
# PIPELINE TO PHOTONICS: A BLUEPRINT

## How WPI Can Facilitate Success Within the Massachusetts Integrated Photonics Ecosystem

*by* Chongyuan Feng & Morgan Kaler

# Pipeline to Photonics: A Blueprint

## How WPI Can Facilitate Success Within the Massachusetts Integrated Photonics Ecosystem

*AN INTERACTIVE QUALIFYING PROJECT SUBMITTED TO THE FACULTY OF*

***WORCESTER POLYTECHNIC INSTITUTE***

*IN PARTIAL FULFILLMENT OF THE REQUIREMENTS FOR THE DEGREE OF BACHELOR OF SCIENCE BY*

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# ABSTRACT

This report addresses how Worcester Polytechnic Institute (WPI) can contribute to their integrated photonics partnership with Quinsigamond Community College (QCC) and facilitate lasting success in the Massachusetts integrated photonics ecosystem. Our project strove to define WPI's role in the ecosystem, increase the web presence of the Lab for Education and Application Prototypes (LEAP @ WPI/QCC), and identify the collaboration barriers present at LEAP @ WPI/QCC. We accomplished this through conducting formative interviews with stakeholders, developing web page frameworks and video storyboards, and conducting post-formative user experience (UX) interviews. Our findings result in concluding recommendations for WPI and for future LEAP @ WPI/QCC stakeholder involvement initiatives.

# ACKNOWLEDGMENTS

Given that every aspect of our project was virtually conducted during the COVID-19 pandemic, our success was especially contingent upon the contributions of several individuals.

First and foremost, we would like to thank all of the organizations and agencies that have made establishing the Lab for Education and Application Prototypes at Worcester Polytechnic Institute and Quinsigamond Community College (LEAP @ WPI/QCC) possible. Without generous support from the United States Department of Defense, Manufacturing USA, AIM Photonics, AIM Photonics Academy, the Commonwealth of Massachusetts, the Massachusetts Technology Collaborative (MassTech Collaborative), and the Massachusetts Manufacturing Innovation Initiative (M2I2), LEAP @ WPI/QCC would not exist.

We would also like to express special gratitude to Quinsigamond Community College (QCC) for approaching Worcester Polytechnic Institute (WPI) with the exciting LEAP @ WPI/QCC partnership opportunity.

Immeasurable thanks are owed to Andy Baron and Jillian Ferguson of WPI Marketing Communications for their willingness to meet with us to discuss the best practices for increasing the presence of LEAP @ WPI/QCC. Their insight was instrumental to the development of every one of our deliverables.

Great appreciation and respect are also due to every stakeholder who agreed to meet and interview with us over Zoom during the universally hectic and unprecedented time frame in which our project was completed. Their receptiveness to our project and eagerness to advise us in every way possible was truly remarkable. Thank you!

We were especially honored to have the opportunity to converse with Farhad Vazehgoo, the Acting Director of Advanced Manufacturing Programs at the MassTech Collaborative.

Additional thanks to Bogdan Vernescu, WPI's Vice Provost for Research, are warranted due to his unbelievably generous offer to use his personal resources to facilitate the production of our deliverables.

Lastly, we want to thank our project advisors, Professor Doug Petkie and Dr. Jim Eakin, who – in many respects – were also our sponsors due to their respective roles as Director and Technical Operations Manager of LEAP @ WPI/QCC. Our project would have been nowhere near as successful as it was had they not been willing to engage in endless email volleys, Google Docs comment threads, and *5 p.m.* meetings over *Zoom* on *Fridays*.

# EXECUTIVE SUMMARY

Distinguishable from electronics, photonics is the field of technology that manipulates light (photons) rather than electricity (electrons) to more effectively transfer, store, and process information. Consequently, applications of photonic technology are pervasive throughout modern society. For example, photonic technologies are routinely employed in telecommunications and the medical industry. Most notable, is the application of photonics that resulted in the development of an entirely new field of research and sector of industry: integrated photonics. In fact, market investigations conducted in the past two years have identified the integrated photonics sector of industry to be a key area that boasts significant potential for growth (MarketsandMarkets, 2019; Mordor Intelligence, 2018).

In response to the emergence of the integrated photonics industry the American Institute for Manufacturing Integrated Photonics (AIM Photonics) was founded by Manufacturing USA and the U.S. Department of Defense to bridge the gap between integrated photonics applied research and product development (Koch et al., 2016; Manufacturing USA, 2020). To aid in the endeavors of AIM Photonics, the Commonwealth of Massachusetts established the Massachusetts Manufacturing Innovation Initiative (M2I2) and partnered with AIM Photonics Academy to establish three Labs for Education & Application Prototypes (LEAPs) across the state of Massachusetts (M2I2, 2020b). Given that the 2018 establishment of LEAP @ WPI/QCC was made possible by the awarding of a $4.05M dollar grant from M2I2, Worcester Polytechnic Institute (WPI) and Quinsigamond Community College (QCC) have expressed great interest in research regarding how best to fulfill its significant role in the partnership and larger Massachusetts integrated photonics ecosystem (M2I2, 2020a).

Despite the fact that research has been published surrounding collaborations between universities and industry, limited literature regarding collaborations between academia, industry, and government exist. Also, while such literature named common barriers to collaboration between industry and academia, advice regarding how to overcome said obstacles was scarce. Another limitation of the existing literature is that there was a lack of research regarding how to market and build these collaborations. Furthermore, the fact that the field of integrated photonics is still evolving, and its applications are – for now – largely invisible and intangible, only complicates the question of how to build awareness of and increase participation in the LEAP @ WPI/QCC.

Thus, a central goal of our project was to assess the current relationships and collaboration barriers between the various stakeholders of LEAP @ WPI/QCC. Another goal of our project was to build broad awareness of LEAP @ WPI/QCC through improving the existing web presence of the collaboration. Lastly, we sought to explicitly define the role that WPI should assume to facilitate the success of LEAP @ WPI/QCC within the central Massachusetts integrated photonics ecosystem.

# METHODOLOGY

To achieve the aforementioned goals of our study, we established the following research objectives.

1. Identify and interview the stakeholders of LEAP @ WPI/QCC to determine the existing barriers to effective collaboration and define the role WPI should assume in the integrated photonics ecosystem.

2. Collaborate with WPI Marketing Communications to identify the best practices for marketing the LEAP @ WPI/QCC collaboration.

3. Build an improved framework for the LEAP @ WPI/QCC website using the identified best practices to enhance the existing web presence for increased stakeholder engagement.

4. Script and storyboard an introduction video that effectively addresses the stakeholders of LEAP @ WPI/QCC to raise awareness and inspire involvement in the collaboration.

In accordance with our first research objective, we directly interviewed members of WPI research leadership, WPI core LEAP faculty, faculty of other academic institutions with a LEAP, and officials from the governing agencies of LEAP. The information gathered from these stakeholder interviews was instrumental in determining the existing barriers to collaboration at LEAP @ WPI/QCC and defining the types of roles and responsibilities that WPI should assume to perpetuate the success in the integrated photonics ecosystem. To bridge the gaps in the literature pertinent to our project, we interviewed two members of the WPI Marketing and Communications team that were well-versed in the marketing of academic partnerships similar to LEAP @ WPI/QCC. These interviews allowed us to formulate a set of best practices for marketing LEAP @ WPI/QCC, which directly enabled us to execute our final two research objectives. Lastly, to assess whether our framework proposal for the LEAP @ WPI/QCC web pages successfully enhanced the user experience (UX) for stakeholders, we conducted post-formative interviews with individuals who had backgrounds in user experience (UX) and involvement initiatives.

## FINDINGS

Through careful analysis of the transcripts from the formative and post-formative interviews, we developed the following findings regarding the relationships between WPI, the LEAP @ WPI/QCC, and the diverse stakeholders of LEAP @ WPI/QCC:

1. **Stakeholders have varied levels of interest and power.** Preliminary research suggested that there were three main stakeholders of LEAP @ WPI/QCC: academia, industry, and government (Koch et al., 2016). However, our formative interviews revealed that these overarching groups are actually comprised of a plethora of individual stakeholder groups. For example, academia includes all the WPI and QCC stakeholders, as well as stakeholders from other institutions with LEAPs. In light of this realization, we conducted a more nuanced stakeholder analysis for LEAP @ WPI/QCC that categorized stakeholders according to their level of interest and power in the collaboration. It is important to note that the stakeholder matrix developed during this analysis is ever evolving. For example, if engagement methods prove successful, it is reasonable to expect the categorization of certain stakeholders to shift.

2. **WPI is expected to be a catalyst for innovative collaborations.** While we were unable to interview members of the industry and student stakeholder groups, the challenges to collaboration reported by the other stakeholder groups all suggested that WPI's overall role in the integrated photonics ecosystem is to be a catalyst for innovative collaborations. Individual responses, however, elucidated that WPI will need to take on a myriad of responsibilities and roles before they can truly spark growth in integrated photonics.

3. **Collaboration challenges stem from stakeholder diversity.** In addition to revealing a wide gamut of stakeholders, interviewees also elucidated just how diverse the stakeholders are and outlined the challenges that have surfaced as a result of that diversity. The most-cited challenge was the complicated nature of just coordinating stakeholders to begin a project proposal. The task of awarding intellectual property (IP) was another often-mentioned challenge. Additionally, members of WPI Research Leadership cited limited stakeholder awareness of the potential of integrated photonics as a barrier to collaboration.

4. **Differentiated engagement methods increase stakeholder participation.** In addition to finding that the collaboration challenges faced by LEAP @ WPI/QCC stakeholders stems from their diversity, we learned that differentiated engagement approaches can increase their participation. To attract industry affiliates, for example, it was suggested that a relevant value proposition that can be visualized is needed. In terms of increasing student

participation, we found that it is especially important to clearly attribute value to student involvement, as well as ensure that multiple avenues for involvement are provided.

5. **The web pages should illustrate the value proposition.** Whether the suggestion was to illustrate the applications of integrated photonics or to make the equipment information more accessible, we found the responses all implied that the web pages should allow stakeholders to thoroughly visualize all aspects of the LEAP @ WPI/QCC value proposition. We found that the most common recommendation spanned three stakeholder groups and suggested that the successes of LEAP @ WPI/QCC be highlighted on the web pages. However, considering LEAP @ WPI/QCC is still being established, very few success stories currently exist. Nevertheless, we were able to incorporate many of the other suggestions into our proposal. For example, we took Professor Pratap Rao's – a Core Faculty Member of LEAP @ WPI/QCC – advice and created side-by-side highlight boxes on the landing page that explored the education and application sides of the LEAP @ WPI/QCC mission.

6. **The introduction video should illustrate understandable value propositions.** Through careful analysis of the interviews, we found that the mutual vision of the stakeholders was for the introduction video to illustrate and offer understandable explanations of the LEAP @ WPI/QCC value proposition. In accordance with this finding, the script guidelines that we developed concisely emphasize differentiated value propositions for each stakeholder, such as affordable application prototyping for industry affiliates. Furthermore, the modular storyboard that we created simultaneously illustrates the value propositions through the use of engaging visuals, such as an infographic about the photonics development cycle.

7. **Diverse stakeholders require specialized marketing tactics.** As a result of our formative interviews with members of the WPI Marketing Communications Team, we found that collaborations composed of diverse stakeholders require specialized marketing and communication techniques. After analyzing the interviews regarding these techniques, we were able to organize the best practices according to whether they were for general use, implementation in our framework proposal, or incorporation into our modular storyboard. The resulting guide titled "Best Practices for Marketing LEAP @ WPI/QCC" was instrumental in our production of the proposed framework for the enhanced web pages, as well as the development of the modular introduction video script and storyboard.

8. **Additional UX enhancements can be made to the web pages.** In accordance with the best practices that we compiled, we conducted post-formative interviews with WPI community members who have backgrounds in involvement initiatives and user

experience (UX). Through presenting our framework proposal for the LEAP @ WPI/QCC web pages to these individuals and analyzing their feedback, we found that our current proposal is proficient from a UX and engagement point of view. These interviews also revealed that further steps can be taken to further enhance the user experience. The single most-mentioned suggestion is to continually test all proposed content on members of each stakeholder group. Similar to testing, it was frequently suggested that the user experience with the text could be improved through following plain language guidelines.

## RECOMMENDATIONS

Many of the key findings that surfaced during the formative and post-formative interview processes lead directly to our provision of two types of recommendations. The first set of recommendations outlines the steps that WPI can take to assume the roles and responsibilities expected of them by the integrated photonics ecosystem. The second set traces out the recommended next steps for the continued study of how stakeholder engagement and participation in LEAP @ WPI/QCC can be increased.

### FULFILLING ROLES & RESPONSIBILITIES: RECOMMENDATIONS FOR WPI

The stakeholders of LEAP @ WPI/QCC indicated that the overall role of WPI in the integrated photonics ecosystem is to be a catalyst for innovative collaborations. Particularly, the stakeholders of LEAP @ WPI/QCC challenge WPI to assume five roles and responsibilities to become said catalyst. Our recommendations as to how WPI can effectuate these five additional roles and responsibilities are as follows:

1. **To foster interdisciplinary collaboration and communication across the LEAP network, it is recommended that WPI:**
    - Send the biosensors prototyped at LEAP @ WPI/QCC to other LEAPs for testing and characterization
    - Have student project groups aid in the development of a centralized, state-run website for the LEAP network
    - Help establish a consortium of industry affiliates that is shared by all the LEAPs to eliminate competition within the network for partnerships
    - Present the findings of this project to the rest of the LEAP network

2. **To facilitate informed collaboration with integrated photonics companies of all sizes, it is recommended that WPI:**
    - Put great effort into identifying the needs of each company
    - Address the needs of each company through individualized plans

- Work with local start-ups and small companies to identify how integrated photonics can be implemented into their business models
- Consider partnering with companies from the general photonics industry

3. **To incorporate LEAP @ WPI/QCC and integrated photonics into WPI and QCC curricula, it is recommended that WPI:**
    - Collaborate with QCC to tailor existing curricula to meet the needs of integrated photonics companies
    - Continue to engage in co-teaching endeavors with QCC faculty
    - Work with QCC to find a delicate balance between theory and practice
    - Have faculty routinely encourage students to get involved
    - Have faculty form a network that hosts webinars for students

4. **To keep workforce development at the heart of LEAP @ WPI/QCC operations, it is recommended that WPI:**
    - Collaborate with QCC to develop a certificate program
    - Host Boot Camps that concentrate on the integrated photonic techniques relevant to the industry in Worcester

5. **To provide resources for the continued development of LEAP @ WPI/QCC, it is recommended that WPI:**
    - Provide internal funding for projects and outreach
    - Create supportive policies for projects and outreach
    - Grant access to their historic industry connection

## INCREASING INVOLVEMENT: RECOMMENDATIONS FOR FUTURE STUDIES

In the remainder of this summary, we outline the recommendations for future studies – many of which arose during the formative and post-formative interview processes – regarding LEAP @ WPI/QCC involvement initiatives.

1. **To enhance the LEAP @ WPI/QCC web pages in the future, it is recommended that future researchers:**
    - Use plain language guidelines for text simplification
    - Apply search engine optimization principles to the web pages
    - Create and post an email template for students to express their interest in LEAP @ WPI/QCC
    - Emphasize on the landing page that all students can get involved
    - Incorporate scrolling success stories into the framework

- Build a Repository of Results page
- Create a Frequently Asked Questions (FAQ) widget for the “Information for Students” page
- Compile comprehensive information regarding the equipment available at LEAP @ WPI/QCC

2. **To finish the production of the LEAP @ WPI/QCC introduction video, we suggest that future production teams:**
    - Use our modular storyboard and script guidelines as a starting point for the final storyboard and script
    - Take great care to provide visualizable value propositions
    - Weave discussions of student research into the script
    - Deliver an understandable elevator pitch that is framed in terms of challenges, solutions, and benefits
    - Consistently consult our marketing best practice guide throughout the production process

3. **Future marketing endeavors should:**
    - Commission WPI Marketing Communications to pen success stories
    - Advertise LEAP @ WPI/QCC on the countless screens in the common spaces across the WPI campus

# CONTRIBUTIONS

Our Interactive Qualifying Project (IQP) was especially unique considering that it was conducted during the COVID-19 pandemic and our team was actually a two-person partnership. Consequently, each team member made innumerable contributions to the project and this report.

***Chongyuan Feng***

Chongyuan's enthusiasm and creative vision throughout the project was truly unparalleled. Consequently, Chongyuan was intimately involved with the production of the Modular Storyboard & Script Guidelines for the LEAP @ WPI/QCC Introduction Video. While writing and transcription responsibilities were shared with Morgan, Chongyuan was largely responsible for the drafting of the Introduction, Background, and Literature Review sections of this report. Despite the unpredictable times during which this project was completed, Chongyuan was remarkably flexible in arranging impromptu meetings and scheduling interviews with stakeholders.

***Morgan Kaler***

Throughout the project, Morgan served as the liaison between our advisors and interviewees, which naturally led to her role as the primary interviewer. While writing responsibilities were shared with Chongyuan, Morgan was the lead author for the Methodology, Findings, and Conclusions & Recommendations chapters. Morgan also took the initiative to meticulously edit the final report and generate its figures and infographics. Morgan's greatest contribution to the project was her rapid development of the Framework Proposal for the LEAP @ WPI/QCC Web Pages.

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# 1. INTRODUCTION

Imagine a device that could analyze the quality of an apple without even breaking the skin of the easily bruised fruit. Better yet, imagine a device that could enter the bloodstream and extract a single cell for an early and rapid diagnosis of cancer. While these devices are not yet on the market, the field of integrated photonics is rapidly growing and evolving to bring these applications to fruition. Distinguishable from electronics, photonics is the field of technology that manipulates light (photons) rather than electricity (electrons) to more effectively transfer, store, and process information. The field of integrated photonics, consequently, capitalizes on these properties by producing devices composed of both photonic and classical electronic components to result in unparalleled performance and innumerable applications.

To facilitate the development and application of integrated photonic technologies in central Massachusetts, the state government partnered with AIM Photonics – a Manufacturing USA Institute – to establish a network of Labs for Education & Application Prototypes (LEAPs) at various academic institutions across the state. Hinted at by their name, the LEAPs all share two main goals. The first goal is for academia to collaborate with local companies to conduct meaningful integrated photonics research and development (R&D). The second mission of the LEAP network is to build a pipeline of skilled technicians and engineers between academia and industry. One of the three current LEAPs – LEAP @ WPI/QCC – is located in Worcester and exists as a partnership between Worcester Polytechnic Institute (WPI) and Quinsigamond Community College (QCC). Given that LEAP @ WPI/QCC was established in 2018 thanks to a $4M dollar grant from the Massachusetts Manufacturing Innovation Initiative (M2I2), WPI and QCC have expressed great interest in research regarding how best to fulfill its significant role in the Massachusetts integrated photonics ecosystem.

It just so happens that the concept of having academia, industry, and government closely collaborate to spur rapid technological growth is not unique to the LEAP network. Rather, extensive research regarding the successful navigation of these collaborations already exists. Some researchers have even gone so far as to develop collaboration procedures and business models with evaluation parameters (Alwerfalli & Jawad, 2015; Ivascu et al., 2016). One such model suggested that all stakeholders need to find relevance in the partnership and identify the barriers to collaboration that need to actively be addressed (Ivascu et al., 2016). Another guide emphasized that broad awareness of the collaboration is critical for its success (Alwerfalli & Jawad, 2015).

Yet, despite the existence of this comprehensive literature, the applicability of the literature to the LEAP @ WPI/QCC collaboration is limited. Perhaps the greatest limitation is that the collaborations discussed existed solely between industry and academia stakeholders, thus making the findings somewhat irrelevant to LEAP @ WPI/QCC and its government stakeholders. Additionally, advice regarding how to overcome collaboration barriers was scarce. Another

limitation of the existing literature is that there is a lack of research regarding how to market and build the presence of these collaborations. Furthermore, the fact that the field of integrated photonics is still evolving, and its applications are – for now – largely invisible and intangible only complicates the question of how to build awareness of and increase participation in the LEAP @ WPI/QCC.

Thus, a central goal of our project was to assess the current relationships and collaboration barriers between the various stakeholders of LEAP @ WPI/QCC. Another goal of our project was to build broad awareness of LEAP @ WPI/QCC through improving the existing web presence of the collaboration. Lastly, we sought to explicitly define the role that WPI should assume to facilitate the success of LEAP @ WPI/QCC within the central Massachusetts integrated photonics ecosystem. To achieve these goals, we established and adhered to the following research objectives:

1. Identify and interview the stakeholders of LEAP @ WPI/QCC to determine the existing barriers to effective collaboration and define the role WPI should assume in the integrated photonics ecosystem.

2. Collaborate with WPI Marketing Communications to identify the best practices for marketing the LEAP @ WPI/QCC collaboration.

3. Build an improved framework for the LEAP @ WPI/QCC website using the identified best practices to enhance the existing web presence for increased stakeholder engagement.

4. Script and storyboard an introduction video that effectively addresses the stakeholders of LEAP @ WPI/QCC to raise awareness and inspire involvement in the collaboration.

It is our hope that our study provides WPI with the resources and recommendations necessary to have a meaningful impact on the central Massachusetts integrated photonics ecosystem. If nothing else, our interactions with the rest of the ecosystem suggested that stakeholders are eager to collaborate with WPI and have great expectations for what is yet to come from LEAP @ WPI/QCC.

# 2. BACKGROUND & LITERATURE REVIEW

In this chapter, we begin with a brief introduction to photonics before exploring the field of integrated photonics and its promising applications. From there, we provide an overview of the Massachusetts integrated photonics ecosystem and introduce the LEAP network. Afterwards, we succinctly introduce LEAP @ WPI/QCC and detail the history of the partnership between WPI and QCC. Subsequently, we synthesize the existing literature regarding the best practices for the successful facilitation of collaborations between academia, industry, and government. We conclude this chapter with a discussion of the gaps in the literature as they pertain to LEAP @ WPI/QCC and the role of WPI in the integrated photonics ecosystem.

## 2.1 A BRIEF INTRODUCTION TO PHOTONICS & INTEGRATED PHOTONICS

Distinguishable from electronics, photonics is the field of technology that manipulates light (photons) rather than electricity (electrons) to more effectively transfer, store, and process information. Consequently, applications of photonic technology are pervasive throughout modern society. For example, photonic technologies are routinely employed in telecommunications and the medical industry. Most notable, however, is the application of photonics that resulted in the development of an entirely new field of research and sector of industry: integrated photonics.

Integrated photonic technologies – such as Photonic Integrated Circuits (PICs) – are unique in that they are hybrid compositions of both photonic and classical electronic components. The end result is a class of technologies characterized by unparalleled performance and innumerable applications. In fact, according to a market investigation conducted by Mordor Intelligence (2019), the global PIC market reached 472.5 million USD in 2018 and was predicted to have a 26.4% Compound Annual Growth Rate (CAGR) from 2019-2024. Similarly, a market review done by MarketsandMarkets (2019) indicated that the overall photonic biosensor market was 2.12 billion USD in 2019, with a CAGR of 8.3% over 2019-2024. Thus, it can be seen that the application of photonics for the development of integrated photonic technologies has resulted in the creation of a new industry sector that boasts significant potential for growth.

## 2.2 APPLICATIONS OF INTEGRATED PHOTONICS

### 2.2.1 PHOTONIC INTEGRATED CIRCUITS

Given that this is the Age of Information, tremendous quantities of data are routinely generated as members of society interact with the internet. Thus, as advancements are made in information technology, faster data transmission and computing power will be necessary to cope with the

ever-growing flow of data. Consequently, PIC solutions are actively being developed to meet the data transmission and processing needs of modern society.

Typically, PICs feature optical components – such as lasers, modulators, and detectors – that are all integrated into a compact chip and connected through waveguides. This configuration is analogous – see **Figures 1 and 2** – to traditional printed circuit boards (PCBs), which feature electronic components – such as capacitors and transistors – that are connected by copper wires – commonly called "traces". According to AIM Academy (2020):

> Electrons are sluggish and interact with one another and the copper wires through which they travel, limiting how much information can be transmitted. In contrast, photons move at light speed with no interference, allowing many discrete pieces of information to be transmitted at once. Electronic currents heat up; photons can transmit great amounts of information, releasing only a fraction of the energy they carry.

Thus, when compared with traditional integrated circuits (ICs), it is found that PICs are "extremely fast, accommodate higher bandwidth, and are highly power efficient" (MarketsandMarkets, 2019).

**Figure 1: Traditional Printed Circuit Board (PCB)**

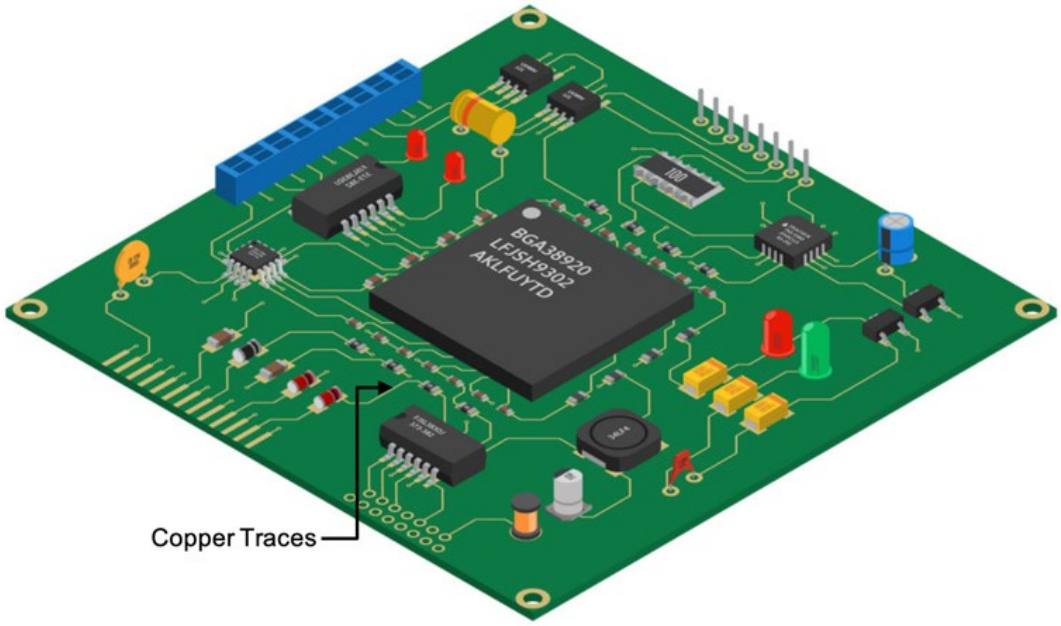


**Figure 1** is a diagram of a traditional printed circuit board (PCB). The copper wires – or traces – allow electrons to travel between the various electronic components that compose the circuit.

Image Source: D1min (n.d.). Isometric printed circuit board vector image [Diagram]. VectorStock. https://www.vectorstock.com/royalty-free-vector/isometric-printed-circuit-board-vector-24911870

**Figure 2: Diagram of a Photonic Integrated Circuit (PIC)**

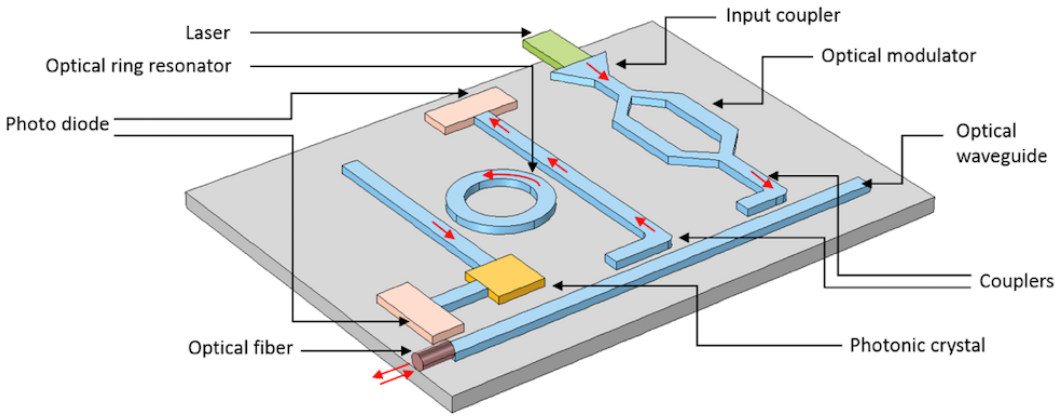


**Figure 2** is a diagram of a photonic integrated circuit (PIC). The optical waveguides throughout the circuit allow photons to travel between the various photonic components that compose the circuit. These optical waveguides are analogous to the copper traces used in traditional printed circuit boards (PCBs).

Image Source: Pal, U. (2017). [Schematic of a photonic integrated circuit that shows different optical components] [Diagram]. COMSOL. https://www.comsol.com/blogs/silicon-photonics-designing-and-prototyping-silicon-waveguides/

When it comes to waveguides, the silicon waveguide is the predominant platform used in PICs due to its "low power consumption, low cost, small footprint, and most importantly, complementary metal-oxide semiconductor (CMOS) compatibility" (Wang & Long, 2018, p. 1267). Another advantage is that the "strong light confinement of silicon waveguides makes it possible to integrate a great number of optical devices in a millimeter level" (Wang & Long, 2018, p. 1267).

In fields such as telecommunication and cloud-computing, PICs are crucial and the demand for advancement is growing. The market research conducted by Mordor Intelligence in 2018 emphasizes that there is a need for data transference to occur at higher rates, be more cost-effective, and consume less power. Additionally, it was revealed that there is a "critical need for advanced switching and data transfer hardware, which can be met by hybrid PICs" (Mordor Intelligence, 2018). Yet PICs are "still new to the market, and hence, experience a very low level of market penetration, when compared to the traditional ICs" (Mordor Intelligence, 2018). As summarized by Wang & Long (2018), "Very recently, with the ever increasing demand for high-speed data transmission and management in fiber-optic communications, data centers, high-performance computing, inter-chip and intra-chip optical networks, optical signaling, and processing technologies using advanced multi-level modulation signals have attracted a lot of attention" (p. 1269).

### 2.2.2 PHOTONIC BIOSENSORS

Another integrated photonics application that has attracted a lot of attention recently is that of photonic biosensors. According to Steve Jobs, "The biggest innovations of the 21st century will be at the intersection of biology and technology" (Nancy J Kelley & Associates, 2018). Provided that a typical biosensor is usually an optical transducer that can detect a multitude of biochemical reactions through the use of photoelectric reactions, such advancements in biomedical technology could entail the production of photonic biosensors (Chen et al., 2019). Compared with traditional biosensors, the photonic variety could feature significantly faster detection rates and still be comparable in size and cost. An important application of photonic biosensors could be their integration into a Point-of-Care (PoC) system that enables real-time detection. Such an application would be similar to current Lab-on-Chip (LoC) applications that use photonic biosensors to study subtle reactions on micro- and nanoscales. Nevertheless, while photonic biosensors show great potential and high market demand, they are still far from commercialization primarily due to price sensitivity (MarketsandMarkets, 2019). This sensitivity also explains why other potential uses for non-healthcare industries - such as food safety, biodefense, and environmental monitoring - are not currently being explored.

Another category of photonic biosensors that is worth mentioning is that of label-free detectors. According to Chen et al. (2019), an optical biosensor features a biorecognition element to which the optical transducer is calibrated. It then follows that biosensors that employ label-based detection target biomolecules that match the fingerprint of the biorecognition element (Chen et al., 2019). Compared with label-based detectors, biosensors that use label-free detection are more accurate in that they detect biomolecules "closer to their natural forms…" instead of altering them through labeling (Chen et al., 2019, p. 1). Furthermore, it was indicated by Chen et al. (2019) that biosensors that use label-free detection are inexpensive to operate and show "great potential for miniaturization and for simultaneous multiplexed detection of multiple analytical targets" (Chen et al., 2019, p. 1).

## 2.3 IMPACT OF COVID-19 ON THE INTEGRATED PHOTONICS INDUSTRY

Although the market research cited in the above sections is current and credible, it is undeniable that the COVID-19 pandemic has caused societal repercussions. Consequently, the economy and market are now unpredictable and may not behave as once predicted. However, the need for a better point-of-care system is self-evident and such a need might accelerate the time to market for photonic integrated circuit solutions. This may especially be the case considering that the pandemic is being perpetuated worldwide by insufficient COVID-19 testing capabilities.

Thus, the National Institute of Health (2020) recently established a national initiative intended to speed up the development of COVID-19 test kits. This initiative is accompanied by a $1.5 billion

investment from the federal government that was made in response to the escalating pandemic (2020). Yet, despite academic advancement on PoC systems, current commercialized point-of-care test kits for COVID-19 are not encouraged by the World Health Organization (2020).

## 2.4 AIM PHOTONICS AND THE MASSACHUSETTS INTEGRATED PHOTONICS ECOSYSTEM

In response to the emergence of many advanced manufacturing industries – such as integrated photonics, tissue fabrication, and flexible electronics – Manufacturing USA was formed in 2014 (Manufacturing USA, 2020). According to Manufacturing USA, the overarching goal of the institutes and their federal sponsors is to "secure America's future through manufacturing innovation, education, and collaboration" (Manufacturing USA, 2020). Sponsored by the U.S. Department of Defense (DOD), the American Institute for Manufacturing Integrated Photonics (AIM Photonics) is just one of Manufacturing USA's 14 public-private institutes (Manufacturing USA, 2020). Consequently, AIM Photonics is tasked with bridging the gap between integrated photonics applied research and product development (Koch et al., 2016). In fact, during the COVID-19 pandemic, AIM Photonics has been working to develop inexpensive PICs that can provide COVID-19 test results in minutes, thus cementing their role "as a vital bridge between labs on campus and in industry and US Defense Department labs" (Burkhart, 2020).

According to Koch et al. (2016), there are four high-level goals of AIM Photonics, which range from the development of a manufacturing infrastructure and framework to the provision of educational and workforce development programs. One such goal is to "provide practical access and technology on-ramps for U.S. industry, government, and academic communities" (Koch et al., 2016, p. 2). In 2016, to achieve this goal, AIM Photonics established the AIM Photonics Academy and tasked it with addressing integrated photonics education, workforce development, and industry road-mapping (Massachusetts Technology Collaborative, 2020). One of the two primary ways in which AIM academy addresses these key areas is through its Lab for Education & Application Prototypes (LEAP) division (Massachusetts Technology Collaborative, 2020).

To aid in the endeavors of Manufacturing USA, the Commonwealth of Massachusetts recently established the Massachusetts Manufacturing Innovation Initiative (M2I2) through the Massachusetts Technology Collaborative (M2I2, 2020b). Particularly, the Commonwealth pledged to "develop the Manufacturing USA infrastructure within the state's academic, research and manufacturing industry" (M2I2, 2020b). Specifically, M2I2 created four Manufacturing USA Centers that align with four of the Manufacturing USA institutes (M2I2, 2020b). Notably, one of these Centers is partnered with the AIM Photonics Institute (M2I2, 2020b). As a result of this partnership, three Labs for Education & Application Prototypes (LEAPs), thus far, have been established at various academic institutions across the state of Massachusetts. Namely, there are LEAPs at: the Massachusetts Institute of Technology (MIT), Worcester Polytechnic Institute

(WPI) & Quinsigamond Community College (QCC), and Bridgewater State University (BSU) & Stonehill College.

Hinted at by their name, the LEAPs all share two primary goals. The first goal is for academia to collaborate with local companies to conduct meaningful integrated photonics research and development (R&D). The second mission of the LEAP network is to build a pipeline of skilled technicians, engineers, and scientists that are well-prepared to enter the integrated photonics workforce. In many cases, this entry is actually a re-entry of workers who have completed additional trainings to remain at the forefront of innovation. A noteworthy consequence of M2I2's partnership with AIM Photonics Academy and founding of the LEAP network is that the Commonwealth of Massachusetts effectively established a state-wide integrated photonics ecosystem.

## 2.5 LEAP @ WPI/QCC: A BRIEF HISTORY

Situated along the I-90 Corridor of the United States, WPI and QCC are uniquely positioned to contribute to the burgeoning hub of innovation in the Massachusetts integrated photonics ecosystem (Quinsigamond Community College, 2020). More important than their location, however, are the contributions to the ecosystem that their synergistic histories will foster. Namely, “QCC’s workforce development acumen and WPI’s industry/technology heritage” made WPI and QCC “perfectly suited” to form a LEAP (Quinsigamond Community College, 2020). Consequently, in 2018, QCC and WPI partnered with the governments, institutes, and organizations discussed in the previous section to form LEAP @ WPI/QCC.

Given that the establishment of LEAP @ WPI/QCC was made possible by the awarding of a $4.05M dollar grant from M2I2, WPI and QCC have expressed great interest in research regarding how best to fulfill its significant role in the partnership and larger Massachusetts integrated photonics ecosystem (M2I2, 2020a).

## 2.6 LEAP @ WPI/QCC: A UNIVERSITY-INDUSTRY-GOVERNMENT COLLABORATION

Given that the LEAP @ WPI/QCC, as described in the previous section, features stakeholders from academia, industry, and government, it can be said that LEAP @ WPI/QCC – and the rest of the LEAP network for that matter – is a University-Industry-Government Collaboration (UIGC).

### 2.6.1 NAVIGATING A UNIVERSITY-INDUSTRY COLLABORATION

The fact that LEAP @ WPI/QCC are UIGCs merits an inquiry into the best practices for facilitating effective collaboration between multiple stakeholders. More specifically, the collaboration between universities and industry requires analysis considering that they – classically – operate within distinct, differing organizational cultures (Ivascu et al., 2016). According to Ivascu et al. (2016), universities traditionally operate with the objectives of creating knowledge and educating the workforce, whereas industry typically focuses on intellectual property and the use of knowledge to develop products and services. Consequently, University-Industry Collaborations (UICs) are intrinsically challenging to navigate.

To aid in demystifying the daunting task of navigating UICs successfully, Ivascu et al. (2016) used data collected in Romania to formulate a business model focused on the optimized production of tangible outcomes – such as tangible research, patent and licensing, and social benefits. The model features six evaluation parameters – collaboration, knowledge sharing, culture, financial support, and communication – accompanied by success factors by which to measure them (Ivascu et al., 2016). For example, some of the key factors that signal successful knowledge sharing in a UIC are publications, networking activities, mobility and employability availability, continuing education, and intellectual property (Ivascu et al., 2016, p. 677). Perhaps one of the more critical components of the model is the consideration of potential barriers to the success of a UIC. According to the proposal, barriers to overcome include finding relevance in the partnership, negotiating contracts, time management, and forming teams with sufficient technical capabilities (Ivascu et al., 2016).

In harmony with the findings of Ivascu et al. (2016), Alwerfalli and Jawad (2015) similarly noted that "success depends on finding common goals and negotiating plans that pay off financially and intellectually for all parties" (p. 2164). Alwerfalli and Jawad (2015) went on to devise a procedure titled "The Seven Keys to Collaboration Success," which features suggestions to find a strategic context for the project, select project managers that span academia-industry boundaries, create and share a vision with value, invest in long-term relationships, and build broad awareness (p. 2166). Instead of detailing tangible outcomes like Ivascu et al., however, Alwerfalli and Jawad (2015) opted to list reasonable expectations that both companies and students can have for UICs. Students, for example, can expect to gain insight into the operations of companies, get exposure to the technologies used by companies, and early-on "training on the job" (Alwerfalli & Jawad, 2015, p. 2166).

### 2.6.2 MARKETING A PHOTONICS-CENTERED COLLABORATION

Given the importance that Alwerfalli and Jawad (2015) assigned to the creation of a strong presence and the construction of a broad awareness for the success of a UIC, further research was conducted into what the best practices are for marketing such a collaboration.

According to Nanton (2014) an online presence is now "an absolute necessity," no matter what is being marketed (p. 28). However, Nanton cautions against simply establishing an Internet-identity and claims that there are five keys to crafting an effective presence (p. 28). Most notable are the tips to make the webpage branded, interactive, and engaging, as well as to demonstrate value. (p. 28). Perhaps most important of the tips, however, is to make use of visuals, considering humans most-effectively process visual information (Manic, 2015, p. 89; Nanton, 2014, p. 29). Manic (2015) claims that there exist three main categories of visuals – illustrations, comics (including infographics), and videos – and that all three have valid roles in marketing (p. 90). No matter the visual type, all can help companies prove their expertise, develop a visual demonstration of the product, present testimonials, and tell success stories (90).

However, since the focus of this best practices inquiry was the LEAP UIGC, special attention was given to marketing practices for the photonics industry. Potently put by d'Humières (2018) in his article, *Marketing for the Photonics Industry*, the photonics "sector is a gem that is not yet aware of its potential and capacity…The reluctance to leave the comfortable cocoon of technical vision to address business logic based on a structured and meticulous approach to marketing is one of the main reasons for this limitation" (p. 27). Fortunately, d'Humières (2018) proffered four tips to broach the unpredictable markets that make marketing photonics so daunting. Two such tips are to build a trusting relationship with the contact and to be able to look to the future (p. 25).

## 2.7 LIMITATIONS OF AVAILABLE LITERATURE

Despite the comprehensive nature of the literature that was synthesized in the previous section, there are many limitations to the applicability of the explored literature to the LEAP @ WPI/QCC collaboration. Perhaps the greatest gap in the literature is that the research done by Ivascu et al. (2016) and Alwerfalli & Jawad (2015) focused only on collaborations that occur between universities and industry. Neither of their models or procedures, respectively, addressed how – or even if – the best practices for collaboration change when government stakeholders are introduced. Similarly, while barriers to effective collaboration were named and evaluation parameters were developed, there was no significant discussion regarding how to overcome said barriers to affect measurable success.

Another significant gap in the literature was that very few publications regarding how to effectively market a multi-organization collaboration could be found. Rather, most of the

literature that we did find was very generic in that it was directed towards individual businesses. Even the best practices that were provided by d'Humières (2018) were only for photonics businesses, not multi-organization collaborations in the field of integrated photonics. Consequently, the question of how to build awareness of and increase participation in LEAP @ WPI/QCC is still largely unanswered.

# 3. METHODOLOGY

A central goal of our project was to assess the current relationships and collaboration barriers between the various stakeholders of LEAP @ WPI/QCC. Another goal of our project was to build broad awareness of LEAP @ WPI/QCC through improving the existing web presence of the collaboration. Lastly, we sought to explicitly define the role that WPI should assume to facilitate the success of the Manufacturing USA collaboration within the central Massachusetts integrated photonics ecosystem. To achieve these goals, the following research objectives were established:

1. Identify and interview the stakeholders of LEAP @ WPI/QCC to determine the existing barriers to effective collaboration and define the role WPI should assume in the integrated photonics ecosystem.
2. Collaborate with WPI Marketing Communications to identify the best practices for marketing the LEAP @ WPI/QCC collaboration.
3. Build an improved framework for the LEAP @ WPI/QCC website using the identified best practices to enhance the existing web presence for increased stakeholder engagement.
4. Script and storyboard an introduction video that effectively addresses the stakeholders of LEAP @ WPI/QCC to raise awareness and inspire involvement in the collaboration.

Throughout this chapter, we explore the methodology that we developed to facilitate the fulfilment of our research objectives.

## 3.1 OBJECTIVE 1

**Identify and interview the stakeholders of LEAP @ WPI/QCC to determine the existing barriers to effective collaboration and define what WPI's role should be in the integrated photonics ecosystem.**

While the literature review informed us that LEAP @ WPI/QCC is a collaboration between academia, industry, and government, we realized that there are many stakeholders within each of the three domains. For example, within WPI, there exists the stakeholder groups of research leadership, the core LEAP faculty, and students. Given that the main motivation of our project was to identify how WPI can facilitate the success of such a multi-faceted collaboration, we set out to determine the types of interactions that already existed between the diverse stakeholder groups and expose any barriers to said collaboration. To achieve this goal, we decided to directly

interview members of WPI research leadership, WPI core LEAP faculty, faculty of other academic institutions with a LEAP, employees of industry affiliates, and officials from the governing agencies of LEAP. However, due to time constraints, we were unable to secure interviews with industry stakeholders and only had the opportunity to interview faculty from two of the three other academic institutions with LEAPs. The interview questions directed towards each of these stakeholder groups all stemmed from the following research questions:

- What role should WPI take to facilitate the success of LEAP @ WPI/QCC and the larger integrated photonics ecosystem?
- Who are all of the stakeholders of the collaboration?
- What challenges are routinely faced by stakeholders of the collaboration?
- How can WPI increase the level of involvement of each stakeholder group – or stakeholder participation – in the collaboration?
- How can WPI accelerate workforce development within the field of photonics?
- What can WPI do to facilitate truly interdisciplinary projects between LEAP @ WPI/QCC and other research groups across campus?
- What enhancements to the collaboration's web presence are needed to effectively engage all stakeholders?
- What content should be incorporated into an introduction video for LEAP @ WPI/QCC

A full schedule of the tailored questions for each stakeholder group can be found in the **Appendix A**, though most of the questions asked were improvised during the interviews. **Table 1** names each of the 11 individuals that we interviewed across the aforementioned stakeholder groups. Each interview was conducted over Zoom and lasted for approximately half an hour. With the permission of each interviewee, the interviews were locally recorded for transcription purposes. The information gathered from these stakeholder interviews was instrumental in determining the existing barriers to collaboration – and their degree of prevalence – within LEAP @ WPI/QCC and the larger LEAP network. The compiled responses also aided in the definition of the types of roles and responsibilities that WPI should assume to perpetuate the success in the integrated photonics ecosystem. Additionally, the interviews with the various stakeholders enabled us to articulate the relationships between each stakeholder group of LEAP @ WPI/QCC through the construction of a stakeholder matrix.

**Table 1: Interviewee Information from Stakeholder Interviews**

| Stakeholder Group | Interviewee Name | Interviewee Title |
|---|---|---|
| Government Officials | Farhad Vazehgoo | Acting Director of Advanced Manufacturing Programs at MassTech Collaborative |
| WPI Research Leadership | Ellen Piccioli | Director of Manufacturing Innovation |
| | Bogdan Vernescu | Vice Provost for Research |
| | Suzanne Weekes | Associate Dean of Undergraduate Studies, ad interim |
| WPI Core LEAP Faculty | Yuxiang "Shawn" Liu | Assistant Professor of Mechanical Engineering |
| | Pratap Rao | Associate Professor of Mechanical Engineering |
| | Lyubov Titova | Associate Professor of Physics |
| QCC Faculty & Staff | Adrienne Linnell | Program Administrator of STEM Initiatives |
| | Jacob Longacre | Associate Professor of Electronics Engineering Technology |
| Faculty of Other LEAPs | Anu Agarwal | Leader of the MIT LEAP & Massachusetts LEAP Network |
| | Ed Deveney | Professor of Physics at Bridgewater State University (BSU) |

## 3.2 OBJECTIVE 2

**Collaborate with WPI Marketing Communications to identify the best practices for marketing the LEAP @ WPI/QCC collaboration.**

Through conducting the literature review, we learned that broad visibility and awareness - especially through one's web presence - is a critical component of ensuring the viability of a collaboration (Alwerfalli & Jawad, 2015). It was this information that led us to realize that WPI can facilitate the success of LEAP @ WPI/QCC through building a stronger web presence for the collaboration. However, very limited literature was found in regard to what the best practices are for achieving such marketing goals. To bridge this gap in the literature we interviewed two members of the WPI Marketing Communications team (see **Table 2** for details) that were well-versed in the publicization of academic partnerships similar to LEAP @ WPI/QCC. The questions that we asked these two members were derived from the following research questions:

- How can WPI increase student awareness of – and participation in – the collaboration?
- What can WPI do to attract potential industry affiliates for the collaboration?

- What are the best practices for effectively marketing a multi-organization collaboration?
- What types of content would enhance the current web presence of the collaboration?

**Table 2: Interviewee Information from WPI Marketing Communications Interviews**

| Interviewee Background | Interviewee Name | Interviewee Title |
|---|---|---|
| Public Relations/ Communications | Andy Baron | Associate Director of Public Relations |
| Marketing | Jillian Ferguson | Director of Marketing |

## 3.3 OBJECTIVE 3

**Build an improved framework for the LEAP @ WPI/QCC website using the identified best practices to enhance the existing web presence for increased stakeholder engagement.**

Using the best practices that we devised from the interviews and training with WPI Marketing Communications, we set out to develop a new, more engaging framework for the LEAP @ WPI/QCC website. This building process involved our use of the WPI Drupal Sandbox for offline experimentation with the possible web page features. Due to the fact that the Sandbox training area is routinely erased and reset, we used Piktochart – a web-based infographic program – to document the proposed changes. More specifically, we generated the desired widgets and content in the Sandbox and took screen captures so that we could arrange them in Piktochart to build the proposed framework for each LEAP @ WPI/QCC webpage. A PDF of the generated framework is included in **Appendix D** and is intended to serve as a roadmap for future implementation. Throughout the framework enhancement process, our changes were driven by the following questions:

- Are we adhering to the best practices outlined by WPI Marketing Communications?
- Are we drawing upon the recommendations outlined in the literature review?
- Are we drawing upon the recommendations that surfaced during the formative interview process?
- How can we effectively present the information we want our stakeholders to know in a way that all stakeholders can understand it?

- Will the content that we incorporate bridge the gaps in awareness and inspire stakeholder involvement in the collaboration?

Following the development of the proposed framework for the webpages, we set out to get constructive feedback as to whether we successfully enhanced the user experience for the stakeholders of LEAP @ WPI/QCC. This was achieved through conducting post-formative interviews with members of the WPI community who had backgrounds with user experience and involvement initiatives (see **Table 3** for more information). The interview procedures remained consistent with those followed during the formative interview process. The feedback generated through the post-formative interviews were compiled and are discussed in the next chapter.

**Table 3: Interviewee Information from Proposed Framework Post-Formative Interviews**

| Interviewee Background | Interviewee Name | Interviewee Title |
|---|---|---|
| User Experience (UX) | Soussan Djamasbi | Professor of Business; Founder & Director of the User Experience and Decision Making (UXDM) Research Laboratory |
| Involvement Initiatives | Ally Salvino | Student Assistant to the Office of Undergraduate Research |

## 3.4 OBJECTIVE 4

**Script and storyboard an introduction video that effectively addresses the stakeholders of LEAP @ WPI/QCC to raise awareness and inspire involvement in the collaboration.**

In our research on how to market the LEAP collaboration, we found that visual content – especially video – is most effective at quickly conveying retainable information (Manic, 2015). Thus, to further WPI's goal of facilitating the success of LEAP @ WPI/QCC, we set out to produce an introduction video that effectively addresses the stakeholders of the collaboration. During the storyboarding and scripting stages, we were sure to consult the marketing best practices that were identified in Objective 2. Unfortunately, the COVID-19 pandemic and time constraints rendered us unable to complete all stages of the production process. Nevertheless, we were able to develop a modular storyboard accompanied by script guidelines. The modular design should provide a future production team with a starting point for the final script and storyboard. The content that was developed and incorporated into the modular storyboard and script guidelines was driven by the following guiding questions:

- How can we effectively address and engage all stakeholders of the collaboration?
- What content can we incorporate to inspire involvement in the collaboration?
- Which of the identified gaps in awareness and collaboration that were identified in Objective 1 can we address and bridge?

The modular script and storyboard guidelines that we developed for the LEAP @ WPI/QCC introduction video can be found in **Appendix E**. The proposed framework that was developed in Objective 3 features a placeholder on the landing page where the final video can, eventually, be embedded.

# 4. FINDINGS

Through careful analysis of the transcripts from the formative and post-formative interviews, several findings surfaced regarding the relationships between WPI, the Lab for Education & Application Prototypes (LEAP @ WPI/QCC), and the diverse stakeholders of LEAP @ WPI/QCC. This chapter starts with an exploration of who the various stakeholders are of LEAP @ WPI/QCC and how said stakeholders envision WPI being a catalyst for growth within the integrated photonics ecosystem. From there, we analyze how stakeholder diversity complicates collaboration and how differentiated methods of engagement can increase stakeholder participation in LEAP @ WPI/QCC. We then examine the recommendations made regarding the LEAP @ WPI/QCC web presence and discuss their implementation. This chapter concludes with a functionality assessment of the proposed framework for the LEAP @ WPI/QCC webpages.

## 4.1 FINDING 1: STAKEHOLDERS HAVE VARIED LEVELS OF INTEREST AND POWER.

To accurately assess the relationships between the stakeholders of LEAP @ WPI/QCC, we first had to explicitly identify said stakeholders. Preliminary research suggested that there were three main stakeholders: academia, industry, and government (Koch et al., 2016). However, our formative interviews revealed that these overarching groups are actually comprised of a plethora of individual stakeholder groups. For example, academia includes all the WPI and QCC stakeholders, as well as stakeholders from other institutions with LEAPs. In light of this realization, we conducted a more nuanced stakeholder analysis for LEAP @ WPI/QCC. The resulting stakeholder matrix is pictured in **Figure 3**.

**Figure 3: LEAP @ WPI/QCC Stakeholder Matrix**

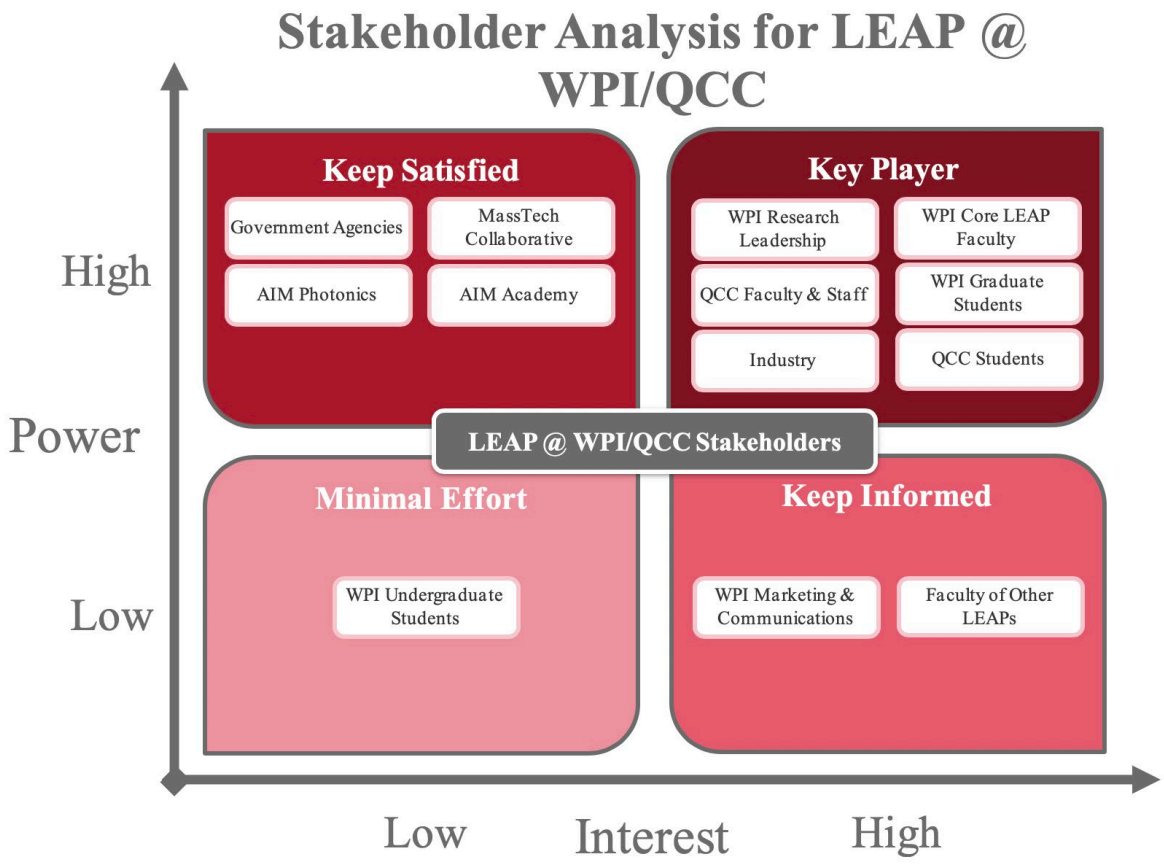


**Figure 3** categorizes the stakeholders of LEAP @ WPI/QCC according to their level of interest in the collaboration as well their power over the operations of the collaboration.

Our stakeholder analysis sought to categorize the LEAP @ WPI/QCC stakeholders according to their level of interest in the collaboration and the amount of power – or influence – that they have over the operations of the collaboration. For instance, the formative interviews revealed that all of the LEAPs must deliver quarterly reports to their governing agencies – such as the MassTech Collaborative – thus suggesting that the granting governing agencies have great influence over the operations of the LEAPs. However, when compared to the stakeholders that routinely interact with LEAP @ WPI/QCC – such as the core LEAP faculty members and graduate students – we found that these governing agencies fall into the "Keep Satisfied" category instead of the "Key Player" group. In contrast, we found that the three LEAPs are largely independent of each other, thus giving the faculty of the other LEAPs limited influence over the operations of LEAP @ WPI/QCC. Additionally, our interviews highlighted that the faculty of the other LEAPs have great interest in what LEAP @ WPI/QCC does and are eager to foster collaboration across the entire LEAP network. As a result of these findings, it was determined that the faculty of the other LEAPs should be kept informed.

It is important to note that the stakeholder matrix shown in **Figure 3** is ever evolving. For example, the conversations we had with the LEAP @ WPI/QCC stakeholders highlighted a lack of participation from the undergraduate students of WPI. Consequently, it can be said that – currently – the WPI undergraduate students have low influence and low interest in LEAP @ WPI/QCC. However, one of our research goals throughout this project was to determine how student involvement in LEAP @ WPI/QCC could be increased. Therefore, if the engagement methods presented later in this chapter prove successful, it is reasonable to expect the categorization of the WPI undergraduate students to shift.

## 4.2 FINDING 2: WPI IS EXPECTED TO BE A CATALYST FOR INNOVATIVE COLLABORATIONS.

A central research objective to our project has been to define how WPI can facilitate the success of LEAP @ WPI/QCC and the larger integrated photonics ecosystem. Consequently, we asked the stakeholder interviewees what roles and responsibilities they expected WPI to assume. To make sense of the plethora of answers received, we grouped similar answers together and tallied how many interviewees gave each response. The responses are displayed in **Figure 4** and are ranked – from highest to lowest – according to this overall tally. Each answer displayed also enumerates how many interviewees from each stakeholder group supplied the response.

**Figure 4: WPI's Roles & Responsibilities in the Integrated Photonics Ecosystem**

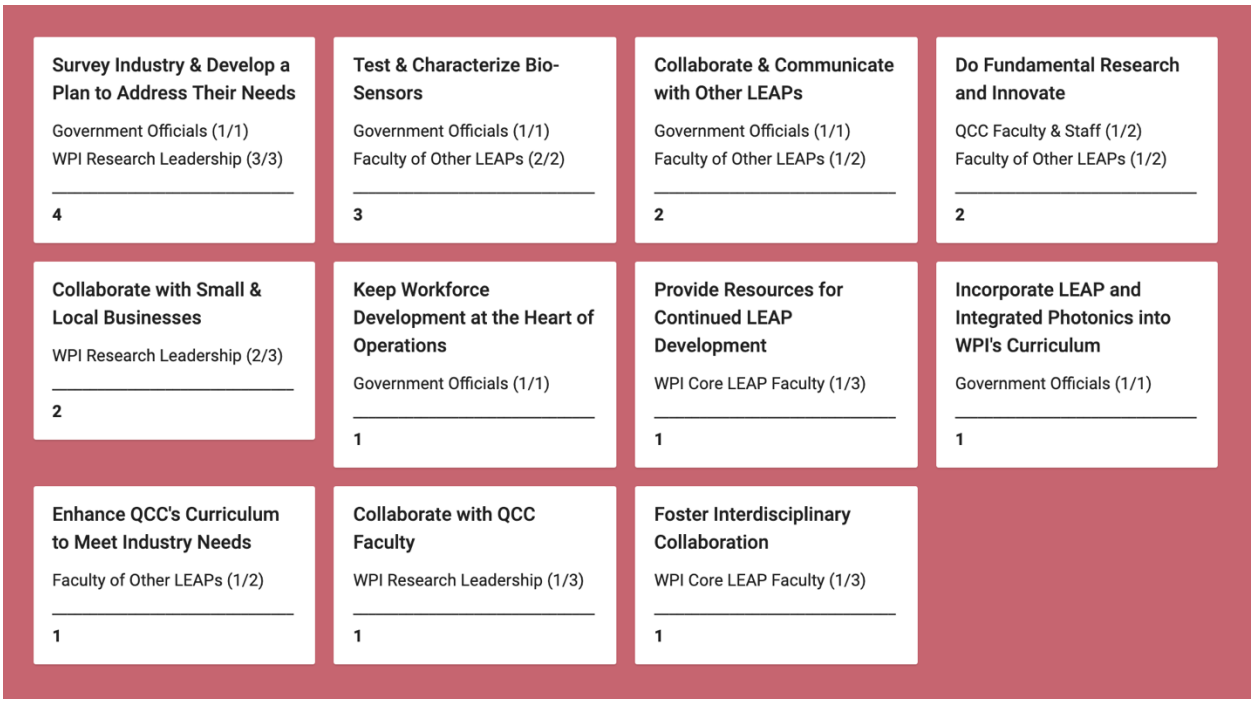

**Figure 4** displays the responses supplied by interviewees when asked about what the roles and responsibilities of WPI are in the integrated photonics ecosystem. The responses are ranked – from highest to lowest – according to the tallied number of stakeholders who supplied it. Each response also enumerates how many interviewees from each stakeholder group supplied the response.

Thus, in accordance with the aforementioned organization system, it can be seen in **Figure 4**, above, that WPI was tasked with the "Test & Characterization of Biosensors" by three interviewees: the government official that we interviewed and both of the faculty members from other LEAPs.

While we were unable to interview members of the industry and student stakeholder groups, the responses from the other stakeholder groups were all connected by one prevailing theme. As Ellen Piccioli – the Director of Manufacturing Innovation at WPI – first put it, WPI is "really in a unique position of being a catalyst for the integrated photonics ecosystem and industry in central Mass [Massachusetts]."

Individual responses, however, elucidated that WPI will need to take on a myriad of responsibilities and roles before they can truly spark growth in integrated photonics. According to the faculty of other LEAPs, these roles include testing and characterizing biosensors, communicating and collaborating with other LEAPs, and doing fundamental research. We found that the government official we interviewed also agreed with the former two roles yet went on to state that WPI has a responsibility to keep workforce development at the heart of LEAP @ WPI/QCC's operations. That same government official and all the WPI Research Leadership interviewees unanimously agreed that WPI needs to carefully survey and listen to industry so that LEAP @ WPI/QCC can effectively address their needs. We found this response especially important to highlight considering it resonates with the findings of Alwerfalli and Jawad (2015). Particularly, Alwerfalli and Jawad (2015) suggested that investment in long-term relationships that span academia-industry boundaries is a key step in the facilitation of a successful collaboration (p. 2166).

An important consequence arose as a result of the stakeholders' articulation of the individual roles and responsibilities that they expect WPI to assume. Namely, the stakeholders provided us with metrics through which the success of the integrated photonics ecosystem can be measured. For example, the suggestion that workforce development be kept at the heart of LEAP @ WPI/QCC's operations implies that a pipeline of skilled technicians, engineers, and scientists that are well-prepared to enter the integrated photonics workforce is indeed required to facilitate success in the integrated photonics ecosystem. During our interviews with stakeholders, Ellen Piccioli aptly summarized many of these metrics when discussing her vision for the future of integrated photonics. In her words:

> It's a very early time to engage in a new and growing field. … And the potential for big gains in research, in building that workforce, and…in really strong business growth for

> the industries that we're working with is huge.…There's just the excitement around the early engagement…the collaboration opportunities are something that really need to be highlighted.…With our stakeholders – whether it's in academia, whether it's an industry, the state and federal government entities – there's…opportunity for collaborations that are really going to produce outcomes.

Thus, the responses organized in **Figure 4**, above, are also indicative of the definitions used by each stakeholder group to assess the development of the integrated photonics ecosystem.

## 4.3 FINDING 3: COLLABORATION CHALLENGES STEM FROM STAKEHOLDER DIVERSITY.

Through reviewing the transcripts from the formative interviews with the stakeholders of LEAP @ WPI/QCC, we found that the reported challenges to effective collaboration shared a common origin: diversity. In addition to revealing the wide gamut of stakeholders discussed in Finding 1, interviewees also elucidated just how diverse the stakeholders are and outlined the challenges that have surfaced as a result of that diversity. The responses regarding such barriers to collaboration were organized in the same manner discussed in Finding 2 and are presented in **Figure 5**.

**Figure 5: Collaboration Challenges for LEAP @ WPI/QCC**

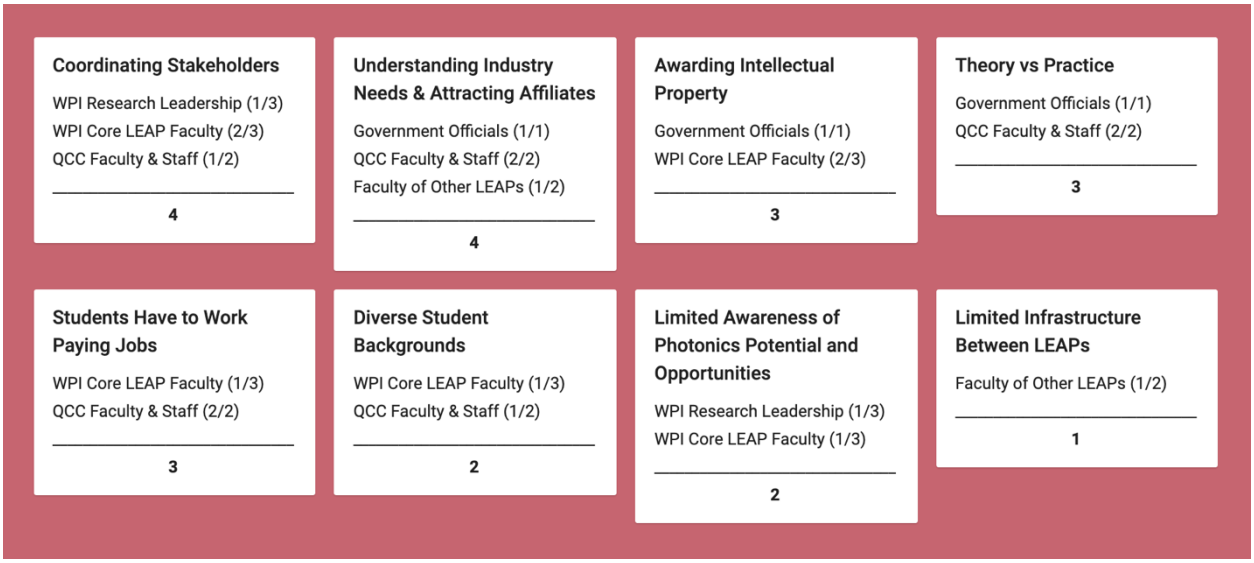


**Figure 5** displays the reported challenges to collaboration at LEAP @ WPI/QCC. The responses are ranked – from highest to lowest – according to the tallied number of stakeholders who supplied it. Each response also enumerates how many interviewees from each stakeholder group supplied the response.

## 4.4 FINDING 4: DIFFERENTIATED ENGAGEMENT METHODS INCREASE STAKEHOLDER PARTICIPATION.

In addition to finding that the collaboration challenges faced by LEAP @ WPI/QCC stakeholders stem from their diversity, we learned that differentiated engagement approaches can increase their participation.

The unifying theme among the responses – displayed in **Figure 6** – regarding the engagement of industry affiliates was that LEAP @ WPI/QCC needs to have a value proposition that is both visualizable and relevant to the current state and needs of the photonics industry. Notably, it was suggested by members of WPI's Research Leadership and Core LEAP Faculty that a demonstrator project be developed for presentation to potential industry collaborators. As Professor Pratap Rao – a WPI Core Faculty Member of LEAP @ WPI/QCC – explained, a device – such as a photonic sensor – needs to be collectively prototyped using all the equipment at LEAP @ WPI/QCC so that the faculty can say, "'Look at this. This is what we made. This is how it works.'" To Professor Rao, this is especially important considering most stakeholders "don't want to sit there and listen to…a talk about physics…They want to see what the actual product can do." This sentiment was echoed by Bogdan Vernescu – the Vice Provost for Research at WPI – when he cited the novelty of integrated photonics as a collaboration challenge and said, "you [LEAP @ WPI/QCC] need to explain why you collaborate" and convey what it is that photonics can do. According to Vice Provost Vernescu, even the former CEO of AIM Photonics has expressed the need of a "gadget" that could be shown to companies to make them say, "'Oh, this is integrated photonics?! Now I understand what it is!'"

**Figure 6: Methods for Engaging Industry Affiliates**

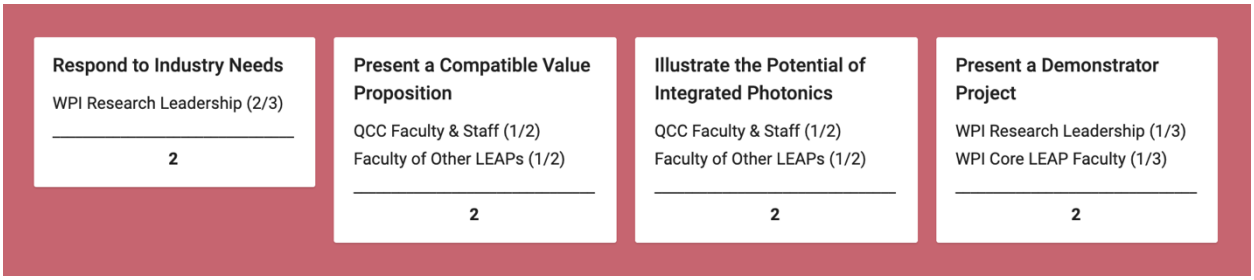


**Figure 6** displays the recommended methods for engaging industry affiliates of LEAP @ WPI/QCC. The responses are ranked – from highest to lowest – according to the tallied number of stakeholders who supplied it. Each response also enumerates how many interviewees from each stakeholder group supplied the response.

Our formative interviews with the stakeholders of LEAP @ WPI/QCC also yielded recommended methods for increasing student engagement and involvement in LEAP @ WPI/QCC. Such suggestions are displayed in **Figure 7**.

**Figure 7: Methods for Engaging Students**

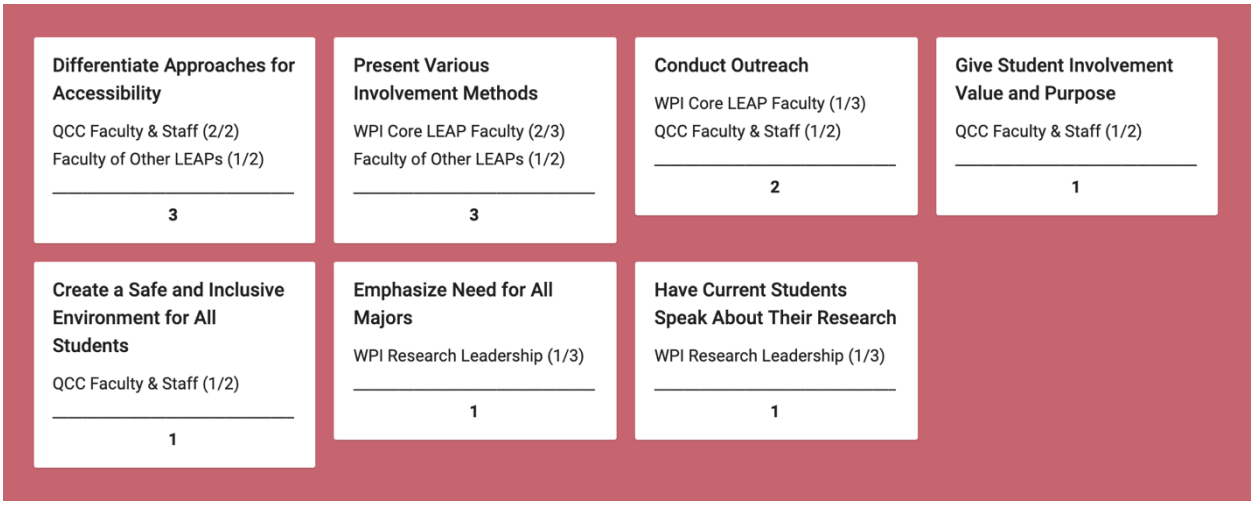


**Figure 7** displays the recommended methods for increasing student engagement and participation in LEAP @ WPI/QCC. The responses are ranked – from highest to lowest – according to the tallied number of stakeholders who supplied it. Each response also enumerates how many interviewees from each stakeholder group supplied the response.

The consensus among the interviewees was that involvement needs to be made as accessible as possible to all students. According to the QCC Faculty & Staff and Faculty of Other LEAPs, this means differentiated approaches should be used to reach different types of students – such as 2-year, 4-year, and graduate students. Professor Jacob Longacre of QCC, for example, said:

> I will do certain things that I would not have to do, or probably wouldn't do in a different environment. So, if I were teaching at WPI, how I would do things would be different. If I were teaching at the high school level, it would be different. And it's not just because...you're dealing with a different age group or anything else. It's how broad [of] a spectrum...you [are] dealing with and... the issues you're dealing with.

One such issue that Professor Longacre elaborated on was the fact that many of his community college students have to work full-time jobs while attending school.

In fact, it is issues like this that make it especially important – as indicated in **Figure 7** – that the value of involvement is made very clear and that multiple avenues for involvement are provided. Which is why Professor Lyubov Titova – another WPI Core Faculty Member of LEAP @ WPI/QCC – suggested that WPI students with heavy course loads and other obligations should simply shadow a graduate student in a lab for an hour or two a week so that they can slowly get acclimated and involved.

## 4.5 FINDING 5: THE WEB PAGES SHOULD ILLUSTRATE THE VALUE PROPOSITION.

Similar to the engagement methods for industry affiliates that were explored in Finding 4 are the stakeholder suggestions for the LEAP @ WPI/QCC web presence enhancements. Whether the suggestion was to illustrate the applications of integrated photonics or to make the equipment information more accessible, we found the responses all implied that the web pages should allow stakeholders to thoroughly visualize all aspects of the LEAP @ WPI/QCC value proposition.

**Figure 8: Enhancement Suggestions for the Web Pages**

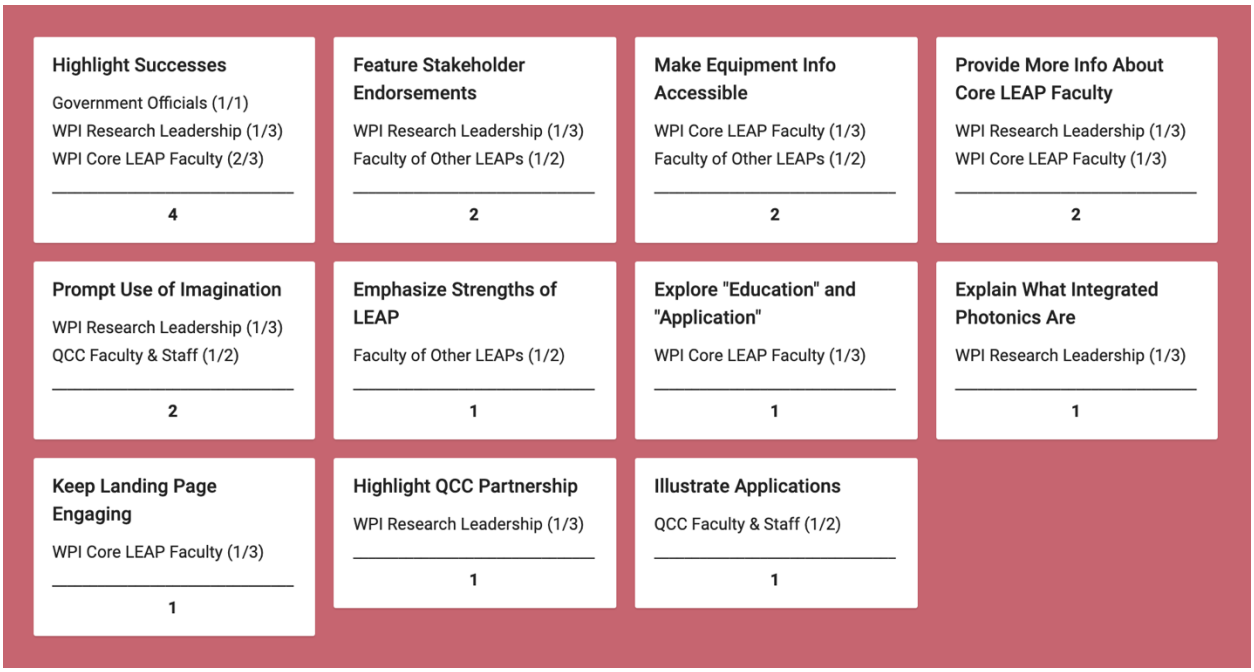


**Figure 8** outlines all of the suggestions that stakeholders made for the LEAP @ WPI/QCC webpages. The responses are ranked – from highest to lowest – according to the tallied number of stakeholders who supplied it. Each response also enumerates how many interviewees from each stakeholder group supplied the response.

Yet, despite the importance that was repeatedly assigned to the value proposition, we found that LEAP @ WPI/QCC does not – currently – have one. However, our analysis of the interviews and the preceding findings allowed us to articulate the following value proposition proposal:

> LEAP @ WPI/QCC is an open-access state-of-the-art center for the advancement of research and development within the central Massachusetts integrated photonics ecosystem. At the heart of the center's every operation, students, technicians, engineers, and scientists from all corners of the ecosystem continuously engage in interdisciplinary collaborative and educational efforts. As a result of these collaborations between individuals with complementary expertise, revolutionary integrated photonic biomedical

applications are routinely innovated, and the workforce pipeline for the ecosystem is consistently fueled and renewed. Consequently, LEAP @ WPI/QCC acts as catalyst for the unprecedented advancement of integrated photonics.

In the remainder of this section, we discuss the suggestions for how the LEAP @ WPI/QCC value proposition can be illustrated on the LEAP @ WPI/QCC web pages.

For example, we found that the most common recommendation spanned three stakeholder groups and suggested that the successes of LEAP @ WPI/QCC be highlighted on the web pages. Specific responses ranged from the suggestion to highlight the stories of successful LEAP @ WPI/QCC alumni to recommendations to build a repository of results. However, considering LEAP @ WPI/QCC is still being established, we were not able to incorporate these suggestions into our proposed framework (see **Appendix D**).

Nevertheless, we were able to incorporate many of the other suggestions into our proposal. For example, we took Professor Rao's advice and created side-by-side highlight boxes on the landing page that explore the education and application sides of the LEAP @ WPI/QCC mission. Similarly, to make information about the equipment more accessible, we converted the original "Laboratories and Facilities" page to a format that allowed the equipment lists and pictures to rotate on a carousel highlight box to limit the need for scrolling. We also included buttons that link stakeholders directly to more specific equipment information – such as manuals – and the equipment reservation portal. In an attempt to feature stakeholder endorsements, we incorporated scrolling quotes from the presidents of WPI and QCC on the "About LEAP" page and featured quotes from the core faculty members on the "Information for Industry Affiliates" page. To illustrate the applications of integrated photonics for potential industry affiliates, we also created a "Featured Application" widget on the industry affiliate page that summarizes and links to longer publications about the innovation occurring at LEAP @ WPI/QCC.

## 4.6 FINDING 6: THE INTRODUCTION VIDEO SHOULD ILLUSTRATE UNDERSTANDABLE VALUE PROPOSITIONS.

The formative interview process with the LEAP @ WPI/QCC stakeholders also allowed us to compile a set of suggestions for the landing page introduction video. Through careful analysis of the responses, we found that the mutual vision of the stakeholders was for the introduction video to illustrate and offer understandable explanations of the LEAP @ WPI/QCC value proposition. In accordance with this finding, the script guidelines that we developed (see **Appendix E**) concisely emphasize differentiated value propositions for each stakeholder, such as affordable application prototyping for industry affiliates. Furthermore, the modular storyboard that we created (see **Appendix E**) simultaneously illustrates the value propositions through the use of

engaging visuals, such as an infographic about the photonics development cycle. **Figure 9** displays the generalized recommendations for the introduction video that surfaced during our interviews with the LEAP @ WPI/QCC stakeholders.

**Figure 9: Introduction Video Suggestions**

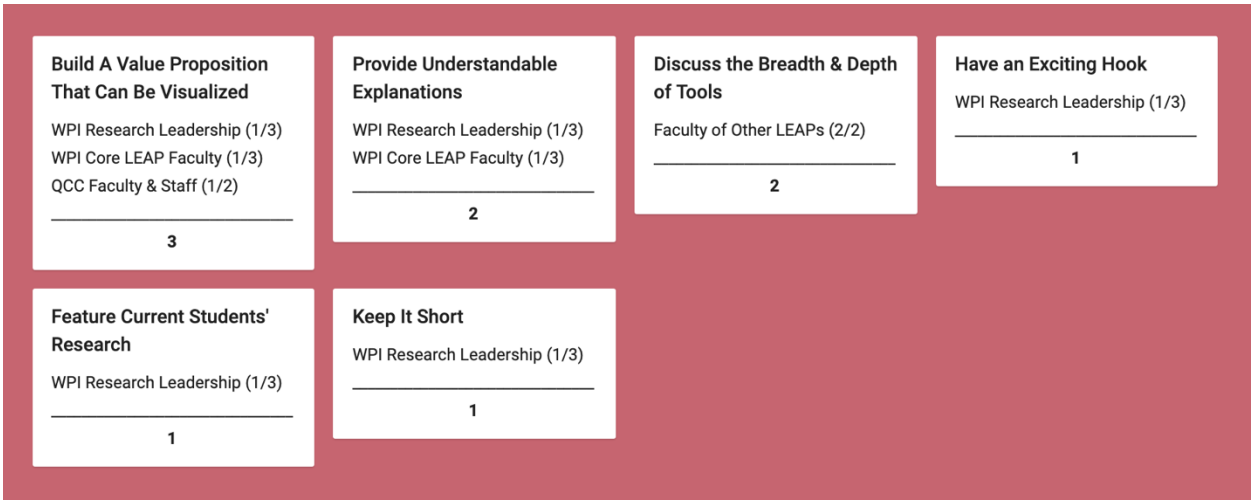


**Figure 9** displays the generalized recommendations for the introduction video that surfaced during our interviews with the LEAP @ WPI/QCC stakeholders. The responses are ranked – from highest to lowest – according to the tallied number of stakeholders who supplied it. Each response also enumerates how many interviewees from each stakeholder group supplied the response.

## 4.7 FINDING 7: DIVERSE STAKEHOLDERS REQUIRE SPECIALIZED MARKETING TACTICS.

To expand upon the recommendations cited in Findings 5 and 6, we conducted formative interviews with Andy Baron and Jillian Ferguson – who are members of the WPI Marketing Communications team – and found that collaborations composed of diverse stakeholders require specialized marketing and communication techniques. During the transcription analysis process, we organized the suggested techniques in a very similar manner to the processes used in Findings 2 through 6. However, instead of displaying stakeholder tallies with each response, we detail the backgrounds of the interviewees that supplied the response. Specifically, each best practice shown in **Figure 10** indicates whether it was provided by an interviewee with a background in marketing or a background in public relations (PR)/communications. For instance, interviewees well-versed in both PR/communications and marketing suggested that supporting visuals and context statements be used in the introduction video, whereas only the interviewee with a background in PR/communications suggested the promotion of student involvement in organizations related to LEAP @ WPI/QCC.

**Figure 10: Best Practices for Marketing LEAP @ WPI/QCC**

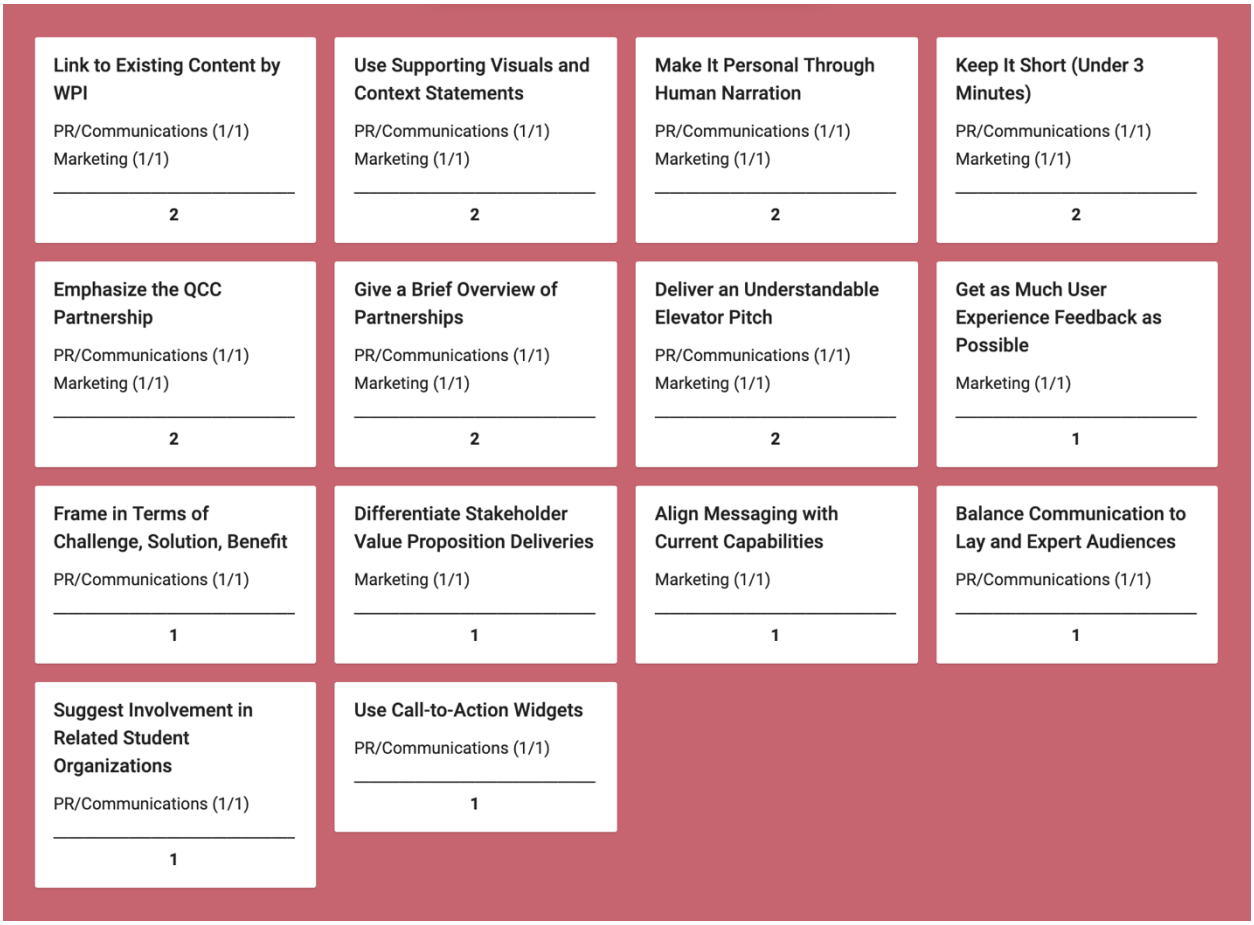


**Figure 10** outlines the techniques recommended by WPI Marketing Communications team members for the marketing of LEAP @ WPI/QCC. The responses are ranked – from highest to lowest – according to the tallied number of WPI Marketing Communications team members who supplied it. Each response also indicates the backgrounds of the WPI Marketing Communications interviewees who supplied the response.

A notable and unanimous suggestion that surfaced from the interviews with the WPI Marketing Communications team members is that the WPI-QCC partnership really needs to be highlighted in the LEAP @ WPI/QCC web pages and introduction video. According to Andy Baron – the Associate Director of Public Relations at WPI – the potential effects that the WPI-QCC partnership could have on the integrated photonics workforce warrant special emphasis. Namely, Baron called attention to the fact that WPI and QCC "…are invigorating the manufacturing sector.…[in that they're] creating career opportunities for young people – at WPI and Quinsigamond – [and]…retraining opportunities for people who are working in manufacturing right now but need a new skill set…[to] stay employed."

Along similar lines, Andy Baron recommended that the LEAP @ WPI/QCC introduction video be concepted "in terms of three areas: challenge, solution, and benefit." Particularly, Baron advised that the video be thought of "…in terms of explaining to people that 'photonics is helping to solve a whole variety of challenges today. It can make industries work better, collaborate better, [and] bring better products to the market.'"

After analyzing the aforementioned recommendations, as well as those outlined in **Figure 10**, we were able to organize the best practices according to whether they were for general use, implementation in our framework proposal, or incorporation into our modular storyboard. The resulting guide titled "Best Practices for Marketing LEAP @ WPI/QCC" (see **Appendix B**) was instrumental in our production of the proposed framework for the enhanced web pages, as well as the development of the modular introduction video script and storyboard. For example, to both give a brief overview of the partnerships involved in LEAP @ WPI/QCC and use supporting visuals in the introduction video, we created an infographic depicting the LEAP Network (see **Appendix C**). This infographic was then included in the modular storyboard, as well as featured on the proposed "About LEAP" web page. Similarly, the "Keep It Short (Under 3 Minutes)" guideline was adhered to through making the script and storyboard modular. Particularly, the future production team can choose from the various scenes we developed using these best practices to produce the 3-minute introduction video.

In our framework proposal for the new LEAP @ WPI/QCC webpages, we also made sure to differentiate the stakeholder value proposition deliveries by creating separate pages for students and industry affiliates. Additionally, we made frequent use of call-to-action widgets – such as buttons with featured links – throughout our framework so that the LEAP @ WPI/QCC stakeholders would find getting involved easy and welcomed.

## 4.8 FINDING 8: ADDITIONAL UX ENHANCEMENTS CAN BE MADE TO THE WEB PAGES.

In accordance with the best practices discussed in the previous finding, we conducted post-formative interviews with WPI community members who have backgrounds in involvement initiatives and user experience (UX). Through presenting our framework proposal for the LEAP @ WPI/QCC web pages to these individuals and analyzing their feedback, we found that our current proposal is proficient from a UX and engagement point of view. The specific feedback that we received detailing the things that we did well in the proposal is presented in **Figure 11**. The organization system for the data extracted from the post-formative interviews is the same as the one introduced in the previous finding; however, the reviewer's background is reported as being in either "User Experience," or "Involvement Initiatives".

**Figure 11: Things We Did Well**

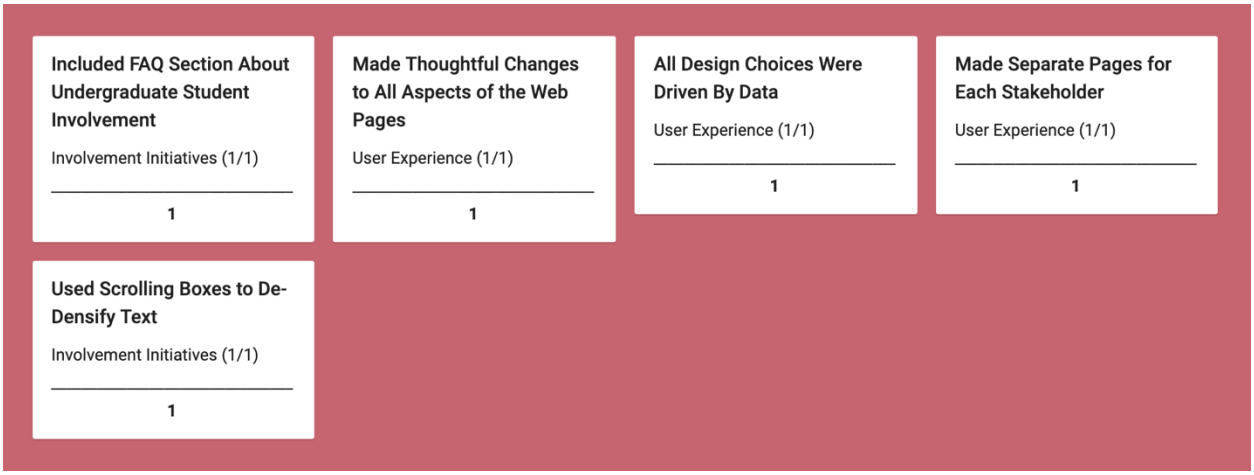


**Figure 11** presents the positive feedback that the framework proposal received during the post-formative interview process. The responses are ranked – from highest to lowest – according to the tallied number of reviewers who supplied it. Each response also indicates the backgrounds of the reviewers who supplied the response.

While it was found that favorable, data-driven changes were made to all aspects of the LEAP @ WPI/QCC webpages, the post-formative interviews also revealed that further steps can be taken to further enhance the user experience. One such suggestion is to continually test all proposed content on members of each stakeholder group. As per the founder and director of the User Experience and Decision Making (UXDM) Research Laboratory at WPI, Professor Soussan Djamasbi, major flaws in the text and infographics will be found by as little as three people. Once those flaws surface and are addressed, testing can resume again – this time with a larger group of people – to identify more nuanced flaws. This suggestion and the other recommendations for enhancing the UX of the LEAP @ WPI/QCC web pages are displayed in **Figure 12**.

**Figure 12: Suggestions to Further Improve Stakeholder Experience and Engagement**

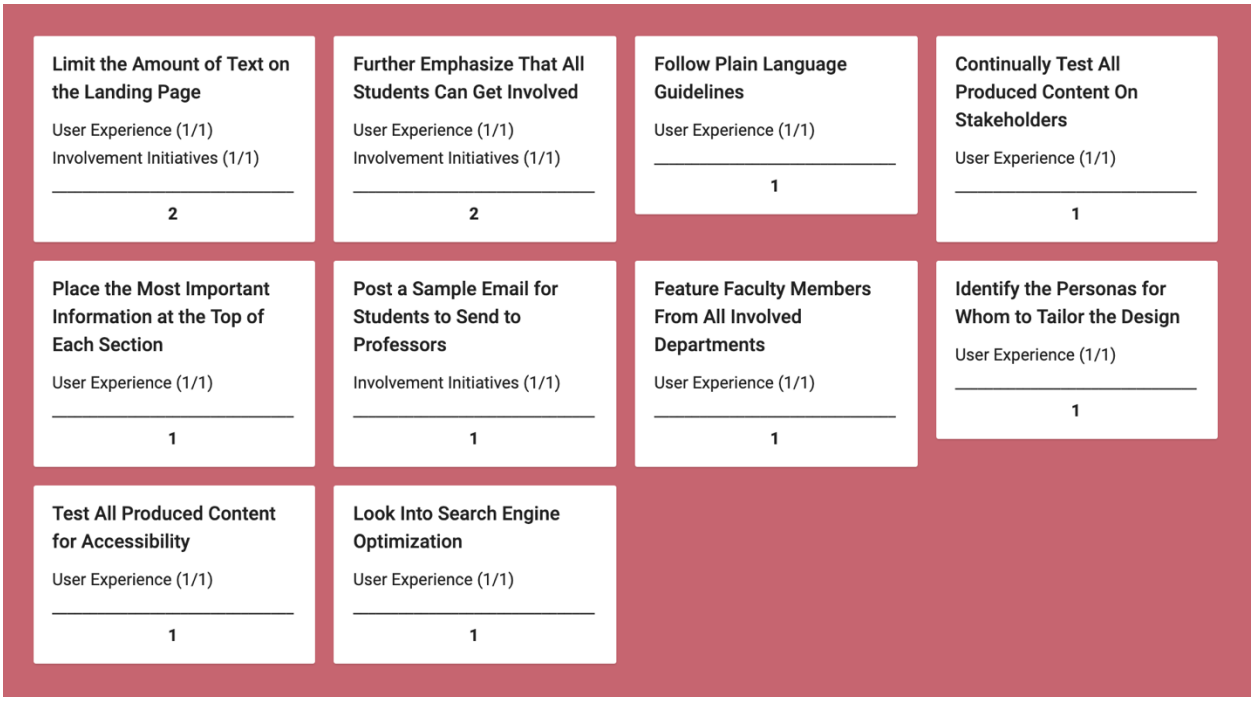


**Figure 12** displays the recommendations made regarding the next steps to take to further enhance the user experience of the LEAP @ WPI/QCC web pages and increase stakeholder engagement. The responses are ranked – from highest to lowest – according to the tallied number of reviewers who supplied it. Each response also indicates the backgrounds of the reviewers who supplied the response.

Similar to testing, it was highly recommended that the user experience with the text could be improved through following plain language guidelines. According to Professor Djamasbi, such guidelines lead to the simplification of text to the point that the reading level is brought down for increased processing speeds. Consequently, it is said by Djamasbi that the use of plain language "increases the engagement [of the stakeholder] with the site." In fact, in 2016, Djamasbi et al. published a paper – titled "Text Simplification and User Experience" – which explored a set of compiled plain language guidelines, provided examples of their implementation, and discussed the data collected regarding their effectiveness. **Figure 13**, below, displays the compiled plain language guidelines that were presented in Djamasbi et al.'s (2016) paper.

## Figure 13: Plain Language Guidelines

**Table 1: Plain Language Guidelines**

| Rules | |
|---|---|
| • Identify and write for your audience<br>• Avoid slang, jargon, colloquialisms, non-literal text<br>• Use short, simple words (no more than ~3 syllables)<br>• Use concrete, familiar words/combinations of words<br>• Use "must" instead of "shall" ("must not" vs. "shall not")<br>• Use an active voice, simple present tense<br>• Avoid weak verbs (def: a verb that is made past tense by adding -ed, -d, -t)<br>• Use parallel sentence structure<br>• Use positive terms (avoid "don't" or "didn't")<br>• Avoid multiple negatives ("don't forget to not…")<br>• Explain all acronyms/abbreviations and avoid if possible | • Write short sentences (20-25 words), be succinct<br>• Short paragraphs (no more than 150 words in 3-8 sentences)<br>• Use transition words in paragraphs (pointing words, echo links, explicit connectives)<br>• Check/use correct grammar and spelling<br>• Use "you" and other pronouns to speak to the reader<br>• Organize document chronologically<br>• Use lists<br>• Use tables to make complex material easier to understand<br>• Do not use ALL CAPS for emphasis<br>• Do not use underlining for emphasis<br>• Use bold and italics for emphasis |
| **Sources** | |
| • WebAIM, http://webaim.org/techniques/writing/<br>• WebAIM – WAVE, http://wave.webaim.org/cognitive<br>• Plain Language Association International, http://plainlanguagenetwork.org/plain-language/what-is-plain-language/<br>• Plain Language Action and Information Network, http://www.plainlanguage.gov/site/about.cfm<br>• U.S. Federal Plain Language Guidelines, http://www.plainlanguage.gov/howto/guidelines/FederalPLGuidelines/index.cfm | |

**Figure 13** displays the plain language guidelines that were compiled and presented in Djamasbi et al.'s 2016 paper titled, "Text Simplification and User Experience."

Image Source: Djamasbi, S., Rochford, J., DaBoll-Lavoie, A., Greff, T., Lally, J., & McAvoy, K. (2016). Text simplification and user experience. Lecture Notes in Computer Science, 9744, 285-295. https://doi.org/10.1007/978-3-319-39952-2_28

As previously mentioned, Djamasbi et al. (2016) also provided examples of how they used these plain language guidelines throughout their study of the impact text simplification had on user experience. **Figure 14**, as a result, depicts two such examples of how Djamasbi et al. (2016) simplified text found on various web pages using the guidelines presented in **Figure 13**.

**Figure 14: Example of Text Simplification Through Plain Language Guidelines**

**Original (A)**

Lux Level is a luxurious, in-theatre dining experience at select theatres. Movie-goers can indulge themselves with premium reserved-seating, in-seat dining throughout the show, as well as other special amenities. Each seat is equipped with a server call button so your server is always there when you need them. This truly is the finest movie-going experience available today.

**Simplified (A)**

Lux Level is a rare movie theatre that acts as a place where you can eat while you are watching your desired movie. If you hit the button that is on the seat, a waiter or waitress will come and serve you.

**Original (B)**

Welcome to Miniclip.com, the leading online games site, where you can play a huge range of free online games including action games, sports games, puzzle games, games for girls, mobile games, iPhone games, Android games, Windows Phone, games for kids, flash games and many more.

**Simplified (B)**

Miniclip.com offers a wide range of games for all users, including:

- Action
- Sports
- Puzzles
- Mobile games
    a. iPhone
    b. Android

- and more!

**Figure 14** illustrates how two passages – (A) and (B) – were simplified by Djamasbi et al. (2016) through the use of plain language guidelines.

Image Source: Djamasbi, S., Rochford, J., DaBoll-Lavoie, A., Greff, T., Lally, J., & McAvoy, K. (2016). Text simplification and user experience. Lecture Notes in Computer Science, 9744, 285-295. https://doi.org/10.1007/978-3-319-39952-2_28

Another suggestion that was proffered for increased stakeholder involvement is to post a sample email on the "Information for Students" web page that students can use to express their interest in a particular professor's research. Similarly, it was unanimously recommended that the framework and text be adjusted – especially on the landing page – to further emphasize in plain language that all students can get involved with LEAP @ WPI/QCC due to the interdisciplinary nature of the collaboration.

# 5. CONCLUSIONS & RECOMMENDATIONS

Throughout this chapter, we provide a brief summary of the key findings that surfaced during the formative and post-formative interview processes. Many of these findings lead directly to our provision of two types of recommendations. In accordance with our research objectives, the first set of recommendations outlines the steps that WPI can take to assume the roles and responsibilities expected of them by the integrated photonics ecosystem. We then trace out the recommended next steps for the continued study of how stakeholder engagement and participation in the Lab for Education & Application Prototypes (LEAP @ WPI/QCC) can be increased.

## 5.1 SUMMARY OF KEY FINDINGS

As a result of conducting numerous interviews, we were able to draw several conclusions regarding the LEAP @ WPI/QCC collaboration. Namely, we defined the roles and responsibilities of WPI in the integrated photonics ecosystem and determined that differentiated engagement approaches are necessary for collaborative success. Additionally, we found that specialized marketing techniques and close attention to user experience (UX) is required to increase stakeholder awareness of LEAP @ WPI/QCC.

### 5.1.1 ROLES & RESPONSIBILITIES OF WPI IN THE INTEGRATED PHOTONICS ECOSYSTEM

Upon analysis of stakeholder interviews, we concluded that the role of WPI in the integrated photonics ecosystem is to be a catalyst for innovative collaborations. Particularly, such collaborations should be highly interdisciplinary and span all stakeholder groups of LEAP @ WPI/QCC. The specific responsibilities of WPI within these interdisciplinary projects is to serve as fundamental researchers and innovators, as well as to test and characterize integrated photonic biosensors. Another responsibility that WPI has to the ecosystem is to keep workforce development at the heart of its operations through collaborating with QCC to incorporate integrated photonics into the curricula of both WPI and QCC.

### 5.1.2 COLLABORATIVE SUCCESS THROUGH DIFFERENTIATED ENGAGEMENT APPROACHES

Our interviews elucidated that LEAP @ WPI/QCC is composed of numerous, incredibly diverse stakeholders with very different backgrounds, experiences, needs, and goals. For example,

students from 2-year community colleges, 4-year undergraduate universities, and graduate programs are all involved with LEAP @ WPI/QCC despite their differing exposures to the rigorous mathematics used in theory and the hands-on knowledge gained through practice. Consequently, many faculty stakeholders claimed that various routes to involvement in LEAP @ WPI/QCC need to be presented. Furthermore, it was said that once students do get involved, faculty members must actively work to create a safe and inclusive environment where students can learn through differentiated approaches. Similar needs for differentiation were also expressed in regard to collaborations with industry affiliates. Specifically, it was suggested that the faculty and leadership of WPI need to deliberately invest time into understanding the diverse needs and business models of each partnering company – especially when it comes to intellectual property [IP]. As Farhad Vazehgoo – the Acting Director of Advanced Manufacturing Programs at MassTech Collaborative – succinctly summarized:

> Somebody is, for example, coming to test and validate some functionality or some capability. You need to disclose some amount of information. And that is, generally, the concern people have about working in a facility that is not their facility. And so, where does that information go? When you're dealing with a public university, or private university for that matter, there needs to be strict processes and procedures around how you take care of IP. How do you protect it? I think that one of the things that we need to make sure of is that we are very open about – or I should say open and vigorous about – how we protect their interest and the disclosure of their IP. I think that needs to be solved. The customer needs to feel safe, that their IP would be protected. And then they can say, "Okay. What kind of capability can I use in that facility?"

Consequently, our interviews also led us to conclude that differentiated approaches to engaging diverse stakeholders is critical to the facilitation of successful collaborations.

### 5.1.3 INCREASED AWARENESS THROUGH SPECIALIZED TECHNIQUES & ATTENTION TO UX

We found another consequence of stakeholder diversity to be that specialized marketing techniques and careful attention to UX is necessary for increased stakeholder awareness of LEAP @ WPI/QCC. Notably, a common theme among the recommendations for the web pages and introduction video was that the produced content should allow stakeholders to easily visualize all aspects of the LEAP @ WPI/QCC value proposition. For example, several stakeholders recommended that specific applications of integrated photonics at LEAP @ WPI/QCC be clearly illustrated and discussed to convey the value of the collaboration. Similarly, it was suggested that the collaboration's name – Lab for Education & Application Prototypes – be decomposed and explored in terms of the education and application prototyping aspects of the LEAP @ WPI/QCC mission statement. From a UX perspective, it was also recommended that

Plain Language Guidelines be utilized to enhance the comprehensibility of the text presented on the new LEAP @ WPI/QCC web pages.

## 5.2 FULFILLING ROLES & RESPONSIBILITIES: RECOMMENDATIONS FOR WPI

As discussed in the previous chapter and above summary, the stakeholders of LEAP @ WPI/QCC indicated that the overall role of WPI in the integrated photonics ecosystem is to be a catalyst for innovative collaborations. Of the more specific roles and responsibilities that WPI was charged with to realize this grand task, the ones that are already being fulfilled are summarized as follows:

- Conduct fundamental research in the area of photonics
- Develop innovative applications of integrated photonics
- Test and characterize integrated photonic biosensors

Nevertheless, to further facilitate the success of the LEAP @ WPI/QCC collaboration and greater integrated photonics ecosystem, the stakeholders of LEAP @ WPI/QCC challenge WPI to:

- Foster interdisciplinary collaboration and communication across the LEAP network
- Facilitate informed collaboration with integrated photonics companies of all sizes
- Incorporate LEAP @ WPI/QCC and integrated photonics into WPI and QCC curricula
- Keep workforce development at the heart of LEAP @ WPI/QCC operations
- Provide resources for the continued development of LEAP @ WPI/QCC

In the remainder of this section, we provide recommendations – many of which were supplied by stakeholders during the formative interview process – as to how WPI can effectuate these five additional roles and responsibilities.

### 5.2.1 FOSTER INTERDISCIPLINARY COLLABORATION & COMMUNICATION ACROSS THE LEAP NETWORK

Throughout the formative interview process, numerous suggestions were provided regarding how WPI can nurture communication and collaboration across the LEAP network. For example,

it was suggested by Professor Ed Deveney of Bridgewater State University (BSU) that the biosensors prototyped at LEAP @ WPI/QCC be sent to the LEAP at BSU and Stonehill College for further testing and characterization. Anu Agarwal – the leader of the Massachusetts Institute of Technology (MIT) LEAP and larger LEAP network – also provided a myriad of suggestions as to how collaboration can be fostered between the LEAPs. One such recommendation was for WPI to have student project groups aid in the development of a centralized, state-run website for the LEAP network. Dr. Agarwal's vision – which is shared by several other stakeholders – is to have a site that specifies the strengths of each LEAP, details the distribution of equipment across the network, and connects visitors to each individual LEAP website. Another recommendation offered by Dr. Agarwal was for WPI to help establish a consortium of industry affiliates that is shared by all the LEAPs in the network so that individual LEAPs are not in competition with one another for industry partnerships. Lastly, in an effort to foster open communication within the LEAP network, Acting Director Vazehgoo recommended that the findings of our project be presented to the rest of the LEAP network at their next quarterly meeting.

### 5.2.2 FACILITATE INFORMED COLLABORATION WITH INTEGRATED PHOTONICS COMPANIES OF ALL SIZES

As discussed in the previous chapter, WPI needs to carefully survey the integrated photonics industry in order to facilitate truly informed collaborations with companies. Particularly, stakeholders recommended that great effort be put into identifying the needs of each company so that said needs can be addressed by LEAP @ WPI/QCC through individualized plans. In fact, members of WPI Research Leadership emphasized that WPI should strive to establish relationships with local start-ups and small companies and work with them to identify how integrated photonics could be incorporated into their business models. Similarly, Acting Director Vazehgoo suggested that, initially, LEAP @ WPI/QCC may need to consider partnering with companies from the general photonics industry due to the fact that the integrated photonics industry is still very new. Furthermore, Vazehgoo indicated that this survey process could result in the realization that additional industry affiliates could be persuaded to collaborate if, for example, one more specific piece of equipment was available at LEAP @ WPI/QCC.

### 5.2.3 INCORPORATE LEAP @ WPI/QCC & INTEGRATED PHOTONICS INTO WPI & QCC CURRICULA

Given that education is a pivotal part of the LEAP @ WPI/QCC mission statement, several stakeholders of the collaboration expressed expectations that integrated photonics and LEAP be incorporated into the course work and teachings at WPI and QCC. To enact such integration in a meaningful way, Dr. Agarwal counseled that WPI should meticulously survey industry to discern

the precise needs of integrated photonics companies. It was then advised by Dr. Agarwal that WPI and QCC collaborate to tailor existing curricula to meet said needs. Several faculty stakeholders across the LEAP network similarly recommended that the WPI Core LEAP Faculty continue to engage in co-teaching endeavors with QCC Faculty. To do so effectively, Adrienne Linnell – Program Administrator of STEM Initiatives at QCC – indicated that WPI and QCC faculty would have to work together to find a delicate balance between the rigorous theory intrinsic in discussions of photonics and the practical applications quintessential for workforce development. From an outreach and involvement perspective, Jillian Ferguson of the WPI Marketing Communications team suggested that WPI faculty routinely encourage students to get involved through talking about their research and student participation at the end of lectures. Along these lines, Andy Baron - another member of the WPI Marketing Communications team - suggested that the faculty affiliated with LEAP @ WPI/QCC form a network that hosts webinars for students to learn more about integrated photonics and opportunities for involvement.

### 5.2.4 KEEP WORKFORCE DEVELOPMENT AT THE HEART OF LEAP @ WPI/QCC OPERATIONS

In terms of maintaining the workforce development efforts of LEAP @ WPI/QCC, many stakeholders indicated that WPI should collaborate with QCC to develop a certificate program. According to Acting Director Vazehgoo, it is crucial that the certificate program be developed using techniques and equipment that are compatible with common industry practices.

Many stakeholders advised, once again, that WPI canvas the integrated photonics industry to identify the types of training modules that the certificate program should encompass. In harmony with such advice, Dr. Agarwal recommended that WPI host Boot Camps that concentrate on the integrated photonic techniques used to prototype biosensors due to the situation of LEAP @ WPI/QCC in the heart of Worcester's burgeoning biomedical industry.

### 5.2.5 PROVIDE RESOURCES FOR THE CONTINUED DEVELOPMENT OF LEAP @ WPI/QCC

On the account of Professor Liu, a WPI Core LEAP Faculty member, one of the most influential things that WPI can do to facilitate long-lasting success of LEAP @ WPI/QCC is to continually allocate resources to the collaboration. Namely, Professor Liu suggested that the mission of LEAP @ WPI/QCC will only be sustainable if internal funding and supportive policies for projects and outreach are provided. Professor Liu also cited access to WPI's historic industry connections as a key resource for the nurturing of future industry collaborations.

## 5.3 INCREASING ENGAGEMENT & PARTICIPATION: RECOMMENDATIONS FOR FUTURE STUDIES

While we explored a myriad of routes through which WPI can catalyze innovative collaborations in the previous section, this section outlines recommendations for future studies regarding LEAP @ WPI/QCC involvement initiatives. Many of the recommendations that we provide are direct results of our conversations with the LEAP @ WPI/QCC stakeholders, as well as the post-formative interviews that we conducted. Such recommendations for the continuation of our research objectives fall into three main categories:

1. Recommendations for Future Enhancements to the LEAP @ WPI/QCC Web Pages
2. Recommendations for the Production of the LEAP @ WPI/QCC Introduction Video
3. General Recommendations for Additional LEAP @ WPI/QCC Marketing Endeavors

In the remainder of this chapter, we detail the specific suggestions pertaining to each of the aforementioned categories.

### 5.3.1 RECOMMENDATIONS FOR FUTURE ENHANCEMENTS TO THE LEAP @ WPI/QCC WEB PAGES

Perhaps the most important recommendations for the continued enhancement of the LEAP @ WPI/QCC web pages are the ones that surfaced during our post-formative interviews. In fact, the number one suggestion that we can offer for future studies is to pay very close attention to the UX and engagement recommendations discussed in the previous chapter. Specifically, we highly recommend heeding the advice Professor Djamasbi – a leading UX expert – gave regarding the usage of plain language guidelines. As discussed in the previous chapter (see Finding 9), adherence to such text simplification guidelines results in increased stakeholder comprehension of presented content, and thus, increased stakeholder engagement. Professor Djamasbi also suggested that a future student project could focus on testing the framework we developed (see **Appendix D**) with members of each stakeholder group in order to identify and address flaws in the user experience. Another meaningful study that Professor Djamasbi proposed is for students to research search engine optimization and apply their findings to increase the amount of traffic the LEAP @ WPI/QCC web pages receive. For students who choose to pursue such projects, we strongly advise reaching out to Professor Djamasbi at the very beginning of the project for additional guidance.

Notable suggestions pertaining to increased student involvement also arose from the post-formative interviews. Particularly, Ally Salvino, a Student Assistant to the Office of Undergraduate Research at WPI, recommended that a sample email to a faculty member of

LEAP @ WPI/QCC be included on the "Information for Students" page. Such a template would serve as a non-intimidating way for students to express their interest in getting involved in LEAP @ WPI/QCC and said faculty member's research. Another recommendation that Salvino and Professor Djamasbi both made was for additional emphasis to be put on the fact that LEAP @ WPI/QCC is a highly interdisciplinary collaboration in which any student can get involved. Specifically, Professor Djamasbi suggested that such a fact be prominently featured on the framework's landing page.

Many stakeholders of the collaboration also offered compelling suggestions for the framework during the formative interviews that we conducted. However, most of the suggestions made could not – yet – be implemented due to the fact that LEAP @ WPI/QCC is still being established. One such recommendation is to build a widget into the framework for the web pages that continuously scrolls through success stories. Professors Pratap Rao and Lyubov Titova specifically recommended the inclusion of student profiles and success stories. Another metric of success that Professor Titova suggested for future implementation is a Repository of Results, which would feature publications, patents, and press releases affiliated with the LEAP @ WPI/QCC collaboration.

Other web page framework recommendations that are not contingent upon such results include our suggestion to build a Frequently Asked Questions (FAQ) widget about getting involved in LEAP @ WPI/QCC as a community college student. This FAQ would serve as a companion to the FAQ for undergraduate students that we already proposed. Professor Rao also pitched the concept of compiling comprehensive information regarding the equipment at LEAP @ WPI/QCC. Principally, Professor Rao envisions stakeholders being able to access PDFs that list both the specifications and rates for each piece of equipment. Lastly, it was recommended by Jillian Ferguson and Professor Titova that short videos featuring each lab space and lab group affiliated with LEAP @ WPI/QCC be produced and embedded in the web pages. The consensus was that such videos should emphasize how the spaces and lab groups are facilitating the development of integrated photonics applications.

### 5.3.2 RECOMMENDATIONS FOR THE PRODUCTION OF THE LEAP @ WPI/QCC INTRODUCTION VIDEO

In terms of producing the LEAP @ WPI/QCC introduction video, we recommend that our modular storyboard and script guidelines (see **Appendix E**) be used as a starting point for the final storyboard and script. Specifically, the modular storyboard and script proposes numerous scene options that can be chosen from to construct an engaging introduction video that is under three minutes in duration. We recommend that great care be taken throughout the production process to continue to provide visualizable and palatable value propositions. Additionally, our formative interviews suggest that discussions of student research should be weaved into the

script. More important in the script, however, is the development and delivery of an understandable elevator pitch that is framed in terms of the challenges tackled by LEAP @ WPI/QCC, the specific solutions that integrated photonics can provide, and the benefits of using integrated photonics applications as a solution. Finally, we recommend that our marketing best practices guide (see **Appendix B**) be consistently consulted at every step of the production process.

### 5.3.3 GENERAL RECOMMENDATIONS FOR FUTURE LEAP @ WPI/QCC MARKETING ENDEAVORS

Aside from the suggestions for the new web pages and introduction video, there are a couple of general recommendations for future LEAP @ WPI/QCC marketing endeavors. Namely, Suzanne Weekes – the Associate Dean for Undergraduate Studies at WPI, ad interim – indicated that it may be beneficial to commission WPI Marketing Communications to pen success stories about the work being done – especially by undergraduate students – at LEAP @ WPI/QCC. Similarly, Jillian Ferguson suggested that the involvement initiatives of LEAP @ WPI/QCC could be bolstered through advertising the collaboration on the countless screens in common spaces across the WPI campus.

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# APPENDIX A: QUESTIONS FOR FORMATIVE INTERVIEWS

## A.1 CONSENT QUESTIONS ASKED BEFORE EACH INTERVIEW TO MINIMIZE RISK TO INTERVIEWEES

1. Before we start, do we have your permission to record the audio of this conversation for transcription purposes?

2. Would you be willing to allow us to include any relevant quotes in our final IQP paper?

## A.2 QUESTIONS FOR WPI RESEARCH LEADERSHIP

1. What part of the LEAP mission and its goals excites you the most?
2. In your opinion, what can WPI do to ensure the success of LEAP partnerships and the larger integrated photonics ecosystem?
3. As a field of advanced manufacturing, photonic development often requires workforce training and re-training. Consequently, one of the focuses of LEAP @ WPI/QCC is workforce development. How do you envision the achievement of this goal?
    a. What do you want to see in the training programs that are developed?
        i. Do you think that online training modules could be beneficial?
4. Two prominent features of the industry affiliate tiers are direct access to student talent and student project involvement.
    a. How should LEAP @ WPI/QCC effectively recruit such talent and promote their participation?
        i. What channels currently exist for students to initiate contact, especially for MQPs? How can we expand upon these channels?
5. Photonics is proving to be a cross-disciplinary field with high potential. How do you picture LEAP coordinating cross-disciplinary projects within WPI?
    a. Will the offices and lab spaces within LEAP continue the traditional organization of Gateway Park? Particularly, do you think faculty should continue to be grouped by area of research?
    b. How should LEAP groups collaborate with other labs to improve the workflow dynamic and rate of innovation?
    c. How should LEAP groups go about increasing industry participation from sectors that are not traditionally associated with photonics?
6. One of the pillars upon which LEAP is built is that of industry affiliate participation.
    a. What does it take to effectively coordinate the goals of WPI research efforts, and the innovation needs of industry affiliates?
7. Oftentimes, academia and industry have different motivations. Specifically, university research groups tend to focus on research publications, whereas companies tend to focus

on the generation of patents and intellectual property. How are these needs balanced within MQPs?

8. Does the WPI Research Solution Institute currently facilitate the pairing of industry sponsors with IQPs, MQPs, and GQPs?
    a. What advice can you offer in regard to this facilitation within LEAP @ WPI/QCC?
9. If there were three things about LEAP @ WPI/QCC that you could ensure every stakeholder knew, what would they be?
10. Is there anything else that you think we should know about the LEAP @ WPI/QCC partnership that we haven't yet addressed?
11. Who else do you recommend that we reach out to?

## A.3 GENERAL QUESTIONS FOR WPI CORE LEAP FACULTY

1. What part of the LEAP mission and its goals excites you the most?
2. What pieces of equipment are you most looking forward to having access to?
3. Historically, what have been the biggest obstacles encountered in your research?
    a. Can LEAP @ WPI/QCC make a difference in those areas?
4. In your opinion, what can WPI do to ensure the success of LEAP partnerships and the larger integrated photonics ecosystem?
5. Two prominent features of the industry affiliate tiers are direct access to student talent and student project involvement.
    a. How should LEAP @ WPI/QCC effectively recruit such talent and promote their participation?
        i. What channels currently exist for students to initiate contact, especially for MQPs? How can we expand upon these channels?
6. What advice can you offer to students who are interested in getting involved with the research and projects at LEAP?
    a. Are there procedures in place for student involvement?
    b. Who should students contact for more information?
7. One of the pillars upon which LEAP is built is that of industry affiliate participation.
    a. What does it take to effectively coordinate the goals of WPI research efforts, and the innovation needs of industry affiliates?
8. Oftentimes, academia and industry have different motivations. Specifically, university research groups tend to focus on research publications, whereas companies tend to focus on the generation of patents and intellectual property. How are these needs balanced within MQPs?
9. What specific types of website content do you feel are most effective at increasing publicity?

    a. What types of content would you include if you were enhancing the LEAP @ WPI/QCC web pages?
10. If there were three things about LEAP @ WPI/QCC that you could ensure every stakeholder knew, what would they be?
11. Is there anything else that you think we should know about the LEAP @ WPI/QCC partnership that we haven't yet addressed?
12. Who else do you recommend that we reach out to?

## A.4 GENERAL QUESTIONS FOR QCC FACULTY & STAFF

1. What are the primary goals and missions of QCC for the Worcester LEAP?
    a. How do you plan to meet these goals?
    b. What have been the greatest challenges in establishing the Worcester LEAP and getting it up and running? What are you doing to overcome those obstacles?
2. What are QCC's key areas of research at the Worcester LEAP?
3. What does QCC do to ensure the success of the Worcester LEAP partnerships and the larger integrated photonics ecosystem?
4. Oftentimes, academia and industry have different motivations. Specifically, university research groups tend to focus on research publications, whereas companies tend to focus on the generation of patents and intellectual property. How are these needs balanced within the Worcester LEAP?
5. How does QCC go about recruiting student talent for the Worcester LEAP? Is there a procedure in place that enables interested students to get involved?
6. What is the framework in place for workforce development at QCC? What training programs are being developed and are any already in place?
    a. Do you think that online training modules could be beneficial?
7. Does QCC engage in K-12 outreach?
    a. If so, what have you found to be most effective and engaging for the students?
8. If there were three things about QCC's involvement in the Worcester LEAP that you could ensure every stakeholder knew, what would they be?
9. Is there anything else that you think we should know about QCC and its involvement in the Worcester LEAP that we haven't yet addressed?
10. Who else do you recommend that we reach out to?

## A.5 GENERAL QUESTIONS FOR FACULTY FROM OTHER INSTITUTIONS WITH LEAPS

1. What are the primary goals and missions of your institution's LEAP?
    a. How do you plan to meet these goals?
    b. What have been the greatest challenges in establishing your institution's LEAP and getting it up and running? What are you doing to overcome those obstacles?
2. What are the key areas of research at your institution's LEAP?
3. What companies are affiliated with your institution's LEAP?
    a. Does your institution's LEAP have a tiered membership program? If so, can you describe the different membership levels?
    b. What does your institution find most effective for attracting potential industry affiliates?
    c. How does your institution's LEAP go about increasing industry participation from sectors that are not traditionally associated with photonics?
4. What does your institution do to ensure the success of your LEAP partnerships and the larger integrated photonics ecosystem?
5. Oftentimes, academia and industry have different motivations. Specifically, university research groups tend to focus on research publications, whereas companies tend to focus on the generation of patents and intellectual property. How are these needs balanced within your institution's LEAP?
6. How does your institution go about recruiting student talent for their LEAP? Is there a procedure in place that enables interested students to get involved?
7. What is the framework in place for workforce development at your institution's LEAP? What training programs are being developed and are any already in place?
    a. Do you think that online training modules could be beneficial?
8. Does your institution's LEAP engage in K-12 outreach?
    a. If so, what have you found to be most effective and engaging for the students?
9. If there were three things about your institution's LEAP that you could ensure every stakeholder knew, what would they be?
10. Is there anything else that you think we should know about your institution's LEAP that we haven't yet addressed?
11. Who else do you recommend that we reach out to?

## A.6 GENERAL QUESTIONS FOR EMPLOYEES OF INDUSTRY AFFILIATES

1. What does your role as (interviewee title) at (interviewee company) entail?
    a. What are the biggest challenges – or pain points – that you encounter in this position?

2. Has your company ever been involved in a partnership with an academic institution?
    a. What did that partnership entail?
    b. What attracted your company to join that partnership?
    c. What were the biggest challenges - or pain points - that your company experienced during the partnership?
    d. What was the most valuable part of the partnership for your company?
3. What is the hiring process like at your company?
    a. What is your biggest challenge in recruiting and hiring applicants?
    b. Where do you generally search for talent to fill vacant positions?
        i. Would you ever consider searching for talent through your partnerships with academic institutions?
4. What types of manufacturing methods and areas of technologies has your company identified as "high potential?"
5. What would it take for your company to get involved in such "high potential" fields?
    a. Would you ever consider a partnership with an academic institution for the training and equipment necessary to get involved?
6. In your opinion, what can WPI do to ensure the success of LEAP partnerships and the larger integrated photonics ecosystem?
7. One of the pillars upon which LEAP is built is that of industry affiliate participation.
    a. What types of marketing strategies are most effective at attracting the attention of your company?
        i. Do you think that it is possible to encourage industry participation through an introduction video and specific website functions?
8. What specific types of website content do you feel are most effective at increasing publicity?
    a. What types of content would you include if you were enhancing the LEAP @ WPI/QCC web pages?
9. Is there anything else that you think we should know about effectively marketing a multi-organization collaboration that we haven't yet addressed?
10. Who else do you recommend that we reach out to?

## A.7 GENERAL QUESTIONS FOR GOVERNMENT OFFICIALS

1. In what capacity is your organization or agency involved with LEAP @ WPI/QCC and the rest of the LEAP network?
2. In your opinion, what can WPI and its partners do to ensure the success of the LEAP collaborations and the larger integrated photonics ecosystem?
3. One of the pillars upon which LEAP is built is that of industry affiliate participation.

    a. What types of marketing strategies do you think – or have you found – to be most effective at attracting the attention of industry partners?
        i. Do you think that it is possible to encourage industry participation through an introduction video and specific website functions?
4. What should universities be mindful of when reaching out to companies through consortiums and LEAP?
5. What specific types of website content do you feel are most effective at increasing publicity?
    a. What types of web content would you include if you were to promote the LEAP @ WPI/QCC collaboration?
6. If there were three things about LEAP @ WPI/QCC and the LEAP network that you could ensure every stakeholder knew, what would they be?
7. Is there anything else that you think we should know about effectively facilitating a multi-organization collaboration that we haven't yet addressed?
8. Who else do you recommend that we reach out to?

## A.8 GENERAL QUESTIONS FOR WPI MARKETING COMMUNICATIONS STAFF

1. In your opinion, what can WPI do to ensure the success of LEAP partnerships and the larger integrated photonics ecosystem?
2. Two prominent features of the industry affiliate tiers are direct access to student talent and student project involvement.
    a. How can LEAP @ WPI/QCC effectively recruit such student talent and promote their participation?
3. One of the pillars upon which LEAP is built is that of industry affiliate participation.
    a. What does it take to effectively attract potential affiliates?
        i. How can we do this through an introduction video and specific website functions?
4. What specific types of website content are effective at increasing publicity?
    a. What types of content would you include if you were enhancing the LEAP @ WPI/QCC web pages?
5. Is there anything else that you think we should know about effectively marketing a multi-organization collaboration that we haven't yet addressed?
6. Who else do you recommend that we reach out to?

# APPENDIX B: BEST PRACTICES FOR MARKETING LEAP @ WPI/QCC

As Indicated by Members of the WPI Marketing Communications Team

## B.1 GENERAL SUGGESTIONS

**Align Messaging with Current Capabilities**

- Use messaging that is aligned only with what is currently possible given that LEAP @ WPI/QCC is not yet fully established.

**Give a Brief Overview of the Partnerships**

- Briefly mention the organizations that make LEAP @ WPI/QCC possible, but do not dwell on them.

**Emphasize the QCC Partnership**

- QCC has a long history with and a large role in the LEAP @WPI/QCC collaboration – highlight it!

## B.2 WEBPAGE RECOMMENDATIONS

**Incorporate Call-to-Action Widgets**

- Make getting involved appealing through the use of call-to-action widgets – such as buttons – that use very intentional and inviting language.

**Link to Existing Content**

- Connect webpage visitors to content related to LEAP @ WPI/QCC that has already been published by WPI Marketing Communications.

**Feature Related Student Organizations**

- Highlight WPI student organizations that can foster interest in optics and photonics and facilitate involvement in LEAP @ WPI/QCC.

## B.3 INTRODUCTION VIDEO RECOMMENDATIONS

**Explore Challenges, Solutions & Benefits**

- Frame the video in terms of current challenges in the world, the solutions to the challenges that integrated photonics can provide, and the benefits of using integrated photonics as a solution.

**Deliver an Understandable Elevator Pitch**

- Formulate and deliver a compelling elevator pitch that makes the value proposition of LEAP @ WPI/QCC easy to understand.

**Keep It Short**

- Strive to keep the video under three minutes in length to maximize viewer engagement and comprehension.

**Provide Context**

- Use supporting visuals (B-roll) and context statements with statistics to make it easy for stakeholders to see the value in the information that is presented.

**Make It Personal**

- Have a human – as opposed to a robot – narrate the video to make it more personal and engaging to the audience. Strongly consider having someone who is actively involved in LEAP @ WPI/QCC do the narration.

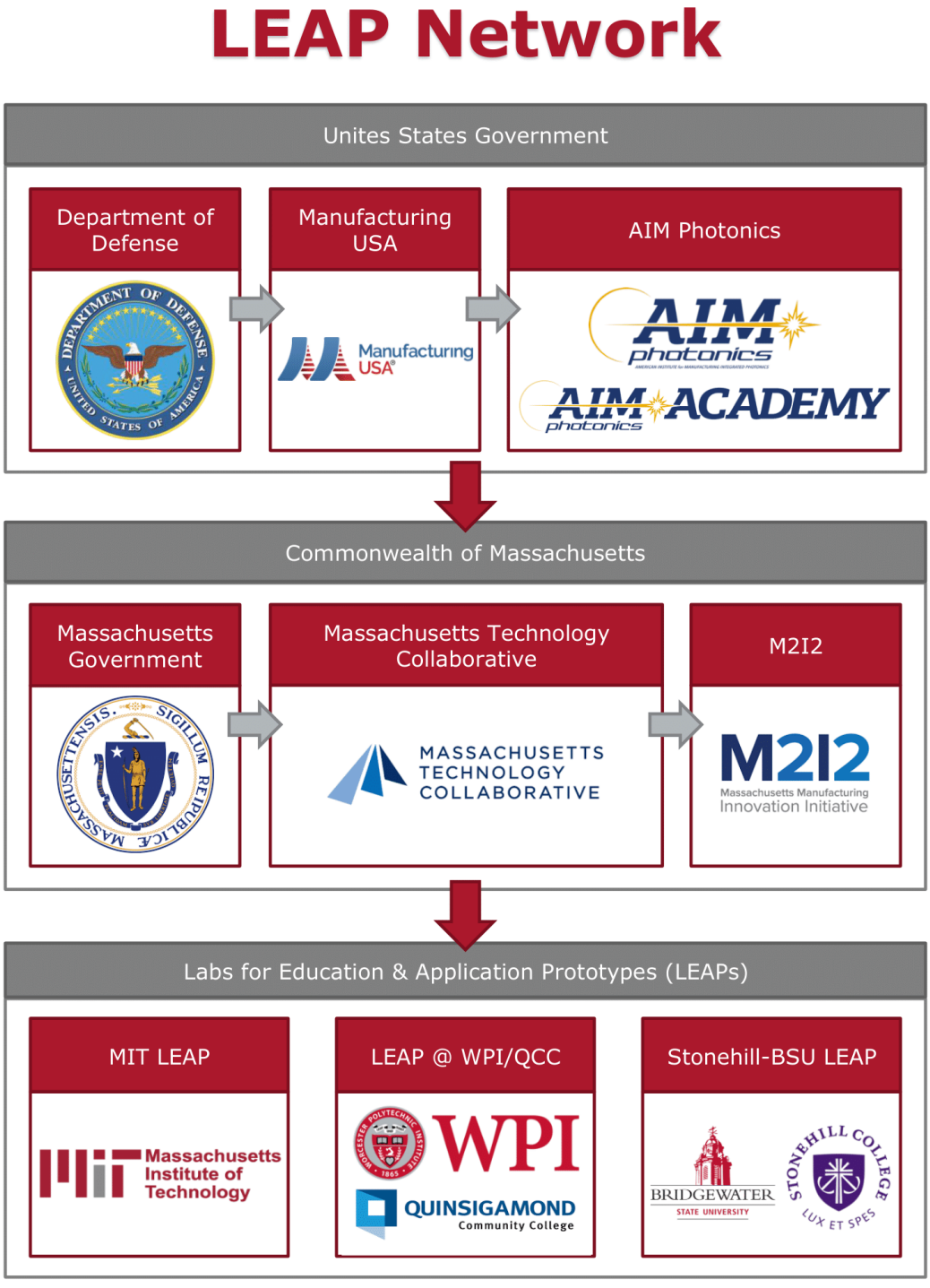
**Make It Accessible**

- Find a balanced communication method that allows both experts and lay audiences to understand the content that is presented.

**Differentiate the Delivery**

- Individually address and deliver a value proposition that is tailored to each stakeholder group.

# APPENDIX C: LEAP NETWORK INFOGRAPHIC



# APPENDIX D: FRAMEWORK PROPOSAL FOR LEAP @ WPI/QCC WEB PAGES

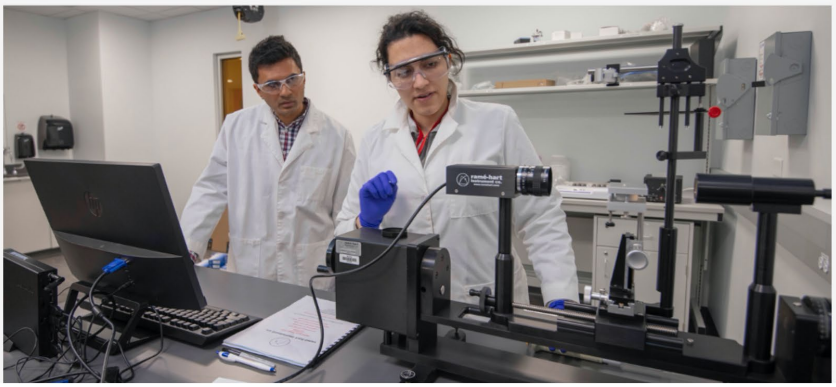
## D.1 LANDING PAGE – LAB FOR EDUCATION & APPLICATION PROTOTYPES

MENU ☰ Worcester Polytechnic Institute SEARCH

••• → RESEARCH → CORE RESEARCH FACILITIES → LAB FOR EDUCATION & APPLICATION PROTOTYPES

CORE RESEARCH FACILITIES

### Lab for Education & Application Prototypes



Imagine a device that could enter the bloodstream and extract a single cell for an early and rapid diagnosis of cancer. Imagine a device that could analyze the quality of an apple without even breaking the skin of the fruit.

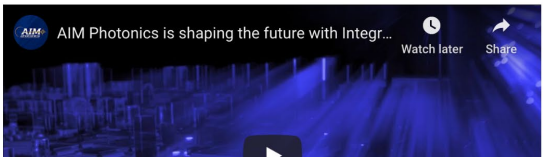
Imagine a place where experts from industry, government, and academia could collaborate without barriers and develop these devices for mass production.

Such a place exists.

Worcester Polytechnic Institute (WPI) and Quinsigamond Community College (QCC) have partnered together to establish the Lab for Education & Application Prototypes (LEAP @ WPI/QCC). LEAP @ WPI/QCC is located at WPI's Gateway Park and features state-of-the-art equipment that will help prototype these world-changing integrated photonic devices, as well as develop the workforce needed to manufacture them.

The video below:

- Offers an introduction to photonics and the integrated photonics ecosystem,
- Discusses the government agencies that have made LEAP @WPI/QCC a reality,
- Explores the capabilities and missions of LEAP @ WPI/QCC.




← Core Research Facilities

**Lab for Education & Application Prototypes**

About LEAP @ WPI/QCC

Laboratories and Facilities

Information for Students

Information for Industry Affiliates

Meet the Team

**CONTACT**

**Location:**
50 Prescott Street (Gateway Park II)
**Phone:** +1-508-831-6298
leap@wpi.edu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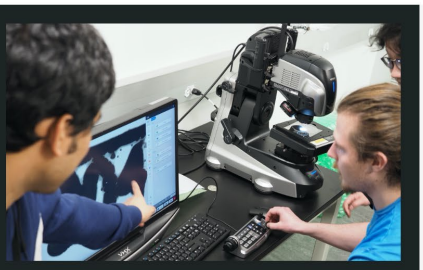


## A Lab for Education

WPI's long-standing collaborations with industry and QCC's trusted history of workforce development put LEAP @ WPI/QCC in a unique position to reinvigorate the integrated photonics workforce. LEAP @ WPI/QCC is committed to building a pipeline of highly-skilled workers that are prepared to excel in the advanced manufacturing of integrated photonic devices.

> LEARN ABOUT THE LEAP MISSION

## A Lab for Application Prototypes

Theory and Practice: the motto of WPI. The co-location of faculty from fundamental and applied disciplines embody that motto and enable LEAP @ WPI/QCC to produce prototypes of integrated photonic devices that will meet the needs of both industry and society.

> LEARN ABOUT THE LABS AND FACILITIES

## Daily Herd Q&A

Douglas Petkie, head of WPI's Department of Physics, describes the promise of integrated photonics and how the partnership between WPI and QCC will strengthen the industry in Central Massachusetts.

> LASER-FOCUSED ON PHOTONICS

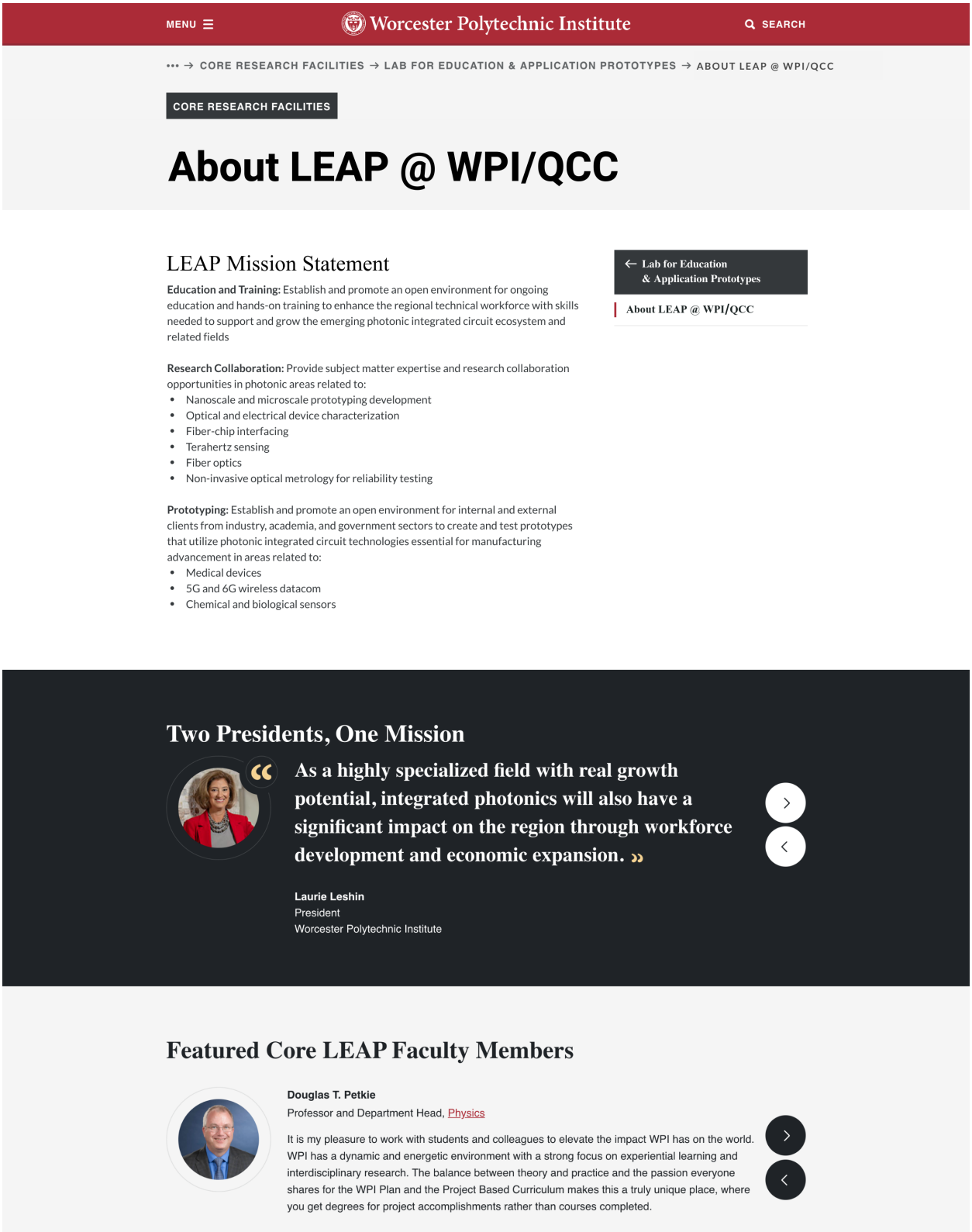


## Daily Herd Q&A

Douglas Petkie, head of WPI's Department of Physics, describes the promise of integrated photonics and how the partnership between WPI and QCC will strengthen the industry in Central Massachusetts.

> LASER-FOCUSED ON PHOTONICS

## D.2 ABOUT LEAP



## Featured Core LEAP Faculty Members

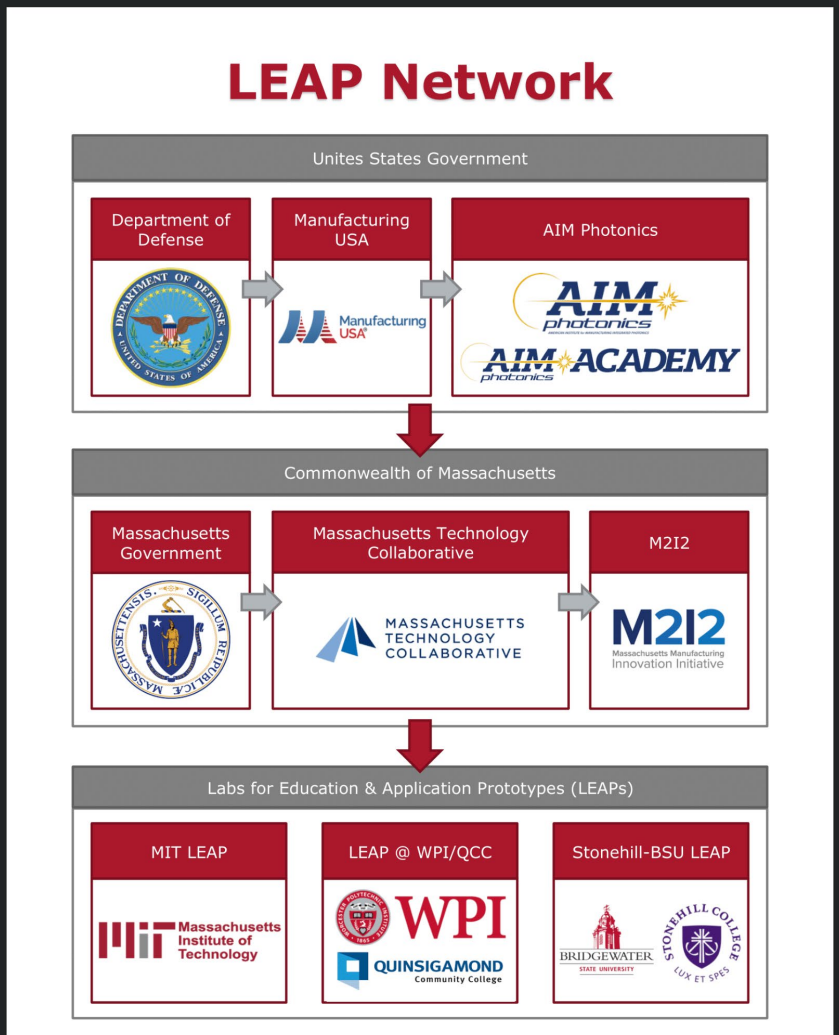
**Douglas T. Petkie**

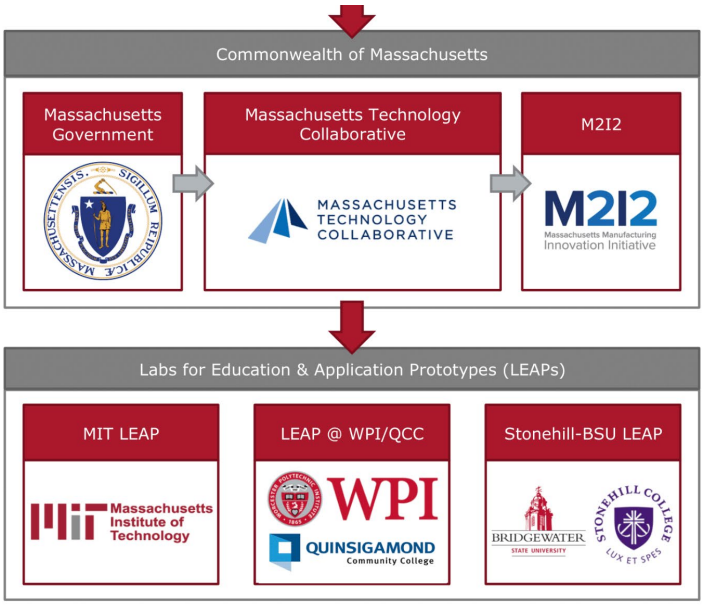
Professor and Department Head, Physics

It is my pleasure to work with students and colleagues to elevate the impact WPI has on the world. WPI has a dynamic and energetic environment with a strong focus on experiential learning and interdisciplinary research. The balance between theory and practice and the passion everyone shares for the WPI Plan and the Project Based Curriculum makes this a truly unique place, where you get degrees for project accomplishments rather than courses completed.

› READ MORE

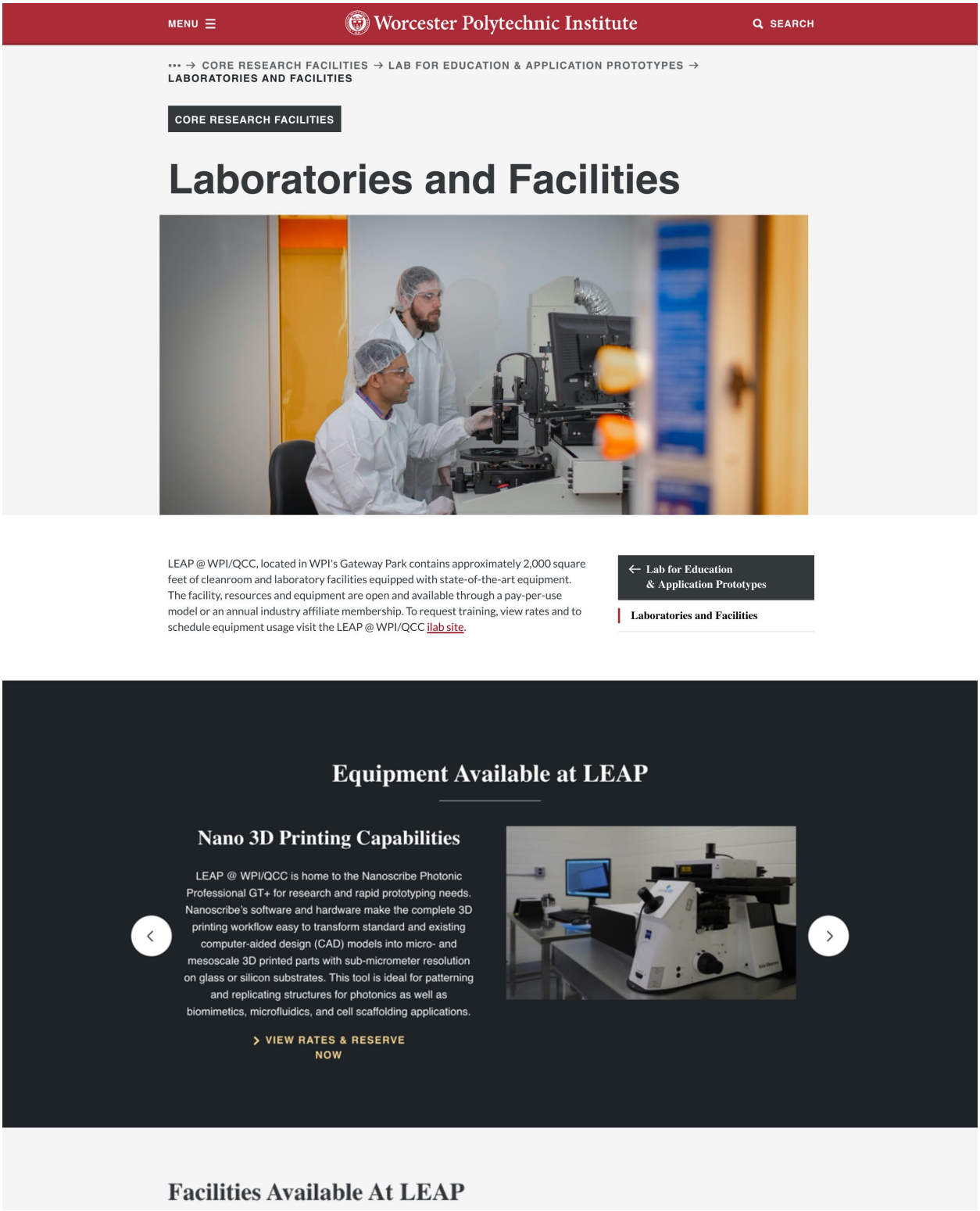
## The LEAP Network






*The LEAP Network is supported by the Commonwealth of Massachusetts' Government, who is in partnership with the Federal Government. Each government tier uses arrows to illustrate the hierarchies within that level of government. For example, it is shown in the Federal Government tier that the Department of Defense oversees the Manufacturing USA Initiative, which oversees AIM Photonics and AIM Photonics Academy. There are no arrows that relate the three LEAPs because there are independent of one another.*

## D.3 LABORATORIES AND FACILITIES



## Facilities Available At LEAP

*Teaching Lab & Classroom*

VISIT ILAB NOW

DOWNLOAD EQUIPMENT & RATES PDF

INTERESTED? CONTACT US!



### WPI in the World

GLOBAL PROJECTS PROGRAM

## D.4 INFORMATION FOR STUDENTS

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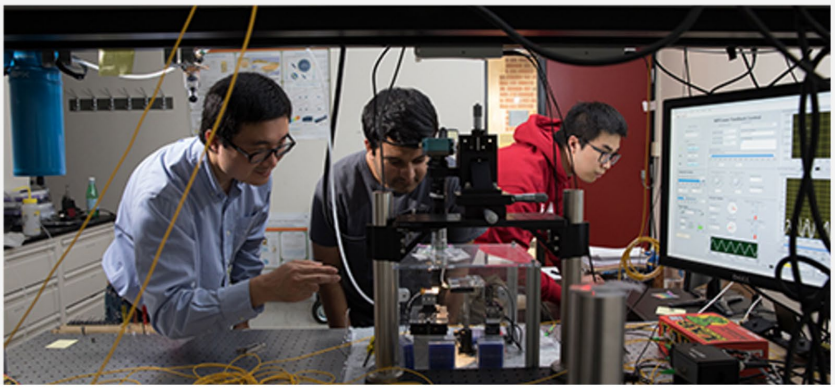
••• → CORE RESEARCH FACILITIES → LAB FOR EDUCATION & APPLICATION PROTOTYPES → INFORMATION FOR STUDENTS

CORE RESEARCH FACILITIES

# Information for Students



### Calling ALL Students

"Education": It's in our name and its at the core of our mission. Thus, students - ALL students - are at the heart of LEAP @ WPI/QCC as well. The field of integrated photonics is unbelievably interdisciplinary, which means there is an opportunity for everyone to get involved. Even if photonics "isn't your major." Research in any capacity and in any major is highly rewarding and something that students should get involved in as soon as possible. To learn more about how to get involved NOW, explore the links, quotes, and FAQ sections below!

← Lab for Education & Application Prototypes

Information for Students

MEET THE FACULTY & EXPLORE THEIR RESEARCH

HAVE A QUESTION? CONTACT US!

### Undergraduate Involvement: Frequently Asked Questions

**Why should I get involved in research at LEAP?**

There are many reasons to get involved in research at LEAP! Involvement allows you to:

- Bridge the gap between the theory taught at WPI and the technical skills necessary in industry
- Gain research experience that can prepare you for a more meaningful MQP
- Learn skills that will bolster your resume and future applications
- Network with Industry Affiliates and faculty from the larger LEAP network

**What majors are able to participate in LEAP research?**

**When can I get involved in LEAP?**

**What is the best way to get involved in LEAP?**

**How can I learn about the research taking place at LEAP?**


## Interested in LEAP? Take Initiative and Get Involved.

**If you see an opportunity, you have to speak up. You have to take initiative to talk to people... So, if you want to get involved in research, you should talk to professors.**

**Yuxiang (Shawn) Liu**
Core LEAP Faculty Member

## Start Networking Today: Student Chapters Related to LEAP

### Society of Physics Students (SPS)

The WPI Chapter of the Society of Physics Students strives to unite all students who are interested in physics, regardless of their major. Members of SPS are routinely presented with opportunities to explore their research and career interests. This includes networking with other students and professors who are passionate about physics and its applications. Student members can also expect to tour research labs on campus and participate in experiment and equipment demonstrations.

> LEARN MORE ABOUT THE WPI SPS

# D.5 INFORMATION FOR INDUSTRY AFFILIATES

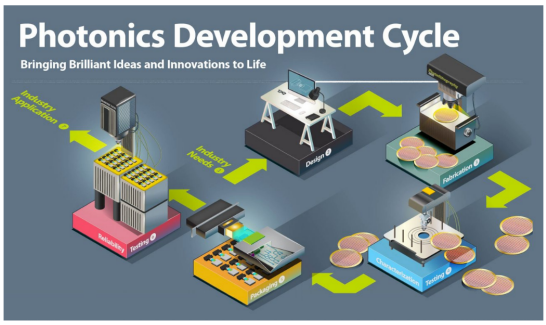
MENU ☰ Worcester Polytechnic Institute SEARCH

••• → CORE RESEARCH FACILITIES → LAB FOR EDUCATION & APPLICATION PROTOTYPES → INFORMATION FOR INDUSTRY AFFILIATES

CORE RESEARCH FACILITIES

## Information for Industry Affiliates

### Feuling the Photonics Development Cycle Through Industry Partnerships




LEAP @ WPI/QCC is committed to collaborating with industry affiliates to accelerate the growth of integrated photonics. From developing training opportunities and certificate programs to application prototyping with state-of-the-art equipment, LEAP is prioritizing the needs of industry in everything it does. Even the advanced manufacturing techniques employed at LEAP are highly-compatible with those used at the AIM Photonics Facilities in Upstate New York. Thus, industry affiliates of LEAP have the unique opportunity to economically-prototype integrated photonic products before embarking on the journey to mass-production.

From small start-ups in Worcester to established corporations, LEAP's highly-flexible membership model allows us to work with companies of any size to identify how integrated photonics can best be incorporated into their business model.

← Lab for Education & Application Prototypes

Information for Industry Affiliates

**Tiered-Membership: A Flexible Approach to Supporting Industry Affiliates**

LEAP @ WPI/QCC is actively supporting the growth of the integrated photonics rapid prototyping and manufacturing sector in Central Massachusetts. Possible Industry Affiliate membership benefits include:

- Usage of laboratory and cleanroom facilities
- Opportunities to engage with experts at the forefront of integrated photonics and related technology sectors
- New distribution channels to promote company products and services
- Access to student talent (AS/BS/MS/Ph.D.) to fulfill hiring needs and for potential project collaboration

For more information about LEAP @ WPI/QCC Industry Affiliate memberships, please contact LEAP@wpi.edu

DISCOVER THE INSTRUMENTS AVAILABLE

LEARN MORE ABOUT BECOMING AN AFFILIATE

MEET THE FACULTY AND EXPLORE THEIR RESEARCH

DISCOVER THE INSTRUMENTS AVAILABLE

LEARN MORE ABOUT BECOMING AN AFFILIATE

MEET THE FACULTY AND EXPLORE THEIR RESEARCH

## Complementary Expertise at the Forefront of Integrated Photonics Innovation

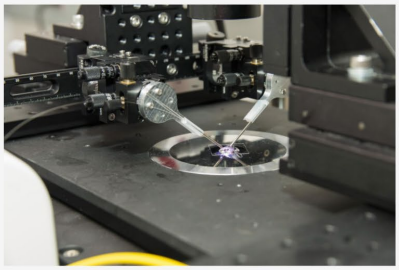
"It's about integrating medicine with engineering, leveraging scientific discoveries for new applications, identifying benefits for community stakeholders, and understanding the impact on society. »

**Douglas Petkie**
Director of LEAP @ WPI/QCC

## Featured Application: Lensless Optical Tweezers Small Enough to Enter the Bloodstream

Learn about how Core LEAP Faculty Member Yuxiang "Shawn" Liu and his fellow researchers have paved the way to incorporate optical tweezers on a lab-on-chip the size of a postage stamp.

> WPI RESEARCHERS TAKING OPTICAL DEVICE OUT OF THE LAB AND INTO THE CLINIC TO DETECT CANCER AT ITS EARLIEST STAGES



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Ph: 508-831-5000




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## D.6 MEET THE TEAM

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••• → CORE RESEARCH FACILITIES → LAB FOR EDUCATION & APPLICATION PROTOTYPES → MEET THE TEAM

RESEARCH PARTNERSHIPS

# Meet the Team

**Douglas T. Petkie**
Department Head and Professor, Physics
Director of Laboratory for Education and Application Prototypes (LEAP)
WPI

**Cosme Furlong Vazquez**
Professor, Mechanical Engineering
WPI

**Yuxiang (Shawn) Liu**
Assistant Professor, Mechanical Engineering
WPI

**Lyubov Titova**
Assistant Professor, Physics
WPI

**Pratap Rao**
Assistant Professor, Mechanical Engineering
WPI

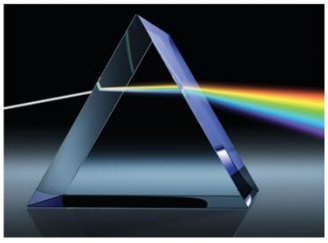
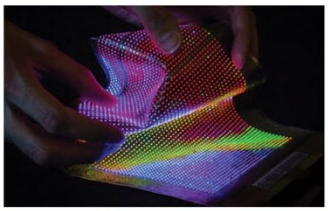
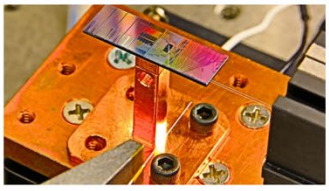
**Ellen Piccioli**
Director of Manufacturing Innovation
WPI

**James Eakin**
Technical Operations Manager, LEAP
WPI

| | |
|---|---|
| | Technical Operations Manager, LEAP<br>WPI |
|  | **Jacob Longacre**<br>Assistant Professor, Electronics Engineering Technology & Photonics<br>Quinsigamond Community College |
|  | **James W. Heffernan**<br>Professor, Electronics Engineering Technology/ Coordinator of the Electronics Engineering Technology Programs<br>Quinsigamond Community College |
|  | **Damian Kieran**<br>Associate Professor, Manufacturing Technology<br>Quinsigamond Community College |
|  | **Lee Duerden**<br>Assistant Professor, Manufacturing Technology/ Coordinator of Manufacturing Technology Programs<br>Quinsigamond Community College |
| | **Hao Loi**<br>Professor, Computer Science/ Coordinator of Computer Science Programs<br>Quinsigamond Community College |
| | **Nicholas Bold**<br>Advanced Manufacturing & Digital Fabrication Learning Resources Manager<br>Quinsigamond Community College |

# APPENDIX E: MODULAR STORYBOARD & SCRIPT GUIDELINES

## LEAP @ WPI/QCC Introduction Video
### Modular Storyboard & Script Guidelines

| Scene | Example Visuals | Visual Guidelines | Script Guidelines |
|---|---|---|---|
| **Scene 1: Introduction to Photonics** |  <br>  | Hook the audience's attention by showing footage of photonics technology.<br><br>Examples:<br>• Daily life scenarios<br>• The WPI Gordon Library prism showing the refraction of light<br>• Animation of light propagating through space<br>• Lasers, sunlight, gamma rays | Start with a grand perspective and then narrow down to:<br>• Photonics is a field where the properties of traveling light are researched and used in new applications<br>• Photonics is a solution looking for a problem to solve<br>• Photonics is the next generation technology<br>• Photonics has advantages over classic electronics |
| **Scene 2: Introduction to Integrated Photonics** |  <br>  | A brief transition from general depictions of light to the manipulation of light in photonics applications.<br><br>Examples:<br>• Waveguides, sensors, transistors and modulators<br>• Researchers handling optical components<br>• Resonant mass antenna<br>• LEAP's photonic biosensors<br>• LEAP's Lab-on-Chip<br>• LEAP's flexible electronics | Briefly explain what photonics is and how photonics is applied at the fundamental level. For example, talk about:<br>• Trapping light, redirecting light, and using light as sensing medium<br>• Specific examples of why a particular property of light is related to the application of photonics technology<br>  ○ Example: Amplitude change of a photonic biosensor implies mass change of a substrate |

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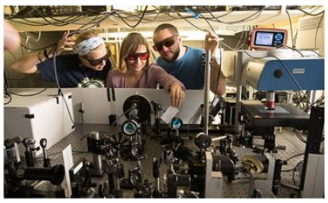
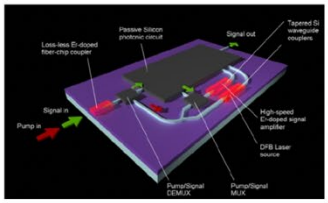
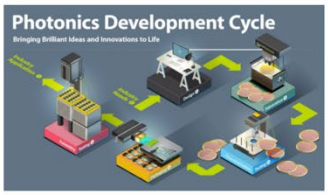
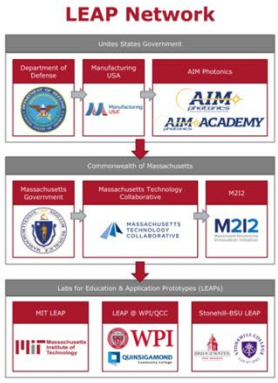
| **Scene 3: Introduction to Photonic Integrated Circuits** |  <br>  | Illustrate what Photonic Integrated Circuits (PICs) look like and the applications of PICs.<br><br>Examples:<br>• Photos of PICs<br>• PIC components diagrams<br>• Related application photos<br>  ○ Data center<br>  ○ Telecommunication<br>  ○ Photonic biosensors<br>  ○ LIDAR<br>  ○ Autonomous driving<br>  ○ Food safety | Explain that a PIC integrates individual function units and allows them to communicate to perform an overall task. Then talk about applications like:<br>• Real-time in vivo monitoring systems<br>• Increasing overall data processing rates |
| **Scene 4: Integrated Photonics – The Next Advanced Manufacturing Frontier** |  <br>  | Briefly illustrate important aspects of Manufacturing USA and AIM Photonics.<br><br>Feature:<br>• Logos<br>• Photonics development cycle infographic<br>• Images from the AIM Foundries<br>  ○ Especially photos with people that depict the manufacturing process and environment | Very briefly discuss Manufacturing USA and the AIM Photonics initiative.<br><br>Explore:<br>• Manufacturing USA goals<br>• AIM Photonics goals<br>• Photonics Development Cycle<br>• AIM Foundries |
| **Scene 5: Overview of the LEAP Network** |  | Explore the LEAP Network infographic.<br><br>Be sure to:<br>• Picture the hierarchy<br>• Zoom in and out to better focus on each component of the central Massachusetts photonics ecosystem | Introduce the LEAP initiative and link the LEAPs back to the photonics development cycle. Then explain what the LEAP network is and talk about the functions of the organizations involved.<br><br>Specifically highlight:<br>• WPI's sensors development and biomedical application<br>• BSU and QCC's technician training, test and characterization<br>• MIT's chip packaging<br>• Potential future collaborations |

| | | | |
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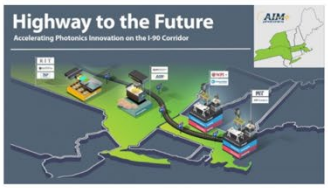
| **Scene 6: Introduction to LEAP @ WPI/QCC** |  <br>  | Introduce LEAP @ WPI/QCC through footage of the interior and exterior of LEAP. Especially feature:<br>• A virtual tour of LEAP<br>• Students and professors interacting<br>• Faculty members talking and collaborating<br>• Equipment that is actively being used | Talk about the LEAP @ WPI/QCC collaboration.<br><br>Incorporate:<br>• The LEAP @ WPI/QCC Mission Statement<br>  ○ Education<br>  ○ Prototype<br>  ○ Collaboration<br>• Quotes from LEAP core faculty members<br>• A faculty-led tour through the laboratory settings |
| **Scene 7: LEAP @ WPI/QCC Value Proposition** |  <br>  | Illustrate that LEAP is open-access and offers education to everyone. Show the challenges that LEAP is tackling – especially the ones that resonate with stakeholders.<br><br>Feature:<br>• Student success stories from LEAP<br>• Illustrations of the challenges and prototype solutions<br>• Diverse, cross-disciplinary collaboration | Emphasize the importance of the stakeholders and contextualize the relevance of applications.<br><br>Explore:<br>• Workforce development and the pipeline from academia to industry<br>• Cross-disciplinary aspects of photonics<br>• Student Value Proposition<br>  ○ Cross-disciplinary research<br>  ○ MQP & IQPs<br>  ○ Hands-on experiences with the equipment<br>• Industry affiliate value proposition<br>  ○ Tier Membership<br>  ○ Access to student and faculty talent<br>  ○ Cost-effective R&D<br>  ○ Cost-reductive MQPs |

| | | | |
|---|---|---|---|
| **Scene 8: Exploration of Available Equipment** |  <br>  | Show highlight footage of hallmark pieces of equipment, such as the Nanoscribe. Incorporate footage of equipment that is actively being used.<br><br>Illustrate:<br>• Nano & micro fabrication capabilities<br>• Optical measuring systems<br>• Wafer, die, and chip prototyping<br>• Test and characterization capabilities<br>• PIC functionalization<br>• Machines in active use<br>• Faculty members and students working together on machines | Introduce key pieces of equipment and explain what the current and future applications are of each piece of equipment.<br><br>Be sure to:<br>• Discuss the policies and procedures regarding equipment use<br>• Highlight the tier membership program and benefits<br>  ○ Cost-effective R&D<br>  ○ Cost-reductive MQPs<br>• Encourage industry affiliates to participate, especially companies who:<br>  ○ Have strong interest in PICs<br>  ○ Manufacture PIC components |
| **9: Conclusion & Call-to-Action** |  <br>  | Re-illustrate the situation of LEAP @ WPI/QCC within the integrated photonics ecosystem. Illustrate that new stakeholder involvement is welcome.<br><br>Include:<br>• Highway to the future infographic<br>  ○ Be sure to zoom in on LEAP @ WPI/QCC<br>• LEAP @ WPI/QCC contact information | Call for stakeholder action. Reiterate that involvement is welcome and summarize the key ways to get involved. Make sure to provide contact methods.<br><br>Restate:<br>• The mission of LEAP @ WPI/QCC<br>• The overall role of LEAP @ WPI/QCC in the ecosystem<br>• Desire to engage in meaningful collaborations |