money to have the museum powered by them. As far as investors, if you look at this list of all the companies that went through TAN there are probably around 30 of the 150 or so that raised money. For each of those, there were probably 5-10 investors so there are a couple hundred investors that are putting money into WPI technology to help WPI be successful. This gallery could help the companies raise money or the enterprises going through TAN to raise money as well as raising money for the investors.

The scope of this question is very broad but how do you envision the implementation of a virtual innovation gallery, if you were to visit it online what do you expect or hope to see?

I always want to see results and quantifiable numbers, which could be paired alongside activities. I could picture a film roll with all of the companies'/innovations' names and then one or two bullets about them. Figure out who your key audiences are and try to find the key bullets that will resonate with those audiences. So, if you are talking about intriguing investors or motivating faculty with real numbers that may work, but that may not work for students so you may want to think of one or two snippets that will inspire students.

A large aspect of inspiring students is creating relatability to the inventor and material, outside of including a list of activities they were involved with at WPI, do you have any thoughts about what elements could be included to promote relatability of to the historic innovators?

Just like what you said, including major and minor as well as what organizations they were a part of. If I were a student, I would be reading the ones in the major I was in because it would help me see what they do and what some possibilities are.

Do you have any ideas as far as visuals or interactive elements go that could be interesting to incorporate into the museum, maybe specifically related to Ascend Elements?

Depending on what technology you are talking about, I think that there is a key story that sells it, so you still must keep in mind your audience. You have to be very careful about telling the story. When you tell the Ascend Elements story there are hundreds of slides, but it comes down to just four that stand to impress people and that could be the key. For each of the

technologies it could be a 3-dimensional rotational graphic, it could be a five second video, it could be a one-minute video, or it could be four slides automatically flashing by on the screen. Depending on the technology I think you could come up with the right tool and right snippet. I also think an interesting aspect could be creating a 'Hall of Fame' of sorts, where there are criteria for who would be included, whether its revenue/profit or uniqueness of patent.

E.6 JIM BAUM

Connection to Project: WPI Alumnus and Trustee, Co-Chairman of the Innovation and Entrepreneurship Council of Strategic Advisors

As an alumnus, would you say that the coursework and atmosphere of WPI promotes innovation and/or drove you to these more entrepreneurial ventures and if yes, how so?

Not in the slightest.

Would you say with your involvement as a trustee that has changed over time?

I think it has, I think WPI has embraced the ideals of innovation and value creation and entrepreneurship much more than they had. I do think a lot of the change can be credited to the way the world has changed. Now, the whole entrepreneurship ecosystem is much more viable than it was when I was a student, and I think more and more students coming to WPI want it and demand it. So, I think WPI has responded to the market to some extent and still can continue to do more.

With that, do you have any outright suggestions or ways you have in mind as to how WPI could incorporate more innovation or encouragement towards innovation at the undergraduate level?

The first thing to be done is to define innovation and what is meant by that. Innovation in many people's minds means invention and intellectual property and patents and maybe commercialization of that somehow. When I think about this, I break it down into all these pieces because I think innovation is over- and often misused. So, as I think about can WPI do more to encourage innovation, I think we are doing a lot. Innovation and invention for innovation's sake can be scientifically and academically interesting but I think innovation in the context of some actual pain point or problem for a person, a company, a culture, a government, a society, is much more interesting to me. There are a lot of people that want to be innovative in basic science and that is not necessarily as appealing. I tend to think of it less in the commercialization sense, but are we creating value for someone, are we solving a problem for some entity, some person, that is worth solving. I think of innovation in that context. I think that WPI is doing a good job with that and the evidence that I see is looking at the amount of funding that WPI now receives for research. It has grown by factors of maybe 10 and I think

that there is a focus on it, and we need to keep doing that. I would like to see us do a better job at getting the output from the research, which is oftentimes some innovative solution, into the world. So, where I think we could do more with and a better job is taking the product of what we create and finding a way for it to actually have an impact in industry, culture, society, or wherever it may be appropriate.

In reading that you were the chair of WPI's initiative in innovation and entrepreneurship, can you speak a bit about the work you have done with that and getting that off the ground?

I graduated in 1986 with that experience that I described and then I went on to have a career that was all built in and around the tech startup community – small companies getting bigger in high-growth environments, venture capitalist based. I came back to WPI around 15 years ago and between then had gotten and remain quite involved with the MIT Martin Trust Center for Entrepreneurship where I had an opportunity to help teach entrepreneurship and I have continued to do so. Through that experience, I felt that WPI was completely missing the boat. I got involved again at WPI first as part of a computer science advisory board then I became a member of the Dean's Council of Strategic Advisors when the original dean of the business school Mark Rice joined. When I got involved with this, Dr. Rice had a very entrepreneurial mindset and wanted to build a community and ecosystem of entrepreneurship around the WPI business school. I felt this was a great idea because having been in the entrepreneurial world and commercial environments, building companies that produce revenue and income but more importantly jobs and lifestyles for employees, I had a very simplistic thought and point of view that we do x thousands of IQPs and MQPs each year and whatever we are doing in graduate research. Then, I am in this MIT environment and seeing these startups just flowing out of MIT and while 60% do not make it, the students are psyched and motivated and building these things and teams and learning about collaboration, entrepreneurship and how to solve problems sort of independently. I thought 'why are we not doing more of this at WPI?', and so that was my initial insight that said I want to help WPI do this and this happened to be around the same time that we were recruiting a new president.

After my initial work with the business school, I had become a trustee and during that time we started the TAN group and a number of other initiatives that had the objective of creating a community ecosystem mindset/framework around entrepreneurship. I transitioned onto the board of trustees nine years ago and I became part of the search committee for the new president. My role on the search committee was very much centered around 'does this person have this kind of entrepreneurial mindset, this innovation and entrepreneurship mindset, is this a partner we can work with to build this out' and Laurie did and has been wonderful and very supportive all the way through. From there we really kind of started to formalize this more. Anytime a new president shows up, the first thing they do is create a new strategic plan and one of the five pillars of President Leshin's playbook was around innovation

and entrepreneurship. So just under a decade ago was when we really started to codify this and bring more people into that style of thinking here. We doubled down on the TAN group and hired Donna Levin, Curtis Abel's predecessor, to build an I&E center. As much as my personal perspective had always been very entrepreneurial, I always felt that if we did a great job getting people to think about entrepreneurship at WPI, we are going to help 5-10% of the students. Most people are not going to come out of their undergraduate degree at WPI and go start a company, so we started thinking about how to broaden that.

Many of the lessons you learn in entrepreneurship can be applied to your job or in personal relationships. Along this journey, I got to know Curt Carlson quite well and Curt likes to talk about this idea that the best engineers from the best universities in the world can solve really hard problems but generally do not know what problem to solve, why they are solving and for whom they are creating value by solving it. This was very well aligned with something we were learning from the Keene Institute, which we had partnered with and taken some grant money from to help us with these I&E initiatives. This really resonated with me because now I started thinking if we can really help our students understand and learn about the ideas of what Curt Carlson calls value creation and if we could train 100% of our student population to understand these concepts and be able to apply them, we would help 100% of our student population. They would find these skills useful for the rest of their lives and of those 100% maybe 10% would go on and do something entrepreneurial and that would be great.

Where we are now is we are very focused on the ideas of value creation and we are working very hard to train faculty, get it embedded into coursework, and it is now the core teaching/teaching/principle of the innovation and entrepreneurship center and is gaining momentum elsewhere as well. This is the journey we have been on, and it has not been easy – making changes in an academic environment like WPI is hard to do, there is academic governance, principles people want to apply, history and momentum. Despite the difficulty that I feel like we are making progress.

You mentioned the strategic plan that new presidents have to develop when coming to the university. Now that we are going through another presidential search, do you think these principles are something that when trying to select a new president, the search committee will strongly emphasize?

While I am not involved in the new presidential search and really have no idea, I strongly hope it is. I doubt that this committee will put as much emphasis on it as the last one did because at the time it was such an obvious thing that needed improvement and now, we have some momentum and a foundation. I would hope we would not bring in someone who is opposed to pursuing innovation/entrepreneurship or value creation, but I have not seen the spec for the new president so I ca not say what is in it. I do, however, know people who are on

the committee and know that they understand the significance of this agenda and am not concerned.

You had briefly addressed the MIT Martin Trust Center and the Keene Institute, would you say in your time in looking at academia as a whole, there are other institutes or universities that have similar celebrations or showcases of innovation that would be a good model to follow or an otherwise good benchmark for WPI to look into?

MIT might not be the best comparable, just because it is so different, and my original thinking was very much modeled around what I saw happening at the Martin Trust Center. The truth is we just cannot reproduce that, we do not have that environment, the same business school, the same undergraduate/graduate research programs, we just are not as big. The other more important reason to not try to reproduce it is I think it is very important that WPI figure out what makes WPI distinctive. 50 years ago, we hatched The Plan, project-based learning, and we are really good at it, and I think WPI can claim to be the best in the world at project-based learning. That was our hallmark, our differentiation, and yet now it is a 'sea of sameness' because every institution advertises project-based learning, working with groups, teaching collaboration, the opportunity to study abroad so there is nothing unique about WPI anymore. I do think we may be and are better, but we are not unique, so I think it is important that WPI figure out what its unique value proposition is in this sea of sameness among mid-sized technical universities. I do not think innovation and entrepreneurship is the answer because I think they are also overplayed in this higher education industry. In Laurie's inaugural speech she talked about the Two Towers at WPI becoming three: Theory, Practice and Impact being the third. I think this is a really important idea because everyone teaches students how to solve problems, how to do math, how to do code, but nobody really focuses on how solving those problems creates a societal impact. I think this concept of value creation gives us an opportunity to claim that distinction because nobody else talks about it is as one of the core pillars. So, as I think about going forward at WPI, I very much like this positioning where theory and practice is something that impacts 100% of our students and has since the 1860s and theory, practice, and impact is also something that should impact 100% of our students and affect their experience at WPI and give them tools to go work with in their lives and careers. Project-based learning was the platform behind which theory and practice took shape and so value creation can become the platform behind which theory, practice, and impact is delivered and I think that is a very powerful positioning for WPI.

So, with the virtual museum, if we were able to center it around value creation and focus more on here are the projects that have had impact on society, would you say that is the most beneficial way this tool could be framed by the institution?

Yes, I think that is a great summary.

To list some examples of how we were thinking of utilizing this tool to get your thoughts on the subject: an admissions tool for prospective students and faculty looking to join the WPI community as well as a motivator and resource for current students and faculty.

There is a lot behind those two examples. I definitely think that for an incoming prospective student, this idea of doing meaningful work that betters society and solves real problems is a really important and powerful idea and easy to understand. And you do not think that about MIT, when you think about going to MIT you basically think about working very hard, surrounding yourself with very intelligent people, and then going on to get a very valuable degree and become a good engineer. What you do not think about is the meaning of it, or at least I do not associate that with MIT or RPI or any other school. This is a very powerful idea of I am going to go to WPI, I am going to become a computer scientist and I am going to be able to apply computer science to solve the world's problems and that is a wonderful, feel-good reason to come to WPI. I think the extent to which we can substantiate that through this project is great and an awesome use. It should become something admissions can use, it really should be the homepage of WPI and when you go to wpi.edu this is what you should see. There is a lot of stuff behind it, but this is why you come to WPI, so I think it is that important.

Another aspect of this project is the thought of what does it take to be mentioned in this project. On one hand you want to be very liberal and have it be very big, with lots of projects showing lots of impact and a lot of value creation. Another way to think about it is more exclusive and like a reward to be included, similar to the prestige behind the Hall of Luminaries. One important thing, regardless of how it is done, is that someone needs to make sure the developed gallery gets institutionalized and make it part of the core fabric of how we talk about ourselves, and this website project is an artifact of that, a manifestation. The concern is that we start these initiatives, like the Hall of Luminaries, and then the momentum wears off, so there would need to be safeguards to make sure this idea continues and gains momentum and becomes something we just do, and we mine our students and alumni for these great innovative, impactful ideas that get published.

Regarding some of the technological components of the museum, with your strong background in innovative technology, in any of your work delivering software solutions, did you encounter anything similar to what WPI is trying to accomplish or any platforms or websites that would be good choices for potential licensing?

Nothing specifically, but I think there are lots of places that showcase innovation, and I would be looking for unique ways to communicate. If the website is a list of inventions and patent numbers, that is not very engaging, and I think that is going to be the magic of the implementation of this project.

E.7 JEREMY HITCHCOCK

Connection to Project: WPI Alumnus and Trustee, Member of Technical Advisors Network, the Management Executive Council, the Venture Form, the Collaborative for Entrepreneurship and Innovation, and Foisie School's Dean's Council of Strategic Advisors

Looking at other examples of similar digital implementations, such as the WPI Jazz History Database, Spotlight at Stanford, and the MIT Museum, can you share some of your thoughts on a WPI gallery?

I love the idea of the implementation of a digital gallery, there are so many things that can be opened up. From my Internet standards days, I met some people who thought about the stability and flexibility of catalog systems - how do you create a numbering system that incorporates the oldest Beowolf/Bluetooth stories and the latest tweet. I also worked on the Jazz History Database in school. You want to provide the highest fidelity of project (VR/AR like things) but also want to ensure that they will be accessible since Flash is no longer around for many 360 panoramas). You also want to think about the ease of capture and how to make that process straightforward. Many museums have more items in storage than on "display" so that is something to think about how to increase the accessibility of these items.

As an alumnus, would you say that the coursework and atmosphere of WPI promoted innovation and/or drove you to more entrepreneurial ventures and if yes, how so? Further on that how would you say the culture of innovation has changed over time?

Not too related to your digital museum question but generally yes. I mentioned the JHDB and thinking on how to do it and while the technical considerations are part of the mix, it was the back and forth with NEJA and other organizations that I recall the most. Also, families or people who had materials to contribute as well.

In what ways do you think a virtual innovation museum would be most beneficial to the institution and how do you imagined it utilized (examples: as an admission tool for prospective students and faculty, a motivator and resource for current students and faculty, etc.)?

Interactivity and permanency are two. You can certainly start with some images of various items, but the traffic comes from the enrichments rather than just a bunch of pictures. You may decide that Wikipedia or some other repository is better and more enriching and make sure that it is accessible.

Have you seen any exciting types of exhibits at other universities or museums that you think should be incorporated into a WPI innovation showcase?

No, but also remember that it is just based on the content that we have. Also, no use in having it be buried, so think of that.

How do you envision the implementation of a virtual innovation gallery, are there any aspects or content related suggestions you would want to see in the eventual product?

Think about how the collection lends itself to offers of other items and collections to be donated. What do we want to capture and why? How could some of the content travel or be used in communities or areas where they do not see what we do.

Do you have any historical knowledge or first-hand accounts of stories regarding innovations that have come out of WPI that come to mind?

The Hall of Luminaries is a good example or the jazz database - what primary information can we put together through storytelling, documentation collection, and transmedia. Aside from Ascend Elements and Bluestream, AiM Medical Robotics from Professor Greg Fischer is an absolute favorite. My belief is that there is something with the red mud group, Solvus Global, that is headquartered out of Leominster, they have got funding and a plant built.

E.8 MICHAEL ASPINWALL
Connection to Project: WPI Alumnus and Trustee

As far as your background goes, can you speak a bit about how you helped co-found Stability Health and how your track at WPI might have led to where you are today?

My degree is in management engineering but is sort of half mechanical, half industrial, and some management engineering. After WPI, I went to the University of Chicago for business school and the first eight years of my career was focused on strategic planning and corporate planning. My job basically consisted of first learning then helping a whole range of different businesses do everything from evaluating various research projects to creating strategic plans. Then I moved on to work for Chase Manhattan Bank and out of that came some additional ideas and created a business within that working with healthcare securitizing. So, it has been 25 years investing in specialty healthcare businesses, tech-enabled services and eventually Stability Health was born after I went to see a presentation on diabetes research in Gateway and joined the advisory board of the researcher.

As an alumnus, would you say that the coursework and atmosphere of WPI promoted innovation and/or drove you to more entrepreneurial ventures and if yes, how so?

Yes and no. I think in many ways, yes in sort of setting up a mindset, but going back to that long story I did not become a true entrepreneur until just now. My class was the first year of the plan and so we survived an experiment – the professors did not know at the time how to teach in seven weeks, the projects were not defined like this and there were only three initial project sits in Worcester, Boston, and D.C. Back then the department head of management, it

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was not a business school back then, was a serial entrepreneur and so he instilled a whole entrepreneurial mindset. So, I would say yes more because of that, the engineering departments thinking entrepreneurially has developed since I left. I think the biggest thing, even though it was experimental in a lot of ways at the time, is the mindset you develop with projects: that they are undefined to begin with, there is a middle where you do the work, and there is an end where you bring it all together and that is different than a course.

Obviously WPI has incorporated more project-based learning and more emphasis on it as time has gone on. In your time as a trustee, how would you say the culture of innovation has changed over the years and where do you see it heading towards in the future?

I have been on the board for eight years, Laurie and I joined at the same time. I had not set foot on the campus for 25 years when I left, and I joined the then department advisory board for management and had a hand in helping turn it into a business school. There have been pieces of development all along the way, but when Laurie came in the phrase she used when developing her first strategic plan was 'I&E', 'Innovation and Entrepreneurship'. In order to define what this meant, a few other trustees and I went out and interviewed five universities, including MIT, UMass Lowell, and Olin and asked, 'what are you doing in entrepreneurship'. In interviewing 30-40 faculty and 70 or students, we presented how everyone thought about it and that became part of the first strategic plan in what she called the 'I&E pillar', which myself and Jim Baum were cochairs of. The reason Alumni Gym was torn down is because it was not doing what it was supposed to, and the Innovation Studio does. So, what has changed with what I have seen is greater growth, we got money from the current foundation for entrepreneurial mindset and another trustee Curt Carlson is working on value creation. In summary, we have tried a lot of things, some of them more so than not have worked to varying degrees and if you are going to be entrepreneurial you have to try a lot of things so there is no one answer or silver bullet that will solve everything.

You had listed MIT and UMass Lowell as a few of the universities that you interviewed, would you say there are others that WPI sort of points to or takes inspiration from when incorporating innovation or looking what to do in that field?

A quote from Steve Jobs says to look at all your competitors and steal all their best ideas, it is okay to steal. So, I think broadly there are a lot of different schools that have different interpretations of I&E. Babson was another one we interviewed, and Babson, for example, is known as the entrepreneurial university and they do a lot of projects and business startup plans. I think they do a very good job with it, but for them innovation and entrepreneurship are academic subjects and frankly, it should not be about studying the concepts but doing it instead. MIT has their center for entrepreneurship and Lowell had an interesting program, very student-oriented, and they start with freshman orientation. Lowell

puts every first-year student into an entrepreneurial experience for their first couple days. Olin has been borrowing our ideas for a very long time, but it is also easier to do a lot of things with a very small student body so we cannot adapt that way. Of the ones we did not talk to, obviously Stanford. Take a look at the d. school, what they have done there is fascinating, and it is not resident in the business school or any one school but really pulls things together in a very different perspective. The University of Texas Austin and Carnegie Mellon – looking at the schools that have technology and business/entrepreneurship since that is a fit for us as well. There are some things at Holy Cross, but liberal arts schools take a different approach than STEM schools.

Relating more to the virtual museum, what are some of your general thoughts related to how it could be beneficial to the institution, how broadly you see it utilized, and what interactive elements you could see implemented?

With anything you do, you have to start with how you frame it – why am I doing this, what is the problem I am trying to solve, and you have to resist being pulled in one direction or another. This could be pulled all together to promote WPI and that might be great for marketing purposes, but it is also a view that creates limitations, number one, and becomes self-serving, number two. I do think of the frames, it should be more oriented on the present and the future, using the past as examples but not the focus.

E.9 SELCUK GUCERI

Connection to Project: Professor of Mechanical and Materials Engineering at WPI, very knowledgeable regarding university history

The role of universities is to be a place of free thinking. A hundred years or so ago, WPI was a top knowledge generator in engineering, and we had our own journal for papers. That journal is no longer in existence, but WPI was one of absolute top schools in the United States at that time, especially in metallurgy metals and materials. Elwood Haynes was a student at WPI, and nobody knows this, but he started the first automobile factory in the US. He also accidentally made a new steel alloy and with that developed a blade of steel that is very rust resistant. Innovation and discovery are at the very core of our current civilization. There has been slow but steady progress throughout human existence and the pace for progress accelerated phenomenally with the Industrial Revolution at the end of 18th Century. A big development, of course, came with Albert Einstein who brought a new paradigm to our understanding of mass, energy, and the universe. It seems that this development will keep people busy for a few centuries working on these concepts and their probable applications in a broad range of applications, mostly focusing on energy. When you review all the historical developments, one notices that high-impact innovations require two essential elements:

1. People with creative/innovative minds
2. Facilities/environment to allow innovative minds to come up with more discoveries

Starting with the 20th Century, universities emerged as places where these two elements started concentrating. Libraries, laboratories, and agile minds took the lead to achieve discoveries. This became particularly evident during the second World War, which is the first war where technology became the single most important factor in U.S. winning. Universities played a major role: MIT with the invention of Radar and Princeton and U. Chicago with the invention of the atomic bomb. This brought in a paradigm shift at the government levels and the NSF (National Science Foundation) was created in 1950 with the sole purpose of funding research at the universities. Some people still kept the notion of universities being only places of education and teaching, i.e., textbook material. The objective was to teach broad knowledge to students through coursework and let the students build their careers using this knowledge when they get employed by companies. Some others realized that the knowledge base kept growing and that there was a need for more focused training that would be in line with what the professional world is looking for. In other words, become part of the development itself; this started the research universities such as MIT, CalTech, Princeton, etc. Graduates from these institutions were more "ready" to jump on the bandwagon of innovation and discovery in new areas, thus increasing the profitability of their respective employers/corporations, which is the baseline of their performance. Research universities are classified by the Carnegie Foundation as class-R1, heavy research involvement, and Class-R2, all the rest of PhD granting institutions that have research activities. There are no lower grades for PhD granting institutions. WPI is in the R2 category.

New nanotechnology has opened unprecedented possibilities in biosciences, new smart materials, energy, imaging, and cross cutting many more technologies that impact our everyday lives. These developments are heavily focused on the availability of the most modern, cutting-edge instrumentation. The next generation of prominence in innovation will come from institutions that can develop the most advanced laboratories and form bonds with key industries that collectively utilize these capabilities to face the grand challenges of the brave new world. Pure teaching functions will progressively shift towards community colleges which have significantly improved their quality, effectiveness, and value proposition for the general audience.

As far as where WPI stands, earlier last century, WPI was a premier institution that supplied excellent talent to meet the needs of the period industries. There were few individuals, such as Atwater Kent and Elwood Hayes, who distinguished themselves based on the fundamental technical knowledge - metallurgy - that they had acquired at WPI.

Unfortunately, these two initiatives discontinued their operations for various reasons, so they have not left a lasting support base for WPI. The broader industries also lost their local momentum with no significant replacements moving in. WPI thought of helping recovery by trying to incorporate projects into the curriculum to reignite industrial activity in the region. However, it did not have a significant impact on the industrial scale. Projects are now part of education in about every institution nationwide. Facilities that are an important element of innovative progress and exploration are needed to rejuvenate WPI's role in the world of technology. Overall, your generation will have increasing competition, this is related to your project in terms of the importance of innovation and discovery in several key areas to preserve our leadership. Universities will increasingly play the most critical role in both generating new knowledge/capabilities as well as producing human resources with strong innovative minds.

Innovators

E.10 DANIEL PELAEZ

Significant Contribution: Artificial Intelligence Infrastructure Management Technology

Can you speak broadly how the founding of your company came about and the process that results in the development of your technology?

The idea came to me sometime between my sophomore and junior year just from growing up in New England. I became interested in the problem and researched how towns and cities everywhere manage roads and other assets of infrastructure - sidewalks, trees, and signs - which is by collecting information manually or relying on citizens to report problems. At the time, I was learning about LiDAR technology in my electrical engineering courses with applications in self-driving cars and robotics and in general using lasers to do 3D scanning. The initial idea was to take technology and apply it to a really outdated problem to save towns and cities both time and money, not only with collecting data but also having more data to act on which saves money in the long run when creating construction plans. Noah Buttress (another founder of Cyvl) and I entered the WPI pitch competition our junior year with no physical prototype, but rather just the idea of our technology and we won a little money from that and bought sensors to do R&D at the beginning of our senior year. We also recruited another friend Noah Parker, a rbe/cs double major, who wrote all of the code for the technology, while Noah Buttress worked on the mechanical engineering. I was in charge of talking to the customers (towns/cities) and working on more of the business side of things. Our senior year we entered a nationwide LiDAR competition put on by a sensing company, which with the help of Todd Keiller and other people from WPI we won the competition and a $10,000 reward. That summer we incorporated our work into a company, went to our full-time jobs but eventually

quit and focused on CYVL full time. Now we have just been raising money from investors and working with customers.

Was your main motivating factor the positive feedback you were receiving or just the inspiration from the problem and what made you determine it was a feasible/worthwhile endeavor to pursue?

The technology is super cool, LiDAR is at forefront of robotics so taking it and bringing it to this space that has been overlooked for a long time is amazing. Infrastructure management and kind of the civil engineering field in general as well has not had a lot of innovation compared to computer science/robotics/electrical engineering. Mostly this started out as just a crazy, fun side project that we were passionate about and interviews with towns and cities suggested that it would be a total gamechanger. What helped keep the project going was talking with customers and civil engineers and hearing them say yes, there is a need for this, and it would make life easier. Alumni and WPI advisors both helped guide us down the right path and the biggest stroke of luck was when Todd put out the story when we won the LiDAR competition and a WPI alumni named Jerry Hitchcock, a very well-known and successful businessman, thought it could be successful and a big business as well. He motivated us to pursue this, gave us our first round of investments and then WPI invested and that is what helped enable us to work on it full time.

What was the methodology you used to solve the problem you identified and how did you figure out what to do along the way?

Our first idea was use lidar to 3D scan road surfaces and then use the scan data to automatically identify the conditions of the roads. Previously people were using their naked eye or tape measures as a means of evaluation, so we decided to work to automate that process. Our team knew how LiDAR worked but we did not build it for a whole year after having that proof-of-concept idea. With help from professors, we tested other sensors on paper, such as radar and sonar. The LiDAR competition provided us with a sensor and since sensors are very expensive that is why it was used. As far as methodology goes, we simulate everything so can test lots of sensors and we also use a camera and IMU accelerometer to simulate everything before building it.

How do you envision the long-term impact of your work, what do you see CYVL as a company moving towards in the future?

We are in the beginning stages but hoping for a broad implementation and the ideal is to build a big company. We are now a team of 6, 5 of whom come from WPI and one from MIT. Our company has 5+ business advisors and we have just raised a second round of funding. CYVL is located out of an office in Boston and our focus at the current moment is trying to grow

business, we are already selling to customers in Massachusetts, Rhode Island, Connecticut, Maryland, and Colorado, where the customers are cities/towns as well as civil engineering firms.

How did specific coursework/professors at WPI help contribute/inspire/help you along the way?

WPI gives students a great foundation of problem-solving skills and teaches students how to do things quickly. Knowing how to move very quickly has helped a lot with building technical prototypes and WPI had also set us up with the right skills to do good technical R&D. What has been huge for securing customers and investors is WPI's network of alumni, the alumni base, and other community relations. Particularly the WPI business mentor network has been phenomenal, everyone Todd was able to put us in contact with and we got our largest investor from WPI alum. Other members of team are applying coursework knowledge on a day-to-day basis, while I have a more business/management role which relates less to what I studied in college.

Future IQP groups may reach out to you to follow-up, would that be alright?

Yes, and we can supply them with visuals/interactive image sensing.

E.11 CHRIS BROWN

Significant Contribution: Professor of Mechanical and Materials Engineering at WPI, Developments in sports engineering, prototyping an ACL prevention shoe

Can you speak about how you got involved in your current research, I read that you were involved with an orthopedic research group for skiers, is that what prompted you to research ACL tears?

I had a strong background with ski racing and our group had introduced this first skiing specific injury mechanism for ACL prevention and that definitely led me to where I am today. One of the reasons I wanted to come to WPI was to work on similar technologies and get them patented. For a while, the patent situation was a disaster and WPI was not interested and then Todd Keiller came in and dramatically transformed the state of intellectual property at the university. I think one of the things that we do not value at WPI that we should is undergraduates getting a patent. There should be a wall up with all the undergraduates that have gotten patents, we have our luminary wall, but if I were on tour and saw this, it would not be something that I would have seen at RPI or somewhere else. It is easy to understand too and could greatly influence people's decisions about where to go if they knew x percent of students at WPI left with a patent based on undergraduate work. The value of the patent to the student is different than that of the value to the school, it is a very important line on a resume, even if

the patent is not granted or has commercial success it gives the students experience with intellectual property. Anyways when Todd came, we did some patents on ski bindings and someone explained to me too that nobody will invest in your binding unless you have a patent. This is because they are going to have to develop from your basic concept into something they can sell, and they want to protect their investment and they do so by owning the patent. With regards to skiing, there is around a 1.3 percent times more risk of women tearing their ACL than men, but with basketball the risk is seven times greater and that is what we are hoping to help solve with our shoe. I had never done this thing before, trying to bring a product to market, and so while I was very overly optimistic, we currently in the process of recruiting investors to hopefully turn this idea into commercial success. Organizations like the NBA and other professional athletes would surely be interested in this, but at the moment they are not a very accessible customer base. A large part of success will also have to do with aesthetics because while some athletes are primarily concerned with safety, many are not willing to overlook the eventual style of the shoes so there needs to a balance between safety and the 'cool factor'. However, this is a lower concern in the moment; we do not have any direct competition as we are the only ones currently working on developing technology like this. Tests are currently being run at the Hospital for Special Surgery in Manhattan, but the problem is just getting investors.

E.12 VJ MANZO

Significant Contribution: Associate Professor of Arts, Communications, and Humanities at WPI, Developer of musical technology to facilitate composition, performance, and education

I read a bit about your motivation behind creating EAMIR on your website, can you speak a bit about how you decided to start developing music software, whether it was because of a lack of better alternative teaching resources or it was something you were really passionate about?

EAMIR specifically was developed when I was a graduate student, I was finishing up my undergraduate and like many music majors, was teaching and realized that in teaching the same stage of learner, I was oftentimes continuously teaching the same concepts and so I started looking into what types of tools there were that served my particular style of teaching. Musicians are very entrepreneurial in general, and this mindset prompted me in the direction of tool making – I started out by just messing around with Microsoft Excel and then effectively started making my own tools. An important idea that I came across was that a large part of life, being a teacher and a researcher, is designing your own thing because you are blazing new paths; there might be something out there that someone else made that works for you but it is a very useful thing to be able to fill your own repertoire and bag of tricks to draw from for whatever you are doing. EAMIR started off as one-off applications that only had to serve one customer's needs, my own. I know what types of tools I need in a classroom or on stage or in a

certain installation space, so the motivating factor for me was just to create tools that a likeminded researcher could use, or a teacher could use in a classroom setting. I was particularly motivated to facilitate instruction of a particular demographic, that happened to be in this situation accommodating people with disabilities and different types of learners. So, to summarize the answer, my motivation sort of split the difference, creating something nuanced just for me based on own vision as well as facilitating a need that was not really quite met in commercial space.

Over the course of developing various technologies what motivated you to turn it into something bigger in the form of your company Clear Blue Media?

It had to do mostly with ease of dissemination, money was not really a motivator as shown by how EAMIR is open source. Clear Blue Media was mostly about formality, creating an easier portal for people to access these applications and organize it in a legal sense so they are protected.

Over the years how have you identified the need for some of the technologies you then eventually went on to develop?

Oftentimes and most often the ideas come from my own frustrations or shortcomings or aspirations as a musician and educator. At WPI, I have tried to reach out to other professionals who do not necessarily have access to all the resources and WPI students to see what needs they have identified. Once I got settled in at WPI, I have been here since 2012, in about 2014 I started looking into ways to support my lab with grants, but mostly external sponsorships. With humanities and arts, it is very easy to attain research grants, and so I started reaching out to people in industries to promote interest in sponsorships of IQPs and independent study projects – the needs of those projects are ones that come from other people. There are lots of artists that have needs for different controllers and oftentimes they have the money to throw behind it but not the expertise, so my labs work to bridge that gap with student effort.

Once you have the idea to develop something new how do you decide that it is a worthwhile endeavor and feasible to pursue and in that thought process is factoring other competition on the market an aspect?

I have a high tolerance for failure and ambiguity, so I always think it is worthwhile to try something and spend a few terms developing a project even if it does not eventually work out. I hope to be a good model for students to show that that is okay, and it is just part of how things work, and that as long as due diligence is performed failure that is encountered is normal. This concept is oftentimes a new one when explaining to sponsors that the project work is going to be conceptual and largely feasibility related, but larger companies and sponsors are more

familiar with this element of research and design. There are many products in the music industry that are truly innovative but did not have enough market staying power and therefore as a business they failed, though the ideas themselves were great. Les Paul was one example of this, and from a lifetime of tinkering with things some of his ideas saw commercial success but a lot of them did not. I now have a grant to pick up some of these concepts and try to realize them with the resources that we have available at WPI. If we were motivated only by what has the market and revenue potential, many innovations would not be around today. However, that is one of the difficulties of being a visionary and a trailblazer is really being innovative and creating something unusual, as those are more difficult to get funding behind.

Obviously, you have a lot of ongoing and past research projects, outside of direct commercial success which ones would you say you are the proudest of, are the most successful in other metrics, or have the most potential for the future?

EAMIR is definitely one of my favorites and that is probably because it has zero potential for earning any money. There is a library embedded into EAMIR called the Modal Object Library that was effectively started when I was a grad student and was my first introduction to any sort of programming ever. I could do a bit of HTML in high school, but this was my start into understanding how you program something, and it was entirely fueled by my desire to explain how musical modes related to each other. This library is under the hood in EAMIR and has an SDK for EAMIR. EAMIR is my favorite project because I did release it commercially for a short window of time and some people explained that there is not a lot of money to be made but you could do a lot of social good if you consider releasing it even as is. That was an eye-opening thing for me because doing so ultimately did launch my career because it taught me how programming works and how musical modes work, but I also learned a great deal of how I work. Without the opportunity to do this, other areas of my life may look drastically different today. Learning to just put an idea out there and have others be able to freely adapt it for their own work gave me a platform from which I could build other types of applications more readily.

Can you speak to the general methodology you use when approaching the problems, you have tasked yourself with and how you work to generate the end product, whether you follow a software development lifecycle or anything?

I would not say I follow any formal lifecycle, like scrums or agile development. Typically, problems related to music and musicians are spelled out that directly and deal with things that are very difficult to quantify. Development methodologies generally fall short in my experience when those types of nuances are on the line and when incredibly abstract questions are raised. For example, with compositions, a very abstract question that could be asked is when is the song done? With computer science, there is a similar concept known as feature creep, which entails just continuously throwing bells and whistles on an application. So oftentimes

methodologies become a stumbling block when you are trying to develop a symbiotic relationship with what you are developing, where the computer returns the next steps to you and informs you what you are doing. It is different than programming with a friend and instead more along the lines of you giving feedback to yourself. The Lab RATs is a group of students that make a commitment to hang around for two semesters and gain access to pedals, effects, and processes and treasure chest of misfit projects and failed products. While very few individuals will fund this, this is not really a part of my research, and is not attributed to me as faculty, it is probably one of the most rewarding things I am involved with at WPI because it is so imaginative. It helps students explore what is out there and potentially find the starting point of something great, which is part of the human tradition.

How do you think your course material promotes student-driven innovation within and/or outside of the classroom setting and how do you contribute to that on campus?

I think they are one and the same, I try to make all my classes project-based, and I feel like I have gotten better at that over the course of the many years I have been teaching higher-education. I like open-ended projects, but also acknowledge that that can be very intimidating for people who do not necessarily have expertise using tools or their own creative ideas. Creativity is a learned behavior and I do not take that lightly so part of what I try to do with the courses is create opportunities for students to do open-ended things but also give some constraints. Everything in my courses, there is ultimately a component that is project-based, the practicum is probably the most liberal of all of them, but the various projects within that tend to lean towards other disciplines and general-purpose research so nobody has to learn entirely new skills. Music technology as a discipline has so many areas of conversion with other areas of study so while it is not possible to know specifically what each student is interested in, I try to be sensitive to what skill students are coming in with and make people feel at home approaching things with a level of enthusiasm.

What resources have you taken advantage of at WPI aside from the ability to reach out to students?

My colleagues are my number one, I am fortunate enough to be surrounded by such a talented community. I offload a lot of things to ARC because when it comes to teaching certain types of tools and software it is much easier to rely on key people to teach quick sessions on that. People in Washburn have been very helpful with machinery use and there are a few key faculty members I am friends with, and we will talk over project ideas – Sonify is one application that has come out of those conversations.