Externships as Professional Development for Secondary School STEM Educators

12 May 2021

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Abstract

Externships in STEM workplaces offer a professional development opportunity, which connects educators with STEM-related employers to gain industry experience. The STEM Education Center at WPI is interested in adding an externship program to its professional development offerings for secondary school teachers in central Massachusetts. We interviewed middle and high school STEM teachers, industry representatives, and other externship organizers and used their perspectives to recommend a pilot externship program design to the STEM Education Center.

Acknowledgements

Our team would like to extend our appreciation to everyone who helped us and supported us during our research. Specifically, these individuals:

- Our project sponsors, *Mia Dubosarsky and Donna Taylor at the WPI STEM Education Center.* Your guidance, insight, and encouragement have been invaluable.
- The Director of Corporate Relations at WPI, *Dave Ortendahl*. Thank you for helping to steer us on the right path for our interviews with companies.
- *The teachers and employers who participated in interviews.* Your interest helped motivate us to create this proposed program.
- All of the externship organizers we interviewed for providing us with valuable insight on key features that could make the program a lasting impact:
    - *Bridget Burger (Cape Cod Regional STEM Network)*
    - *Jason Lang (Iowa Governor's STEM Advisory Council)*
    - *John MacFarlane and Matthew Thomsen (Idaho STEM Action Center)*
- Our advisors, *Chrys Demetry and Rick Vaz*, for supporting us and providing us with feedback that motivated this project to be the best that it can be.

Executive Summary

United States leaders in recent years have expressed concern over a slowed rate of advancement in STEM, which has been attributed to difficulties in secondary education (U.S. Department of Education, n.d.). Additionally, expectations for student performance are on the rise and educators have been tasked with the difficult job of preparing students for future careers (Seifert & Sutton, 2009; Leahey, 2016). Professional development programs serve as a valuable tool to provide educators with the skills necessary to prepare students for success (Massachusetts Department of Elementary and Secondary Education, 2012a). Professional development programs provide educators with exposure to new knowledge, which allows them to remain current in teaching methods, improve student outcomes, and make learning more relevant for students (Desimone, 2011; Gibson & Gray, 2010). As industry expectations evolve, it is crucial that professional development providers, such as the WPI STEM Education Center, address these expectations and help educators remain current and knowledgeable of real-world STEM. These needs can be addressed through externship programs.

For the purpose of this project, an externship is defined as a professional development opportunity that connects educators with a STEM-related company to gain first-hand experience about what it is like to work in the industry (Greater Los Angeles Consortium on Externships (GLACE), 2017). Through an externship, educators are able to gain industry work experience to further cultivate their professional identity and discover the professional skills that students may value in the workplace (Terry, 2009). Externships provide many benefits over other forms of professional development, such as providing an immersive and interactive learning experience, letting educators gain relevant industry experience, and aiding in the creation of curriculum that resembles what is current in the real world.

Currently, there are few STEM educator externship programs available to middle and high school educators in central Massachusetts. This gap creates an opportunity to address an area in teacher education that has the potential to improve the learning outcomes and interest of students in STEM. Through implementation of a STEM educator externship program, there is promise to fill a gap in real-world experience for secondary school educators, which has further potential to benefit the learning of students for years to come.

Project Goal and Objectives

The goal of our project was to develop a pilot externship program for the WPI STEM Education Center, intended for middle and high school STEM educators in central Massachusetts. Our group developed the following research objectives and methods to help direct our efforts:

1. To understand the needs, interests, and ideas of educators, employers, and the WPI STEM Education Center for a STEM educator externship program: We interviewed 12 middle and high school STEM teachers, representatives from 6 companies located in Massachusetts, and our sponsors from the WPI STEM Education Center.

2. To apply lessons learned from existing STEM educator externship programs: We interviewed experienced externship organizers from 3 different externship programs in different states across the United States. These lessons allowed us to see the motivation for choosing certain parameters in an externship design and the success of these choices.

3. To develop and refine a pilot externship program design that accommodates stakeholder preferences and requirements: Using the data from preliminary interviews and from externship providers, we created two contrasting program design models and presented them to educators and employers in follow-up interviews. We asked which aspects of each model they found appealing and used their feedback to propose a program design for the STEM Education Center that could appeal to all stakeholders.

Perspectives of Externship Stakeholders

Figure ES.1 depicts similarities and differences in stakeholder responses from our first round of interviews. Some of the essential findings from preliminary interviews are: stakeholders found benefit in a program that provides real-world experiences to teachers, all parties valued some amount of compensation for externs, and all stakeholders found value in independent,

hands-on work during the program. Other responses regarding the suggested program design are addressed in the following sections.

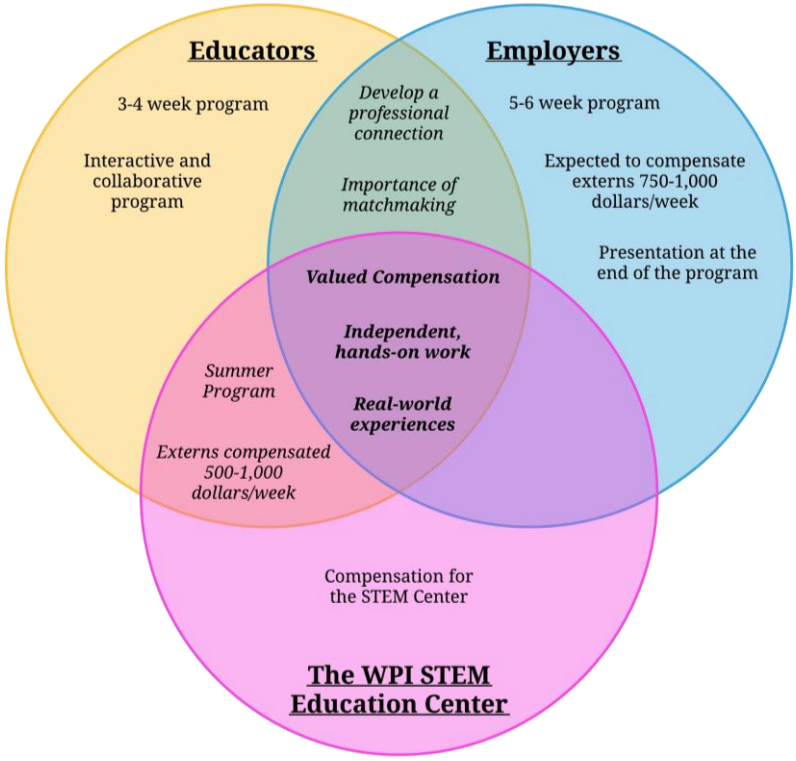

Figure ES.1: Stakeholder Responses Regarding an Externship Design

A recommended design for the WPI STEM Educator Externship Program

From interviews with educators, company representatives, the WPI STEM Education Center, and experienced externship organizers, we suggest the following parameters that have shown promise for success in an externship program.

A duration between four and five weeks during the summer

Educators preferred that the program length be around 3-4 weeks because it would occur during their summer break from classes. Employers preferred that the program length be between 5-6 weeks to allow for longer projects to be completed. A weekly schedule consisting of four 8-hour workdays would allow the extern to become fully immersed in the workplace environment.

A combination of independent work and a shadowing role for educators

Educators stated in preliminary interviews that they would be interested in performing independent work in industry, with many noting that they would prefer to shadow employees first and then perform independent work. Similarly, employers expressed that they wanted externs to shadow industry professionals before the externs perform independent work. A shadowing period at the beginning of the program would allow for educators to be trained prior to completing independent work. This combination is a promising way to satisfy both educator and employer desires.

A weekly stipend of 500-1000 dollars for the duration of the program

Both educators and employers noted in preliminary interviews that payment would be important in an externship program. The externship program representatives that we interviewed offered payments in weekly stipends. We estimate that a weekly stipend of 500 to 1,000 dollars could satisfy both educator and employer needs. With the estimated 32-hour work week, this equates to approximately 16 to 31 dollars an hour.

One half-day of professional development each week with the WPI STEM Education Center to create a curriculum module

Educators commented that one aspect of notable professional development programs was when a full curriculum module was created as an end result. A half-day of professional development work with the WPI STEM Education Center would allow educators to turn their industry experiences into material that can be used in the classroom. This aspect also allows for the externship organizer to certify the program with state or district standards for professional development, which allows for approved professional development providers to sign off on credit hours at the end of the program.

Recommendations for implementing an externship program:

Based on our conversations with externship experts, we recommend considering these points to help implement an externship program:

1. The importance of matchmaking. The matchmaking process between participants and host companies is one of the most challenging aspects of organizing an educator externship program. Through personal interviews, we found that both educators and employers expressed concern with the matchmaking process because they wanted teacher participants to be paired with a company related to the material that they teach in the classroom. Externship organizers stated that one of their struggles with the matchmaking process is whether to reach out to participants or host companies first. They further explained that accepting too many participants from one group without confirming their place in the program may cause some participants to be turned away, which could dissuade participation in subsequent years. The advice from externship organizers to combat these issues was to maintain constant communication with potential participants as well as host companies and to shorten the timeline between the application process and the start date of the program.

2. Online advertising. Online advertising is desirable to both teachers and employers because it allows both parties to see the opportunities offered and their impacts. Through personal interviews, we found that most educators look online for professional development opportunities. Advertising the program online allows teachers the ability to read about the opportunities that each company is offering so that they can select the program that is most applicable to their curriculum. Further, online media, such as social media or blog posts, allows employers to see the impact that their company has on teachers, students, and the community through previous teacher experiences.

3. Messages to promote participation. Through our interviews with stakeholders, we were able to learn what aspects of a potential externship program would be the most appealing. For educators, the main points of interest were the real-world professional experience that an externship would provide as well as the professional development credits and weekly stipends that participating educators would receive. Additionally, educators found benefit in creating a curriculum module with the help of the WPI STEM Education Center and building industry connections through their time at a host company. For employers, key potential benefits of an

externship program are the project work that an extern would complete for the company, community outreach through connections with local educators and schools, and the strengthening of the future talent pipeline through the improvement of local STEM education. Through advertisements delivered over online media, such as a website or social media platform, these key points of interest can be effectively promoted to their target stakeholder group in order to increase participation in an externship program.

4. Benefits of external funding through grants. Each of the existing externship programs that we investigated had received financial support for early iterations of their programs. This funding was found through grants awarded by various educational organizations, both public and private, such as the National Science Foundation or state-level departments of education. According to externship organizers, the use of grant funding proved to be a valuable tool in helping the program gain traction and increase participation. Using external funds to cover the operating costs of the program allows employers and educators to take part in the externship experience without any financial risk. After seeing the benefits and impacts of an externship program, host companies and externs are likely to return in future years in which some financial investment may be required in order to help sustain the program.

Authorship

The process of writing this report was completed in 3 steps. In the first step, one or two individuals would write a section or paragraph using an outline that we developed as a group. In the second step, two or more group members would read and edit the writing together. They would go through the whole section or chapter that was being edited using the suggestion mode in Google Docs. The third step involved the whole group reading through the section or chapter with the newly proposed edits and agreeing on any changes before they were confirmed in the draft. This process helped us capitalize on the skills of the more talented writers and editors in the group. Additionally, the third step ensured that the whole group was on the same page with the status of the report. A more specific breakdown of content authorship can be found in Appendix E.

The project team.

(left to right) Michael Biando, Michael Berwanger, David Tomer, Tyler Hunt, Ethan Washock

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1. Introduction

Due to difficulties in secondary education, United States leaders are concerned about the nation's advancements in STEM (U.S. Department of Education, n.d.). Expectations of student performance and accountability are rising, which is motivating educators to improve their success in the classroom and be more accountable for their lesson plans (Seifert & Sutton, 2009). Educators have been tasked with the difficult job of adequately preparing students in this time of change (Leahey, 2016). Research suggests that educators are having a difficult time relaying STEM career information to their students because they typically do not have experience in STEM-related industries (Bowen & Shume, 2018).

Professional development programs are designed to support educators as they teach STEM subjects (Massachusetts Department of Elementary and Secondary Education, 2012a). These programs serve as a means to expose educators to new knowledge that will allow them to remain up to date in their teaching methods (Desimone, 2011). As industry expectations evolve, it is crucial that professional development providers, such as the WPI STEM Education Center, address these expectations and help educators remain current and knowledgeable of real-world STEM. Research shows that professional development is a key factor in enhancing pedagogy to make learning more relevant for students (Gibson & Gray, 2010). This is reflected in a study which found that students performed better on science subject tests when their teacher participated in a professional development course in the same subject (Fields et al., 2012).

Educators who build a connection between the classroom and the workplace are better equipped to provide students with a deeper understanding of subject material that can be applied to real-world problems (Newmann & Wehlage, 1995). Industry experience is seen to have a positive impact on educator success, but few professional development programs include such experience (Ryder & Perabo, 1985). Professional development programs that offer work-related experience help teachers create targeted lesson plans and activities that facilitate teaching STEM in the classroom (Harpole et al., 2010). Industry experience in professional development also helps to introduce the growing importance of professional skills in the STEM workplace (Stewart, 2017).

An educator externship is a professional development opportunity that allows educators to enter into an apprentice-like work experience to cultivate their professional identity and discover what professional skills students might use in the workforce (Terry, 2009). Stickney and Alamprese (2001) assert that externships are not widely available for teachers due to the limited resources devoted to professional development programs. They believe that if more resources were allocated, then expanding the availability of externships may become a priority. The WPI STEM Education Center hopes to address this concern in central Massachusetts by developing and implementing a STEM educator externship.

The goal of this project was to create a design for a STEM educator externship program in central Massachusetts for the WPI STEM Education Center in order to increase real-world industry exposure for secondary school educators. To accomplish this, we researched the needs and interests of educators and employers for an externship program. Additionally, we consulted organizers of existing externship programs. Using the information gained, we recommended a pilot externship program design that accommodated the preferences of all stakeholders.

2. Background

In this chapter, we begin by looking into challenges that educators face with student outcomes in STEM subjects. We then present the benefits of professional development for educators in STEM. We continue by examining work-related professional development for STEM educators and its potential impact on STEM industries. Next, we investigate how externships for STEM educators align with high quality professional development requirements and fulfill certain professional development credit hours. We conclude by discussing the WPI STEM Education Center's current professional development offerings as well as efforts to expand their professional development offerings through the use of a STEM educator externship.

2.1. Challenges with student outcomes in STEM subjects

Secondary school educators are facing challenges in teaching STEM topics. In this section, we bring to light some challenges surrounding STEM education in the United States, which is linked to the recent stall in STEM-related industry. Then, we discuss the connection between increased industry experience for STEM educators and student success.

2.1.1. The stall in STEM industry and decrease in student outcomes

Students are struggling with math and science in the United States. "Rising Above the Gathering Storm," an article published by the National Academies of Science, Engineering, and Medicine, mentions that the U.S. had dominated the global economy both financially and socially because of its prior investments in STEM research and development (Bissell et al., 2007). The growth in U.S. STEM industries has slowed in recent years, which can be attributed to decreased student achievement in both science and math relative to other rising global powers. This is reflected in the 2018 results of the Program for International Student Assessment (PISA), where students from 28 rising global powers were assessed on their abilities in math and science. The United States placed last in mathematics and within the bottom 35 percent in science (Walker, 2019).

Due to the poor performance of U.S. students in math and science, industry leaders are concerned about the future. In a national conference held in 2005, a group of scientists were polled about the status of science and innovation in America. Forty percent of the group reflected that the status of science-related research and production was in a stall, and the remainder claimed that these industries were in decline. The National Academy report concludes by attributing a scarcity of funding within the STEM workforce at all education levels to the lack of upcoming STEM talent (Bissell et al., 2007).

Students who lack exposure to STEM-related experiences may develop less interest in STEM career paths. The National Research Council, the U.S. Department of Education, and the National Academy of Science have all individually concluded that a shortage of STEM knowledge and experience in educators is contributing to a low science and mathematical understanding in K-12 students (Hutchison, 2012). Hutchinson claims that this lack of STEM expertise is attributed in part to the shortage of teachers who are formally educated in STEM. A study conducted by the American Society of Quality, who partnered with Harris Interactive, discovered that experience in STEM-related subject areas was not included in early education curricula. This absence of experience results in a lack of stimulated interest in these subjects (Angle et al., 2016).

2.1.2. Impact of STEM experience for educators on student outcomes

Increased STEM experience for educators has been found to be beneficial for the outcomes of students, which is reflected through improvements in course curricula. Research conducted by Bowen and Shume (2018) suggests that educators are having difficulty relaying STEM career information to their students because they typically do not have work experience in any STEM-related industry. Furthermore, a study done by Salha and Abu Sarah (2019) found that increasing an educator's knowledge and experience in STEM helped improve the educator's approach to conducting activities that more closely resemble real-world scenarios.

Increasing an educator's experience in STEM can help improve the effectiveness of their teaching. A study published in the *International Journal of Science Education* revealed that an increase in STEM experience can improve instructional effectiveness (Barker et al., 2015). Research conducted by Darling-Hammond et al. (2017) concluded that increasing an educator's

STEM experience had a positive impact on their content knowledge and teaching strategies. A study conducted by Affouneh et al. (2020) suggested that the acquired knowledge of STEM goes further than the ability of memorizing miscellaneous facts. He further argued that educators need to understand STEM from personal experiences so that they can build the confidence necessary to teach it in a way that is intriguing, integrated, interdisciplinary, and connected to the real world (Affouneh et al., 2020).

2.2. Professional development and student outcomes

In this section, we will first discuss the need for professional development for educators. We then address the effectiveness of professional development through measurement of student performance.

Professional development can be a useful tool to increase teacher effectiveness in the classroom. In the article *Professional Development: Does it Matter?*, Leahey (2016) describes professional development programs as a means to keep the knowledge of educators current and up to the standard of modern-day education requirements. Following initial training, an educator must maintain specified benchmarks for quality and content as courses change and evolve. This article further describes how material taught in middle and high school classes can change over time, meaning teaching styles and curricula can become outdated. Despite changing educational requirements, effective professional development programs ensure that educators are able to deliver sufficient knowledge to their students.

Educator participation in STEM professional development has been shown to increase student success in STEM subjects. A study by Fields (2012) found that educators who took professional development courses translated their new skills into greater success for their students. As shown in Figure 1, research found that the percentage of students who passed the state test for biology was higher if their teacher took part in a professional development program run by the Boston Science Partnership. The percentage of students that scored “proficient” and “advanced” on this test was also noticeably higher (Fields et al., 2012). Additionally, the

percentage of students who scored “warning” or “failing” in biology was lower when their teacher participated in the program.

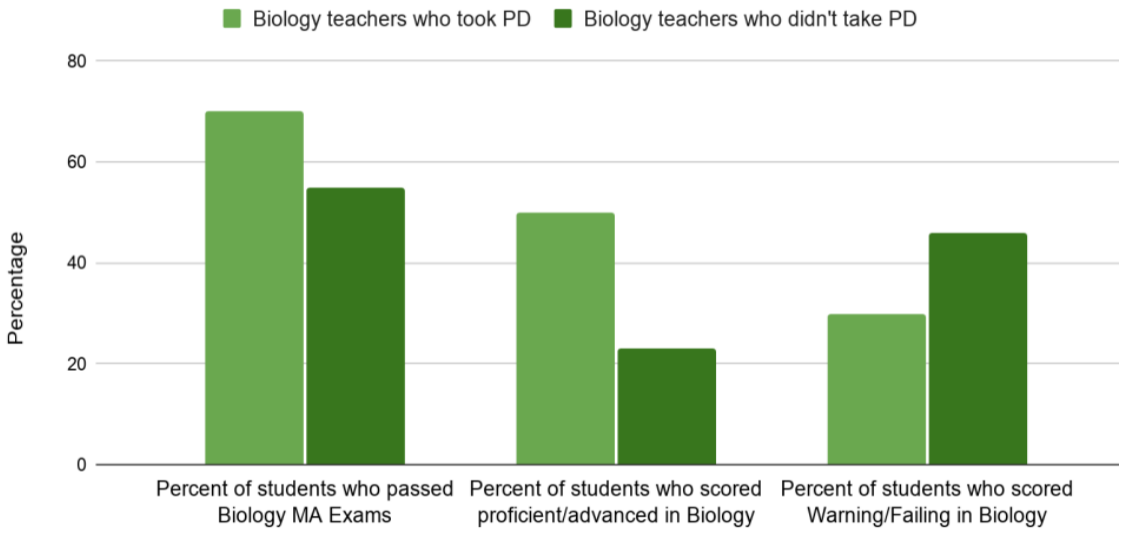

Figure 1: Student Scores Affected by Professional Development (Fields et al., 2012).

Looking beyond test scores, professional development programs have also been found to positively affect student engagement and interest in the subject matter (Hayden et al., 2011). California State University San Marcos and the International Society for Technology and Education (ISTE) conducted a study on this effect using the iQUEST program, a STEM professional development program designed by the ISTE. Their research found that middle school STEM teachers who participated in the program reported higher levels of student engagement and involvement in class activities. Professional development programs designed for STEM educators, such as the iQUEST program, provide educators with the knowledge to keep their lesson plans up-to-date, which is crucial for fostering student interest in STEM subjects (Hayden et al., 2011).

2.3. Work-related professional development for STEM educators

In this section, we first discuss the potential of industry-aligned professional development in STEM education. Next, we review the benefit of hands-on experience in workplace professional development. Lastly, we review the increased importance of professional skills in STEM-related careers.

2.3.1. Industry-aligned professional development

Increased educator exposure to STEM-related subjects through workplace professional development provides educators with personal experience that can increase confidence in their subject and their ability to stimulate interest in students (Fields et al., 2012). An article written by the BellSouth Foundation (1999) noted that 80 percent of classroom teachers have never worked outside of a school building. In another article published in Educational Technology and Society, Wu and Albion (2019) assert that the reason there is a lack of attention to STEM subjects from teachers is due to a limited exposure to STEM in their own education and experiences. They also argue that this limited exposure affects the educator's confidence in teaching related subjects. The combination of these two sources suggests that there is a connection between an educator's STEM subject experience and their confidence in teaching STEM-related curricula.

Hands-on experience can be an effective way for educators to gain professional development in the workplace. In the previously mentioned study performed by Wu and Albion (2019), there is an emphasis on the impact of hands-on learning. They claim that many educators believe that when learning in new areas, especially when beginning in a new field, a hands-on approach is most effective. An article by Harpole et al. (2010) argues that the most effective way for a teacher to improve their abilities is through programs that transform real-world experiences into hands-on activities, which can be obtained through industry experience. In a 1995 study, Newmann and Wehlage (1995) found that educators who have the opportunity to experience the connection between schooling and the workplace are better positioned to teach in a way that guides students to think and develop a deep understanding of the subject at hand.

2.3.2. Professional skills in educator professional development

Professional development programs that provide teachers with exposure to the professional skills that their students will need in the workplace can be immensely valuable. Professional skills are defined as a combination of interpersonal skills, social intelligence, and character traits that allow a person to succeed in a professional environment (Lippman et al., 2015). Examples of professional skills include communication, teamwork, professionalism, ethics, continuous learning, and knowledge of contemporary issues (Shuman et al., 2005). A regional survey conducted by Stevens and Norman (2016) found that industry professionals are becoming less concerned with technical skills and more concerned with professional skills, which are necessary for team-based, customer-focused business environments. *The STEM Dilemma: Skills that Matter to Regions* explores the correlation between the level of STEM skills and professional skills required to complete a given job and the salary associated with that job (Stewart, 2017). The article found that jobs that require a higher level of STEM and professional skills were, on average, paid greater salaries than similar jobs where a high level of STEM was practiced but a lower level of professional skills were necessary. Oberst and Jones (2004) argued that professional skills are important for educators to teach since engineers and professionals in STEM are becoming more than a commodity. Rather, industry professionals are viewed as highly educated people with advanced technical knowledge, and it is necessary that they possess effective professional skills.

2.4. Externships as professional development for STEM educators

Industry externships have the potential to serve as a valuable form of professional development for teachers. In this section, we first describe standards that professional development programs are held to in the state of Massachusetts. Next, we discuss what an externship program is and what one can expect to learn from an externship program. Finally, we review previous externship programs that have found success amongst those who participated.

2.4.1. Massachusetts standards for professional development

The state of Massachusetts defines a professional development program as “a set of coherent learning experiences that is systematic, purposeful, and structured over a sustained period of time with the goal of improving educator practice and student outcomes" (Massachusetts Department of Elementary and Secondary Education, 2012a). In addition to this general definition, the Massachusetts Department of Elementary and Secondary Education also maintains 10 standards to which professional development programs are held in order to be considered “high quality professional development.” According to the Department, high quality professional development:

1. Has clear goals and objectives relevant to desired student outcomes.
2. Aligns with state, district, school, and/or educator goals or priorities.
3. Is designed based on the analysis of data relevant to the identified goals, objectives, and audience.
4. Is assessed to ensure that it is meeting the targeted goals and objectives.
5. Promotes collaboration among educators to encourage sharing of ideas and working together to achieve the identified goals and objectives.
6. Advances an educator's ability to apply learnings from the professional development to his/her particular content and/or context.
7. Models good pedagogical practice and applies knowledge of adult learning theory to engage educators.
8. Makes use of relevant resources to ensure that the identified goals and objectives are met.
9. Is taught or facilitated by a professional who is knowledgeable about the identified objectives.
10. Sessions connect and build upon each other to provide a coherent and useful learning experience for educators.

(Massachusetts Department of Elementary and Secondary Education, 2012b)

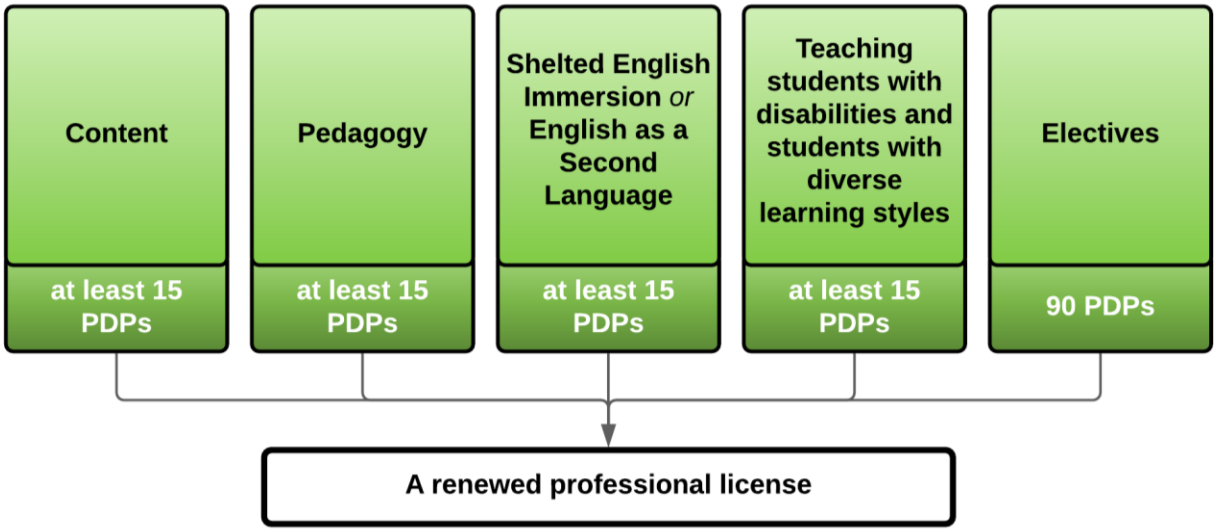

Figure 2: PDP Requirements for Massachusetts

(Massachusetts Department of Elementary and Secondary Education, 2012a)

The Massachusetts Department of Elementary and Secondary Education requires that all educators complete a minimum of 150 professional development points (PDPs) every five years in order to renew their teaching license. The required 150 PDPs is approximately equivalent to participating in 150 hours of approved professional development programs (Massachusetts Department of Elementary and Secondary Education, 2012a). These PDPs must be earned in various categories and disciplines, as shown in Figure 2. Externship programs could fit into one or both categories titled 'Content' or 'Pedagogy'.

2.4.2. The advantages of hands-on externships

An externship program is a learning opportunity focused on providing business or industry experience (Greater Los Angeles Consortium on Externships (GLACE), 2017). This type of program is typically run through a partnership between an educational institution and a company or organization within a given industry. The goal of an externship program as a form of educator professional development is to equip educators with the knowledge to teach students about practical experiences associated with an area of study (Greater Los Angeles Consortium on Externships (GLACE), 2017).

The advantages of an educator externship program originate from the immersive experience that it provides. Bowen and Shume (2018) emphasize that the focus of professional development should be on the knowledge gained from hands-on work rather than the knowledge gained from traditional education. An educator externship provides an opportunity for teachers to work in an industry environment so they can bring valuable knowledge back to the classroom (Bowen & Shume, 2018). The advantages of an externship program are outlined in the article *Educator Externships: How Classroom Teachers Can Acquire Business and Industry Experience*. The authors argue that an educator externship program helps participants develop more relevant classroom curricula, teaching strategies, and classroom management techniques through work-based experience in a business setting (Luft & Vidoni, 2000).

2.4.3. Examples of externships as professional development

There are several examples of STEM educator externship programs in the United States. One program is delivered by the Cape Cod Regional STEM Network, which was established to unite educators, school districts, businesses, and community members to inform and inspire youth about STEM (Cape Cod Regional STEM Network, n.d.). The network has partnered with over 85 businesses and organizations to connect educators with STEM experts in Massachusetts. Their notable externship program for educators is the Teacher-in-Residence Program. This aims to immerse educators in various experiences involving STEM outside of the classroom (STEM Ecosystems, n.d.). Organizations such as the Cape Cod Museum of Natural History, the National Marine Life Center, and the Chatham Marconi Maritime were paired with educators who were interested in their work. The educators spent two weeks at the organization creating an activity for their students that integrated various pieces of STEM knowledge. An example of a project done within the program involved an educator creating an engineering curriculum for her class after working with Teledyne Marine Systems (STEM Ecosystems, n.d.).

Figure 3: Nashville High School Educators Using a Kemmerer Water Sampler

Another successful externship program was run by the U.S. Army Corps of Engineers (USACE) out of Nashville, Tennessee (Roberts, 2013). Local high school educators were able to partake in some of the USACE projects that were in progress. Throughout the program, educators were encouraged to investigate, explore, experiment, problem solve, create, and invent. Using their experience, the teachers then created class curricula that could be used to expose their students to real-world applications of STEM. In one project, an engineer demonstrated how to collect various water samples from a lake in Nashville using a water sampler at varying depths for further testing as shown in Figure 3. After the samples were collected, the educators were trained on how the USACE uses the data from these samples in order to keep lakes and rivers clean in the area. Educators that attended the program commented that they planned to use the collaborative project-based lessons in the classroom (Roberts, 2013).

2.5. The WPI STEM Education Center's professional development offerings

In this section, we first discuss the WPI STEM Education Center, specifically their mission and some examples of their current professional development programs. We then discuss how the STEM Education Center is planning to expand on its current offerings.

The mission of the WPI STEM Education Center is to transform STEM education through collaboration with PK-12 educators (Worcester Polytechnic Institute, 2011). The center aims to achieve this goal with a three-pronged approach: professional development, research, and community engagement. The center's group of fewer than ten education professionals and administrative staff members have engaged with over 4,500 educators and administrators in 12 states and 3 continents since 2012 (WPI STEM Education Center, n.d.).

The WPI STEM Education Center offers a wide variety of professional development programs that incorporate project-based learning (PBL). Project-based learning is described as a pedagogical approach that focuses on complex and unique problems that require students to design solutions, make important decisions, and investigate subjects within the realm of STEM. These programs include curriculum development workshops, coding and computational courses, and project-based learning workshops (WPI STEM Education Center, n.d.). An example professional development program currently held by the center is the PBL Institute, a program aimed at teaching STEM-related material through all-encompassing projects, which provide a hands-on opportunity for students (WPI STEM Education Center, n.d.). This program trains educators on how to integrate project-based, STEM-related activities into their core curriculum.

The WPI STEM Education Center plans to expand its professional development offerings by developing a STEM externship program for secondary school educators in central Massachusetts that gives educators real-world experience.

3. Methodology

The goal of our project was to develop a pilot externship program for the WPI STEM Education Center, intended for middle and high school STEM educators in central Massachusetts. Our group developed the following research objectives to help direct our efforts:

1) To understand the needs, interests, and ideas of educators, employers, and the WPI STEM Education Center for a STEM educator externship program.
2) To apply lessons learned from existing STEM educator externship programs.
3) To develop and refine a pilot externship program design that accommodates stakeholder preferences and requirements.

Throughout this chapter, we discuss the methods that we used to analyze the data that we collected and how that analysis helped us to develop a pilot externship program. This process is captured in Figure 4.

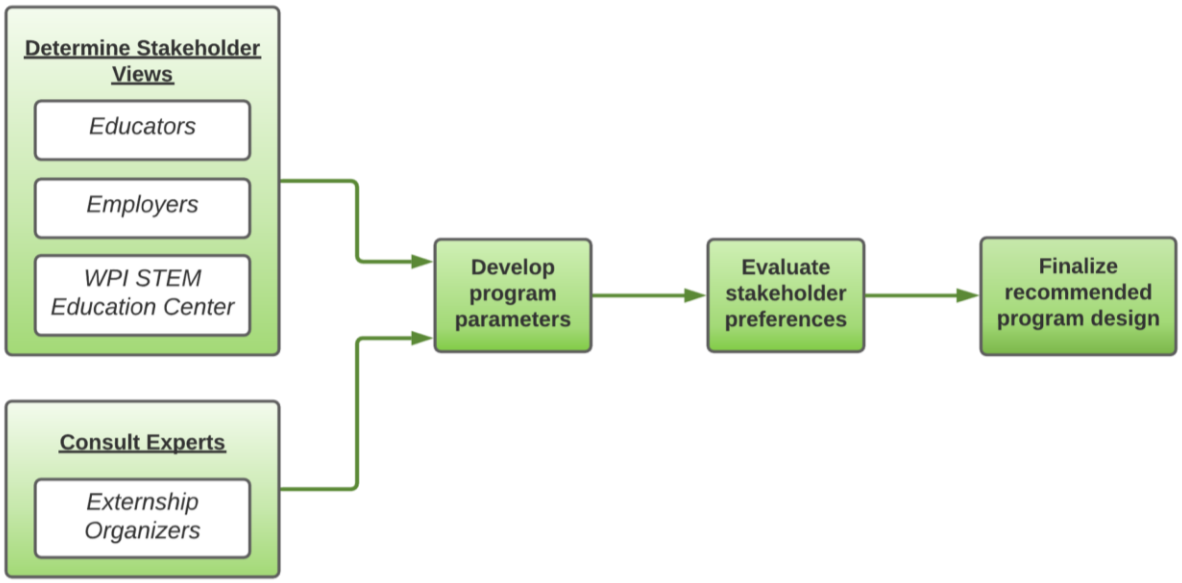

Figure 4: Objectives Flowchart

3.1. Objective 1: Understand stakeholder interests

In this objective, we organize our stakeholders into three groups: educators, employers and the WPI STEM Education Center. We discuss information that we intended to gain from stakeholders in order to create a design that is appealing to all parties involved. Our method for obtaining this information was based on specific research questions that were explored through the use of personal interviews. Interviews allowed us to ask open-ended questions, which triggered more in-depth responses (Tyreman, 2020). The use of interviews also allowed our group to rely on other sources of information apart from literary research in order to accommodate stakeholder preferences. The research questions were based on rhetorical moves found in *Helping Teachers Connect Academics to the Workplace: An Implementation Guide for Teacher Worksite Externships* (Bidwell, 1997).

3.1.1. The perspective of the WPI STEM Education Center

In order to understand the perspective of the WPI STEM Education Center, we investigated research questions intended to help us understand the interests and ideas they had in mind. We aimed to gain the following information from the WPI STEM Education Center:

- What was the driving force behind the addition of an educator externship program to the existing professional development opportunities offered by the WPI STEM Education Center?
- How does the WPI STEM Education Center intend to deliver effective professional development during an educator externship program?
- What outcomes does the WPI STEM Education Center hope teachers and employers will accomplish through participation in an externship program?
- What ideas does the WPI STEM Education Center have for the framework of the externship program (duration, compensation, etc.)?

We obtained this information by doing personal interviews over Zoom with our sponsors from the WPI STEM Education Center, Donna Taylor and Mia Dubosarsky. Understanding the

perspective of the WPI STEM Education Center as a stakeholder helped us to clarify what they expected the program to look like as well as what they hoped to see as outcomes of the program.

3.1.2. The educator perspective

In order to understand the educator perspective, we investigated several research questions that aided in the design of the externship program. The research questions are as follows:

- What types of professional development programs appeal to educators and why?
- How do educators find professional development programs?
- What outcomes would educators expect from an externship opportunity?
- What deliverables would educators want to accomplish in an externship program?
- What program features are important to educators (ex. work role, location, duration, etc.)?

These questions were answered by a group of secondary school educators to gain their perspective on the program design. The educators that we interviewed had a focus in a STEM subject area, were located in central Massachusetts, and taught middle or high school students.

We compiled a list of names and contact information for potential interviewees to begin the interview process. We created this list through recommendations from the WPI STEM Education Center and through a snowball-style interview process, where initial candidates provided other contacts that were interested in being interviewed iteratively until the interview pool was much larger than the initial set of contacts. In total, our team interviewed 12 educators from 6 different school districts in central Massachusetts. Of these 12 educators, 5 were men and 7 were women. Of the teachers interviewed, 6 taught at a middle school, and the other 6 were high school educators. The subjects taught by these teachers cover a range of topics including robotics, engineering design, lab sciences, computer science, and STEM. Additionally, the teaching experience of our interviewees varied from less than 1 year to more than 35 years. One limitation of our educator interview process was that a gap existed in years of teaching

experience between 10 and 20 years. We interviewed 7 teachers with 10 or fewer years of experience, and 5 teachers with 20 or greater years of experience.

Our interviews included deductive questioning about the parameters and qualifications of the externship program design. To ensure that our list of questions encompassed the scope of the project description, it was reviewed by the WPI STEM Education Center. There was also a list of confidentiality questions that were used to address the privacy concerns of the interviewees. Interviewees were given the option to refuse recording of the interview, to remain anonymous in our report, or to refrain from being quoted. Both lists of questions can be found in Appendix A under *Educator Interview Protocol*.

We refined our research questions through a series of practice interviews to determine the effectiveness of our interview process. The length of each interview was kept to a maximum of 30 minutes. During each interview, there were two individuals taking notes, which were cross compared for consistency. Further, the interviews were recorded with an automated transcript.

Following the interview process, we performed a modified version of Maykut and Morehouse constant comparative method of content analysis on the results of the personal interviews (Memon et al., 2017). Our method included deductively categorizing questions that provide certain responses, filtering through responses to expel outliers, relating the categories across stakeholders, and integrating our data into a final design. A more detailed description of the content analysis process is found in Appendix B under *Maykut-Morehouse content analysis description*.

3.1.3. The employer perspective

In order to understand the employer perspective, we created several research questions intended to help us design the externship program. The research questions are as follows:

- Does the company currently offer any community outreach or professional development programs?
- What type of work might educators accomplish in an externship program at the company?

- What outcomes would employers expect from educators in an externship opportunity?
- What deliverables would employers want to see from educators from an externship program?
- What program features are important to employers (ex. work role, compensation, duration, etc.)?

The scope of our project focused on the STEM industry in central Massachusetts. To create our list of contacts for companies, we used the lists provided by the WPI STEM Education Center and our advisor Rick Vaz as our basis. Further, we reached out to Dave Ortendahl, the Executive Director of Corporate Relations at WPI, and gained strategies for finding and contacting more company representatives. We performed personal and group networking through LinkedIn to expand our list of company contacts. Within the companies, we conducted interviews with employees in community outreach or mid-level management positions in order to understand the expectations and responsibilities associated with a potential externship program. Additionally, we reached out to human resources representatives to determine any challenges associated with organizing an externship program. By the end of our interview process, our team had conducted personal interviews with employees at 6 companies. This pool of companies reached into a variety of STEM topics, including software, manufacturing, marketing, insurance, and education. Additional interviews with other STEM industries could be used to further generalize the information provided by these companies.

As with the educator interview process, we created a list of interview questions to facilitate a design that was appealing to companies. To ensure that our list of questions properly addressed the scope of the project description, it was reviewed by both the WPI STEM Education Center and Dave Ortendahl. This list of interview questions, as well as confidentiality questions, can be found in Appendix A under *Employer Interview Protocol*. Immediately following the interview process, we performed a modified version of the Maykut and Morehouse constant comparative method of content analysis, which is described in Appendix B under *Maykut-Morehouse content analysis description*.

3.2. Objective 2: Apply lessons from existing externships

In this objective, we explored parameters, outcomes, and deliverables in other externship programs that would be beneficial to incorporate into our proposed design. Then, we set out to learn how externship organizers incentivized company participation, certified the content in their program, addressed encountered challenges, and measured the success of their program.

Through personal interviews with externship organizers, we wanted to acquire insight about how externship organizers run their programs. We also aimed to learn about which parameters in preliminary iterations of their program were effective. The questions we hoped to answer are as follows:

- How is the program advertised to both potential teacher participants and host companies?
- How does the program meet state or district professional development requirements?
- How are companies incentivized to participate in the externship program?
- Which program parameters (duration, location, work type, etc.) were successful and which were not, and why?

We obtained this information by conducting personal interviews with representatives from existing externship programs. We reached out to 5 programs and set up personal interviews with representatives from 3 of them. We found these externship programs through researching state education department websites and through literature found while performing our background research. When interviewing the externship organizers, we were able to obtain information that was not available in literature about the design and implementation of these programs. Additional information about the programs that were consulted was compiled into case studies, which can be found in Appendix D. The feedback from externship organizers helped us to create a design for our program that could incorporate successful traits and acknowledge the challenges that teachers or employers could face.

3.3. Objective 3: Develop and refine a program design

In this objective, we first elaborate on the logical steps necessary to create a preliminary design of the externship program. Next, we discuss the process of developing and refining the preliminary program design through the use of follow-up interviews.

3.3.1. Creating preliminary ideas for a program design

While creating the initial program models, we followed a set of steps intended to ensure stakeholder preferences and requirements were addressed. The key factors that were considered in the preliminary design of the STEM Externship Program are as follows:

- The desired outcomes of the externship program
- How the program will be structured
- The roles and responsibilities of externship program partners
- The length, frequency, and range of externship visits
- Curriculum implementation strategies

These factors, along with the information from our first round of personal interviews, influenced the design ideas for a STEM externship program. Following the content analysis process mentioned in Objective 1 and described in Appendix B under *Maykut-Morehouse content analysis description*, conclusions were made in regard to stakeholder responses and preferences for the program characteristics mentioned above. Our team used the most common responses from educators and employers to determine the ideal characteristics of the program design. We then used the information gained from interviews with existing externship program organizers to improve upon these design ideas. This process was used to create two program models, with each model having varied parameters and features to capture the suggestions from stakeholders and externship organizers.

3.3.2. Engaging stakeholders to refine the program design

The design ideas were refined through the use of follow-up interviews with our stakeholders. Follow-up interviewees were identified throughout our initial interview process through formal request by email, as outlined in our *Follow-up Interview Protocol* found in Appendix C. Four educators and one employer were consulted during the follow-up interview process. In the follow-up meetings, we presented our findings from the first round of interviews as well as the two preliminary models of the program. We then asked the interviewee to discuss their opinions of each model, which they would prefer, and any suggestions they may have to further improve either model. Descriptions of the preliminary program designs and the list of follow-up interview questions can also be found in Appendix C under *Follow-up Interview Protocol*.

After the completion of the follow-up interview process, we organized interviewee responses to the competing model designs and cross-referenced them to identify themes and repeated answers. Using the conclusions from the follow-up interviews to refine our findings and suggestions from the initial interviews, we developed recommendations for the design of an externship program. These recommendations include duration, compensation, intended outcomes, advertising methods, and the involvement of the WPI STEM Education Center. The result of this refining step was our team's suggested design of the pilot STEM Educator Externship Program for the WPI STEM Education Center.

4. Findings

In this chapter, we present findings on how stakeholders suggested an externship program could be structured, including the preferred form of advertisement, parameters, deliverables, and expected outcomes. Then, we compare and contrast several existing externship programs that were successful and point out key features, which were suggested by externship organizers, that may be taken into consideration when designing an externship. Finally, we describe a proposed design for the WPI STEM Educator Externship Program, which includes program parameters and deliverables.

4.1. Thoughts, interests, and ideas of stakeholders

Our research provided insight into the needs and desires of the project stakeholders for a STEM educator externship program in central Massachusetts. The most important stakeholder needs can be divided into several categories: program outcomes, participation role, program duration, and financial compensation. These categories suggest aspects of a program design that attempts to mutually benefit all stakeholders. Figure 5 displays the three stakeholder viewpoints in the form of a Venn diagram, showing areas of agreement and difference in stakeholder responses. A summary of these findings can be found in the sections below.

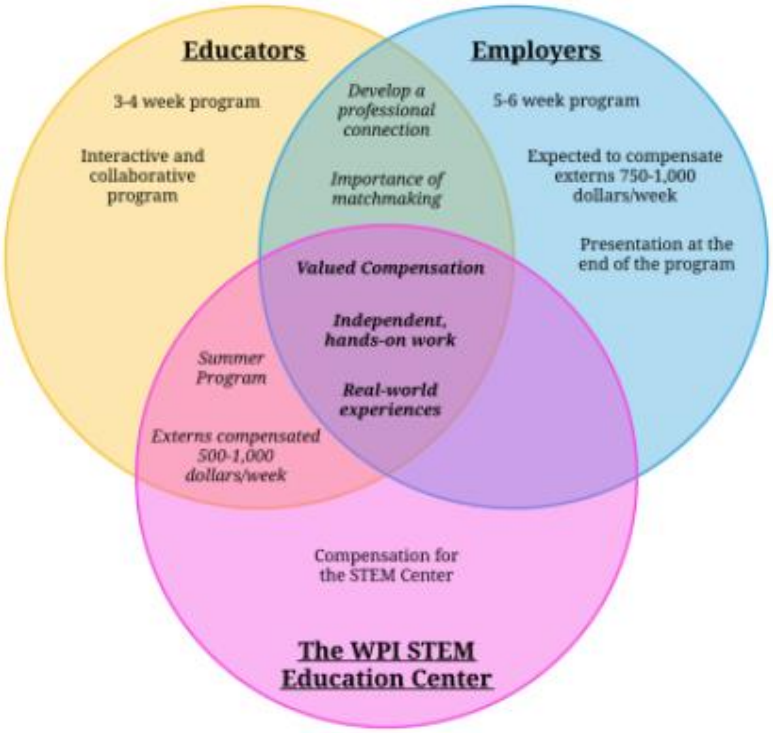

Figure 5: Stakeholder Responses Regarding an Externship Design

Stakeholders want teachers to capture real-world experiences through their classroom curricula in order to more accurately and confidently teach STEM topics and stimulate student interest. Educators, employers, and the STEM Education Center all stated in interviews that there is a notable disconnect between how STEM is practiced in industry and what is taught in the classroom. Educators also stated that they felt they could gain more confidence in their teaching by developing a better understanding of how their subjects are practiced in industry. Over 80 percent of educators responded that they wanted an externship program to integrate the real-world context of their STEM subject into the classroom to more accurately represent real-world applications. This additional experience has the potential to provide more context to students who want the information taught in school to resemble industry knowledge in their fields of interest. Brenda DiSessa, a teacher at Clinton High School, noted: "The world is changing rapidly, how am I going to know if I don't see it?" Another teacher, Christine Robbins, commented on ways that an externship would bridge the gap between the classroom and the workplace. She wanted to "help [her students] at least make a little bit of a real-life connection to something they're doing in school, to something that's going on outside of school." Additionally, all of the company contacts that were interviewed noted that industry exposure and experience were the most valued outcomes of an externship that would help increase interest in the employer's industry. The necessity of showing enthusiasm for the curriculum one creates was noted by 7th grade teacher, Kerry Palumbo, who explained, "If you don't have enthusiasm for something, you're not going to get [students] excited about it. So, to have that experience and confidence to have done it yourself is, I think, really, really valuable."

Stakeholders would like externs to complete independent work during an externship program. One third of the educator interviewees expressed interest in performing independent project work, while the other two thirds said that they would prefer to perform a mix of self-directed work and shadowing work. Regardless, all of the educators stated that they would be interested in performing some level of independent work that was primarily self-directed. Companies felt that this was feasible as long as the teachers were given the proper training. Additionally, company representatives felt that they could benefit from the contributions educators could make to their current projects. They suggested a model that included a

combination of shadowing an industry professional as well as completing a project that complemented teacher experiences and benefited the company.

Educators and employers both expressed a desire to form lasting connections that extend beyond the externship program. Educators stated that they would like to form professional connections with a host company. This connection would be used to facilitate opportunities for the students to be directly exposed to industry experience through field trips or guest speakers. Employers expressed a similar interest in developing connections with educators and their students in order to influence STEM education in local schools. This would allow companies to stimulate interest in their fields by exposing students to real-world applications of STEM.

Stakeholders expressed varying opinions regarding the duration of an externship program. The responses for the suggested duration of the externship program are shown in Figure 6, which aims to display the disagreement between educator and employer preferences. Teachers wanted the program to occur during the summer so that they would not have to miss time in the classroom. Most teachers said that the program duration should not exceed 3-4 weeks, with the mean and median responses being 3.8 weeks and 3 weeks respectively. On the other hand, companies suggested that the duration should be 5-6 weeks minimum due to the training period that would be required at the beginning of the program. The mean and median responses from company representatives were 5.6 weeks and 6 weeks respectively. Employers noted that some of their software or machinery has a high learning curve, so training would be necessary before externs were able to participate more independently. Companies stated that they wanted the teachers to have enough time to contribute to the company and to execute meaningful projects after the training period was completed. They also noted that a duration under 4 weeks would likely not provide any meaningful experiences as progress moves slowly and an adequate depth of understanding may not be achieved. Our sponsors at the WPI STEM Education Center stated that they felt the duration of the program must be within 3 to 6 weeks, which would include the preferred durations given by both educators and employers. Similarly to employers, a key concern of the STEM Education Center is that the externship program must be long enough

to allow for an educator to be fully immersed in the industry, meaning that the program would likely need to run for longer than 3 weeks.

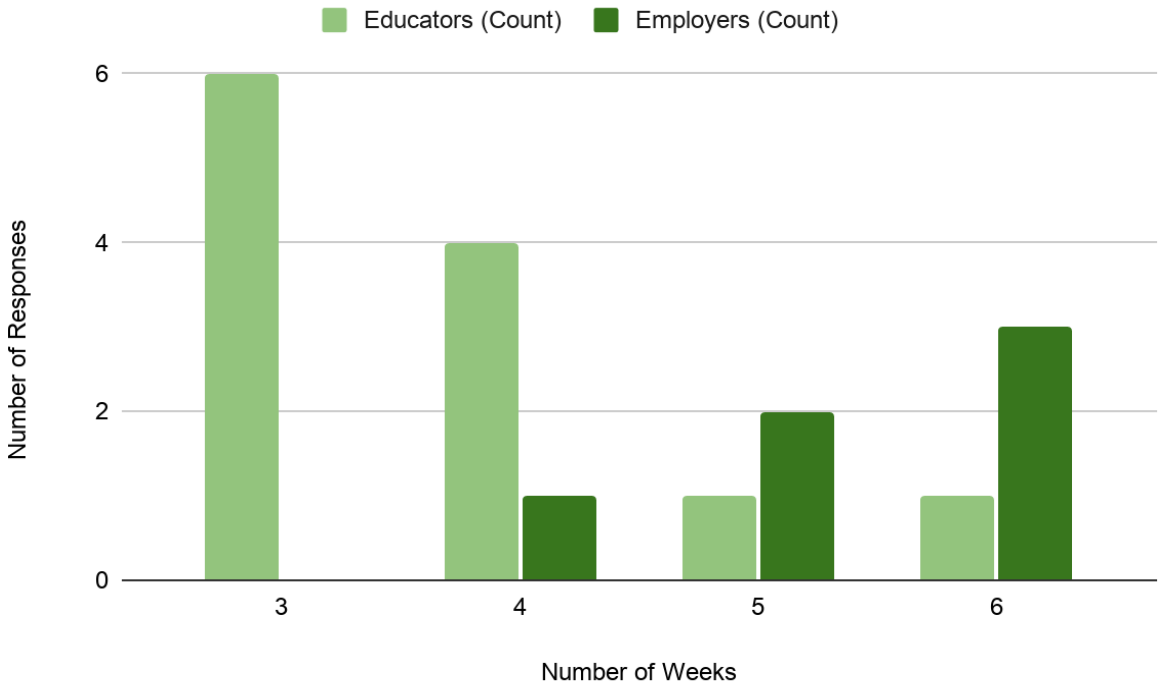

Figure 6: Desired Externship Duration

(Number of educators = 12, Number of employers = 6)

Companies are open to providing compensation to externs, which is likely to satisfy both educators and the WPI STEM Education Center. Out of the 12 educators interviewed, 4 educators noted that payment to attend the program was unimportant or very unimportant. The remainder of educators responded that they were indifferent, that it was important, or that it was very important to be compensated for their time in an externship program. When educators were asked what they felt was an appropriate amount for a weekly stipend for this program, the median response was 500 dollars per week, while the average response was 738 dollars per week. Similarly, our sponsors from the WPI STEM Education Center, Mia Dubosarsky and Donna Taylor, felt strongly that compensation for the participants' time in the program should be provided. Further, they mentioned that there needs to be compensation, ideally from companies,

to the WPI STEM Education Center for providing weekly professional development meetings as well as for coordination and delivery of the externship program.

When company contacts were asked about the importance of financially compensating teachers for their time in an externship, all companies expressed that they were open to providing payment. Several companies noted that compensation would be contingent upon the type of work performed in the program. Purely shadowing an industry professional may not warrant financial compensation, but work similar to what would be completed by an entry-level employee could provide reason for payment. When company representatives were asked about the amount of financial compensation through the mode of a weekly stipend, several were unable to provide an estimated stipend value. The remainder noted that payment would be similar to the amount an intern would be paid at their company. This ranged from 750-1000 dollars per week or 19-25 dollars per hour for a 40-hour week. Comparing educator and employer responses on the importance and amount of compensation, the consensus suggests that educators should be paid for their time in some respect.

4.2. Lessons from successful externship programs

In this section, we present a table outlining the similarities and differences of several successful STEM externship programs that we interviewed. For each program, we define their key parameters and deliverables. Then, we analyze several key features of the existing externship programs to gain insight on some ideas that could be implemented into the design for the WPI STEM Education Center's Educator Externship Program. A summary of these key features can be seen in Table 1. These key features provide valuable insight into some of the challenges that these existing externships have experienced. Detailed case studies about these externship programs can also be found in Appendix D.

Table 1: Comparison of Researched Externship Programs

	Idaho	Iowa	Cape Cod
Duration	6 weeks	5-6 weeks	2 weeks
Stipend	$5,000	$4,000-$4,800	$1,000
Deliverable	Blog postings, project submitted to Boise State for credit	Course module that meets state requirements	3-4 lesson curriculum module
Type of work	Broad experience of all aspects of work at host company	Collaborative project work with the company	Wide blend of shadowing work within the company
Hours/week	40	40	Hours may vary
Method of advertisement	Social media, event table sitting, emails, website	Emails, newspapers, and website	MA. STEM Network, Social media, website

Providing professional development credits for participation in an externship program is a promising method to incentivize teacher participation. Professional development credits can be provided through accreditation of graduate credits from a local college or through a signature from an approved professional development provider. Through communication with the Idaho STEM Action Center, we learned that they were able to certify their program with the Idaho Department of Education by having teachers create an applicable lesson plan that related their curriculum to industry experience. Then, they were able to provide graduate credits to their participants through submission of the created assignment to Boise State University. Moreover, our contact from the Cape Cod Regional STEM Network, Bridget Burger, mentioned that they were able to sign off on professional development credits since their host institution, Cape Cod Community College, is an approved professional development provider.

The match-making process between educators and employers is one of the most challenging aspects of an externship program. This challenge arises from the need to connect an educator to a host company where the educator can have a meaningful and relevant

experience. According to Jason Lang from the Iowa STEM Advisory Council, one of their struggles in matchmaking is determining whether to reach out to educators or employers first. He went on to explain that turning away a teacher or host company due to insufficient participation from the other group often results in reduced involvement in future years. His advice to overcome this challenge was to inform both parties that their placement into the program is contingent on the mutual interest of both groups. He additionally stressed the importance of constant communication throughout the application process to find the best matches across teachers and companies. Matthew Thomson and John MacFarlane from the Idaho STEM Action Center expressed a similar concern with overpopulation of one group over the other. John MacFarlane noted, "Matchmaking is the biggest issue we face. It's a real challenge in rural areas where we might have several educators apply to be externs, but we don't have enough local businesses to host them." Their suggestion to combat this issue was to have a shorter timeline between the application process and the start date of the program. This recommendation ensures that the size of each group stays relatively similar throughout the pairing process and that the interest of both parties remains high before the program begins.

Different programs use a range of models for work within a company to achieve the same goal. One model emphasizes a breadth of exposure to fill the extern's time at a company, where participants gain a holistic experience about the industry by working in a different part of the company each week. Externs that partake in this kind of model perform a mix of shadowing roles and guided, hands-on work. Another model emphasizes the importance of depth into one part of a company. In this program model, externs work in one section of a company performing project-based work that reflects how one part of an industry functions. Both program models attempt to provide participants with relevant, real-world experiences that can be implemented into course curricula in order to reflect what externs learned during their time in a company.

External funding through educational grants is a method that many externships use to aid in the launch of their program. The Cape Cod Regional STEM Network stated that their Teacher-in-Residence Program began with an NSF grant that funded the expansion of the STEM network in 2015. The Iowa program also indicated that the initial framework of their program relied on a 1.2-million-dollar grant from the NSF. The Idaho program followed a similar

approach where they obtained funding from a workforce development training fund. All of the externship organizers suggested that new programs could use grant funding to pay the teacher stipend for the first year in hope that the company would continue to fund the program for future iterations. This would provide companies the opportunity to see the impact that the program makes on teachers and their students without financial risk.

4.3. A recommended pilot design for WPI's STEM Educator Externship Program

In this section, we suggest a pilot design of the WPI STEM Educator Externship Program that accommodates stakeholder preferences and requirements in conjunction with the recommendations of existing externship organizers. This proposed design was created using the feedback about Model A and Model B from the follow-up interviews. The similarities and differences can be found in Table 2 below.

Table 2: Model A/B Program Designs

<table>
<tr><th>Model A</th><th>Model B</th></tr>
<tr><td colspan="2">4 days a week, 8 hours each day during the summer</td></tr>
<tr><td colspan="2">Weekly stipend of $500-$1,000, provided by companies</td></tr>
<tr><td colspan="2">Half-day, virtual, weekly meeting with STEM Education Center</td></tr>
<tr><td colspan="2">Externship experiences shared with company through end-of-program presentation</td></tr>
<tr><td>4 weeks</td><td>6 weeks</td></tr>
<tr><td rowspan="2">Moving to different aspects of the company each week, performing collaborative, hands-on work</td><td>2 weeks of shadowing, 4 weeks of self-directed project work</td></tr>
<tr><td>Remain in same department for entirety of program</td></tr>
<tr><td>Curriculum created based on holistic experience in industry</td><td>Curriculum created based on their self-directed project</td></tr>
<tr><td></td><td>Single-day activity sponsored by the company with the classroom</td></tr>
</table>

We recommend that the externship program have a duration ranging from four to five weeks during the summer. In the follow-up interviews, teachers reiterated the importance of the program having a duration closer to four weeks as to not take up too much of their summer. Furthermore, externship organizers suggested that the preferred duration of similar programs was about 200 hours, which equates to 5 weeks of full-time work. When considering the interests of both employers and educators, as well as the advice of current externship organizers, our recommendation settled on a range of 4 to 5 weeks with each week consisting of four 8-hour workdays. Feedback from the follow-up interviews indicated that participants felt this duration would be long enough to allow for educators to receive training in order to make meaningful contributions to their host companies.

We suggest that the externship program have a combination of independent work and shadowing positions available to educators. When discussing the content of the two proposed externship program models, participants indicated that the program content included in Model B was more desirable. The details of both program model designs can be found in Table 2 as well as in Appendix C under *Follow-up Interview Protocol*. Teachers noted in follow-up interviews that a program which focused on completing a project in a specific part of a company provided more benefit than moving between departments, as teachers are often specialized in a single subject. While a holistic understanding of a company throughout an externship program was interesting to some participants, they suggested it may not provide material on the same scale of relevance as a deeply focused project in a subject of interest. Both educators and company representatives indicated that shadowing an industry professional for one week or less before performing project work would be ideal. The externship organizers that were interviewed suggested a brief shadowing role in order to allow the educator externs to become comfortable in the industry setting prior to making meaningful contributions to the host companies. Several participants noted in the follow-up interviews that the ideal length for shadowing an industry professional would be less than one week for a four-to-five-week program. Externship organizers also indicated that their programs followed a similar design which provided educators with guided projects that encompassed a mix of shadowing and independent work.

We suggest that the externship program provide teachers with a weekly stipend of 500 to 1000 dollars for the duration of the program. Given the input of the stakeholders as well as current externship organizers, we suggest teachers should be compensated 500-1000 dollars per week in the form of weekly stipends for the duration of the program. This proposed stipend equates to about 16-31 dollars per hour for the suggested 32-hour work week, which is similar to the stipends offered by educator externship programs located in Iowa and Idaho. Based on our discussions with company representatives, a stipend of this value would also be reasonable to host companies, since they pay a similar hourly rate to interns. Further details about the externship programs that were consulted can be found in Appendix D.

We recommend that the externship program provide teachers with one half-day of professional development each week with the WPI STEM Education Center to develop a curriculum module that can be implemented into the classroom. Teachers commented that one aspect of notable professional development programs was when the outcome included a full curriculum module, which could be implemented into their course upon completion. Providing educators with a few hours each week to work directly with the WPI STEM Education Center would allow educators to share their experiences in the externship program and discuss how to translate those experiences to the classroom. Further, it would provide guidance to the participating educators when creating this deliverable to ensure that it is of high quality. Additionally, companies have stated that they would like to be involved in professional development programs that accurately and effectively impact the curricula taught in the classroom. Allowing educators to review their experience at host companies on a weekly basis would help ensure that the experience is broken down into lesson plans or activities that may have a positive effect on students in the classroom. The externship program organizers that were interviewed also stated that they had a similar component in their programs, where educators created a deliverable. This component allowed the organizers to certify the program with the state or district standards for professional development for educators.

5. Recommendations and Conclusions

In this chapter, we suggest implementation recommendations for an externship program based on interviews with stakeholders. Next, we discuss a recommended timeline of events for carrying out a proposed externship program. We finish by summarizing potential long-term program benefits during this period of change in STEM industry and education.

5.1. Implementation recommendations for an externship program

Below, we note the implementation recommendations that show promise in helping an externship program gain traction through its beginning stages. These suggestions include methods for advertising as well as potential for grant funding for initial iterations of the program.

We suggest an online method of advertising that allows for educators and companies to be effectively matched. When conducting follow-up interviews, educators expressed that they would need more information about the company that they would be working with. Educators needed to know that the company they would be matched with would be doing work relevant to their field of interest. Matching educators with companies that have similar interests and focuses could be accomplished through the use of a website, considering the externship organizers that we interviewed used this sort of matchmaking process. The website could feature an in-depth description of each offering to allow educators to find a project that is appealing to them. Additionally, advertisements could be done through social media posts or emails directed towards the educators.

We suggest that online advertising be used to incentivize educators and employers to participate in the program. Points of interest that could be used to incentivize both educators and employers through the form of advertisements are as follows:

<u>Educators:</u>

- Hands-on, real-world, professional experience
- PDP credits awarded to the educator through the WPI STEM Education Center
- A weekly stipend

- A curriculum module upon completion of the program
- Industry connections

Employers:

- Strengthen the future talent pipeline by influencing the teaching of STEM
- A project to be completed for the company as a deliverable
- Help improve local education
- Expand community outreach

We recommend that the STEM Education Center pursue potential grants to help fund a pilot run of the STEM Educator Externship Program. Successful externship programs suggested that the pilot program run using grant funding to reduce initial cost for employers, which allowed them to see the impact of the program without financial risk. These grants would be used to cover the stipends provided for educators as well as any costs associated with the organization and maintenance of the pilot program. The weekly professional development sessions held by the STEM Education Center, as proposed in the previous chapter, would also require similar funding, as this would be considered part of the operating cost of the program. The majority of grants discussed by externship organizers were awarded through either the National Science Foundation (NSF) or through state-level departments of education. For example, the Cape Cod Regional STEM Network has funded its Teacher-in-Residence program using the NSF grant for Transforming STEM Education on Cape Cod and Region (NSF Grant #1347610). This targeted grant is intended to help improve STEM education practices in the Cape Cod region through funding professional development programs for K-12 educators. Similarly, the Iowa Governor's STEM Advisory Council has received the Real World Experiences for Teachers of Mathematics and Science grant, also through the NSF (NSF Grant #1031784). This grant was awarded in order to support programs that would allow for STEM educators to be exposed to the real-world STEM industry, such as an educator externship program. The NSF also offers the Accelerating Discovery: Educating the Future STEM Workforce grant, which is directed towards researching and implementing new methods of teaching students in STEM in order to better prepare them for the workplace.

In addition to federal grants, the Massachusetts Department of Elementary and Secondary Education (DESE) has also offered many relevant grants. In 2018 and 2020, Fitchburg State University was awarded the Teacher Externship Summer Program Grant (Fund Code 404). This grant, with a total value of up to $400,000, is intended to support the continuation of a summer educator externship program. Although this specific grant has already been awarded, it is an indication that the Massachusetts DESE is motivated to offer financial support to the administrators of externship programs. Similar grants offered in recent years include the Summer and Vacation Learning Program Grant (Fund Codes 114/333/238) and the Educational Technology Professional Development Grant (Fund Code 421), both of which are meant to provide financial support to the administrators of educator professional development programs. In addition to the NSF and state departments of education, other grants can be found through private educational organizations, such as foundations or corporations.

5.2. Proposed timeline for an externship

In this section, we suggest a timeline for a pilot externship program. This timeline aims to facilitate the process of organizing an externship program by incorporating suggested deadlines for each step.

Figure 7: Proposed Externship Timeline

We recommend a timeline for a pilot externship program design as shown in Figure 7. When conducting interviews with stakeholders and externship organizers, we gained valuable information about the deadlines and steps that are implemented in order to run a successful program. Each timeline step is explained below.

1. **Secure Host Companies (December - February):** First, we suggest that the STEM Education Center begin to reach out to host companies in early December and initiate

discussions about their interest in participating in an externship program. It is important to begin company discussions early in order to better understand and be able to advertise the types of projects that could be available to teacher externs.

2. **Begin Application Process (February - April):** We recommend that the application process, which includes opening the application for participants, not begin until February and not run past April. This could keep potential participants from losing interest over time.
3. **Accept Externship Applicants (April - June):** We recommend that the process of accepting teacher applicants and matching them with relevant companies begin in April and continue into June. We suggest ample time to accept applicants to allow discussions with the accepted participants and their matched host company to decide on the content for the duration-long project and their focus at the company.
4. **Run Program (4-5 Weeks in July):** We recommend that the program run for 4 to 5 weeks starting in July. In central Massachusetts, teachers are typically released for summer in mid-June and return for classes in late August or early September. Starting the program in July would allow the participants to have a couple weeks of break before and after the program.
5. **Gain Participant Feedback (After Program Completion):** After the program is completed, it is recommended that the STEM Education Center connect with participants for follow-up discussions about the program. During interviews with externship organizers, it was found that feedback from externs was crucial to continuously improving their program. We suggest that follow-up interviews or surveys are used to gain relevant suggestions for program improvements.

5.3. Long term impacts

Beyond the immediate outcomes that this program provides, there are several long-term benefits. These benefits include an improved talent pipeline, a more relevant STEM curriculum, and heightened STEM industry awareness. In this section, we summarize these impacts and their importance to both educators and employers.

The introduction of a STEM educator externship program in central Massachusetts can improve the local talent pipeline and impact the STEM industry. A STEM educator externship program increases an educator's knowledge capacity and awareness of a STEM career that is ideally related to their subject. Providing this experience to teachers through an externship program can supply them with years of relevant knowledge in an industry related to the subject that they teach. Further, both a curriculum module and a company sponsored activity, which are deliverables of the proposed externship program, would translate the educators' involvement into a tangible experience for their students. These deliverables can improve the STEM curriculum by making it more closely resemble real-world industry practices. This experience has the potential to make students more aware of the capacity of STEM careers available and to hopefully stimulate their interest at a younger age. Additionally, this exposure and interest could then make STEM-related subjects more engaging to students. Improving the way STEM is taught and increasing the awareness of STEM careers in central Massachusetts could ultimately increase the quantity and improve the quality of students pursuing STEM-related careers.

References

2021 News: Cape Cod regional STEM network at 4Cs looks to pair pre-k-12 educators with "teacher-in-residence" opportunities. (n.d.). Cape Cod Community College. Retrieved May 6, 2021, from https://www.capecod.edu/news/2021-news/cape-cod-regional-stem-network-at-4cs-looks-to-pair-pre-k-12-educators-with-teacher-in-residence-opportunities.html

Affouneh, S., Burgos, D., Khlaif, Z., Mater, N., Odeh, A., Saifi, A., & Salha, S. (2020). *Factors that foster and deter STEM professional development among teachers* (Vol. 104, pp. 857–872). Science Education. https://onlinelibrary.wiley.com/doi/epdf/10.1002/sce.21591?saml_referrer=

Alamprese, J., & Stickney, E. (2001). *Connecting people, practices, and policies: Evaluation of the outreach and technical assistance network* (Evaluative No. 142). Abt Associates. https://files.eric.ed.gov/fulltext/ED467527.pdf

Angle, J., Colston, N., French, D., Gustafson, J., & Shaw, E. (2016). Addressing the call to increase high school student's STEM awareness through a collaborative event hosted by science and education faculty: A how-to approach. *Science Educator*, *25*(1), 43–50.

Barker, B., Welch, G., Grandgenett, N., Wu, C., & Nelson, C. (2015). A model of factors contributing to STEM learning and career orientation. *International Journal of Science Education*, *37*(7), 1067–1088. https://doi.org/10.1080/09500693.2015.1017863

BellSouth Foundation. (1999). *A new model for business investment in educational change. Shaping the "before, during and after" of teacher internships*. Bell South Foundation. https://files.eric.ed.gov/fulltext/ED434229.pdf

Bidwell, S. E. (1997). *Helping teachers connect academics to the workplace: An implementation guide for teacher worksite externships*. Publications, Center on Education and Training for Employment, 1900 Kenny Road, Columbus, OH 43210-1090; telephone: (800) 848-4815, ext. https://eric.ed.gov/?id=ED411439

Bissell, R., Haak, L., Ramsey, M., Reed, C., & Stine, D. (2007). *Rising above the gathering storm: Energizing and employing America for a brighter economic future*. The National Academies of Science Engineering Medicine. https://books.nap.edu/read/11463/chapter/1#iii

Bowen, B., & Shume, T. (2018). Educators in industry: An exploratory study to determine how teacher externships influence K-12 classroom practices. *Journal of STEM Education*, *19*(1), 5–10.

Cape Cod Regional STEM Network. (n.d.). *Supporting STEM at School and in the Community*. Cape Cod Regional STEM Network. Retrieved March 12, 2021, from https://capecodstemnetwork.org/about-us/

Darling-Hammond, L., Hyler, M., & Gardner, M. (2017). Effective teacher professional development. *Learning Policy Institute*. https://learningpolicyinstitute.org/product/effective-teacher-professional-development-report

Desimone, L. (2011). A primer on effective professional development. *The Phi Delta Kappan*, *92*(6), 68–71.

Fields, E., Levy, A., Karelitz, T., Martinez-Gudapakkam, A., & Jablonski, E. (2012). The science of professional development. *The Phi Delta Kappan, 93*(8), 44–46.

Gibson, L., & Gray, G. (2010). Knowledge and understanding of the 21st century skills through educator externships: Programs in southern new england. *Center for Research and Evaluation*. https://scholarsarchive.jwu.edu/cgi/viewcontent.cgi?referer=https://www.google.com/&httpsredir=1&article=1001&context=k12_ed

Greater Los Angeles Consortium on Externships (GLACE). (2017). Field Placement Supervision Manual. *Greater Los Angeles Consortium on Externships (GLACE)*. https://www.lls.edu/media/loyolalawschool/glace/GLACE%20Manual%202017newupdate.pdf

Harpole, S., Kerley, L., Silvernail, D., Kinard, F., & Brooks, P. (2010). SCIENCE on the shipyard: Bridging the gap between industry and the classroom. *The Science Teacher*, *77*(4), 48–52.

Hayden, K., Ouyang, Y., Scinski, L., Olszewski, B., & Bielefeldt, T. (2011). Increasing student interest and attitudes in STEM: Professional development and activities to engage and inspire learners. *Contemporary Issues in Technology and Teacher Education*, *11*(1), 47–69.

Hutchison, L. F. (2012). Addressing the STEM teacher shortage in American schools: Ways to recruit and retain effective STEM teachers. *Action in Teacher Education*, *34*, 541–550. https://doi.org/10.1080/01626620.2012.729483

Leahey, T. E. (2016). Professional development: Does it matter? In G. S. Edmonds & T. M. Squires (Eds.), *Bridging the High School-College Gap* (pp. 33–40). Syracuse University Press. https://www.jstor.org/stable/j.ctt1j1nwch.9

Lippman, L., Ryberg, R., Carney, R., & Moore, K. A. (2015). *Key "soft skills" that foster youth workforce success: Toward a consensus across fields*. Child Trends. https://www.childtrends.org/publications/key-soft-skills-that-foster-youth-workforce-success-toward-a-consensus-across-fields

Luft, V., & Vidoni, K. (2000). Educator externships: How classroom teachers can acquire business and industry experience. *Taylor & Francis, Ltd.*, *74*, 81–83.

Massachusetts Department of Elementary and Secondary Education. (2012a). License Renewal Guidelines for Massachusetts Educators. *Massachusetts Department of Elementary and Secondary Education*. https://www.doe.mass.edu/licensure/academic-prek12/guidelines-recert-ma-educators.pdf

Massachusetts Department of Elementary and Secondary Education. (2012b). *The Massachusetts Standards for Professional Development*. Massachusetts Department of Elementary and Secondary Education. https://www.doe.mass.edu/pd/standards.html

Memon, S., Umrani, S., & Pathan, H. (2017). Application of constant comparison method in social sciences: A useful technique to analyze interviews. *Journal of Grassroot*, *51*(1), 152–165.

Newmann, F. M., & Wehlage, G. G. (1995). *Successful school restructuring: A report to the public and educators*. 72.

Oberst, B., & Jones, R. (2004). *Canaries in the mineshaft*. World Expertise. https://www.worldexpertise.com/Canaries_in_the_Mineshaft_-_Engineers_in_the_Global_Workplace.htm

Roberts, L. (2013). Nashville teachers graduate STEM curriculum with Corps externships. *U.S*

Army. https://www.army.mil/article/106688/nashville_teachers_graduate_stem_curriculum_with_corps_externships

Ryder, H., & Perabo, G. (1985). *The complex challenge of professional development: Current trends and future opportunities.* https://eric.ed.gov/?id=ED265911

Salha, Dr. S. H., & Abu Sarah, A. M. (2019). The effectiveness of using science, technology, engineering, and mathematics (STEM) approach on the achievement of students of the tenth grade in mathematics. *Journal of Al-Quds Open University for Educational & Psychological Research & Studies*, *10*(28), 101–113. https://doi.org/10.5281/zenodo.3474118

Seifert, K., & Sutton, R. (2009). The changing teaching profession and you. In *Educational psychology*.

Shuman, L. J., Besterfield-Sacre, M., & McGourty, J. (2005). The ABET "professional skills" — Can they be taught? Can they be assessed? *Journal of Engineering Education*, *94*(1), 41–55. https://doi.org/10.1002/j.2168-9830.2005.tb00828.x

STEM Ecosystems. (n.d.). *Ecosystem spotlight: Cape Cod regional STEM network*. STEM ecosystems. https://stemecosystems.org/ecosystem-spotlight-cape-cod-regional-stem-network/?print=pdf

Stevens, M., & Norman, R. (2016). Industry expectations of soft skills in IT graduates: A regional survey. *Proceedings of the Australasian Computer Science Week Multiconference*, 1–9. https://doi.org/10.1145/2843043.2843068

Stewart, F. (2017). *The STEM dilemma: Skills that matter to regions*. W.E. Upjohn Institute.

https://research.upjohn.org/up_press/245/

Terry, K. (2009). Externships: A signature pedagogy for the apprenticeship of professional identity and purpose. *Journal of Legal Education, 59*, 240–268.

Tyreman, J. (2020). In-depth interview vs online survey: A marketing director's guide to brand research data collection. *Professional Services Marketing Today*. https://hingemarketing.com/blog/story/in-depth-interviews-vs-online-surveys-a-marketing-directors-guide-for-brand

U.S. Department of Education. (n.d.). *Science, Technology, Engineering, and Math, including Computer Science*. U.S. Department of Education. Retrieved April 16, 2021, from https://www.ed.gov/STEM

Walker, T. (2019). PISA 2018: Slight U.S. progress, but what do the results really tell us? *National Education Association*. https://www.nea.org/advocating-for-change/new-from-nea/pisa-2018-slight-us-progress-what-do-results-really-tell-us

Worcester Polytechnic Institute. (2011). *WPI to create a STEM Education Center*. WPI. https://www.wpi.edu/news/stem-edcenter

WPI STEM Education Center. (n.d.). *For PK-12 educators*. Retrieved March 13, 2021, from https://www.wpi.edu/academics/stem-education-center/professional-development

Wu, T., & Albion, P. (2019). *Investigating remote access laboratories for increasing pre-service teachers' STEM capabilities*. *22*(1), 82–93.

Appendices

Appendix A: Interview Protocol

Educator Interview Protocol

Date:

Location:

Type of Interview:

Interviewee:

Interviewers/Roles:

Interviewer A: Questioner

Interviewer B: Note Taker

Interviewer C: (if applicable) Note Taker/Follow-up Questions

Introduction Script:

Hello, we are students at WPI conducting research in collaboration with the WPI STEM Education Center. XXXXX gave us your contact information because they felt that your perspective would be beneficial to our project. Our team is designing a pilot externship program for secondary school STEM educators. We define an externship as a professional development opportunity, which will connect educators with a STEM-related company to gain first-hand experience about what it is like to work in the industry. They can then use these experiences to further develop their curricula to stimulate their students' interest in STEM subjects and to provide insight into what it is like to work in STEM-related careers. The interview is intended to take less than thirty minutes.

Confidentiality Protocol Questions:

- Do you mind if we record this interview?
- Are you comfortable with us using your name and/or position in our final report or would you prefer to remain anonymous?

- Is it okay if we quote you in our report? If yes, you will be allowed a chance to review the quote before it is added to the final report.
- Would you like a copy of our final report?

*The confidentiality protocol questions will be asked at the beginning of the interview as well as at the end of the interview to verify that the interviewee is still comfortable with the use of their information.

Ice Breakers:

- What subject do you currently teach, and how long have you been teaching it?
- What grade level(s) do you teach?

Project-specific questions:

1. What has been a notable professional development experience you have had?
    a. What made it notable?
2. How do you find new professional development opportunities?
3. Are you familiar with the idea of an externship program?
    a. We define an externship program as a learning opportunity focused on providing business or industry experience to those who participate. One example from the Army Corps of Engineers brought a group of teachers to participate in their projects; in one specific example, the teachers collected water samples at different depths for testing in efforts to preserve local ecosystems. Another program by the Cape Cod Regional STEM Network brought teachers into a museum to observe hands-on preservation work. In both cases, the teachers created a deliverable at the end of the program that reflected what they learned.
4. If you were to partake in an externship program, what outcomes would you want to gain from the experience?
5. After partaking in an externship program, how would you hope for the program to affect the curricula you teach in the classroom?
6. If you were to participate in an externship program, would you be more interested in a shadowing role or would you like to perform independent work such as a project?

7. What types of worksites (factory floor, lab, office space, etc.) would you value the most in an externship program? What types of worksites would you not find helpful in an externship program?
8. During an externship program, participants might be expected to work on-site 3-5 days a week. When would you prefer to complete the program (during the summer or during the school year)?
9. What would be the ideal duration for this program? (for the preliminary design of the program, the duration being considered is 3 to 6 weeks. Should this duration be longer or shorter? By how much?)
10. How important do you feel it is for teachers to receive payment for professional development experiences? How much would you expect in compensation for participation in this kind of program?
11. Do you have any other contacts, such as other middle or high school STEM teachers, that you think could provide useful information to our team and would you be willing to forward their contact information?

Employer Interview Protocol

Date:

Location:

Type of Interview:

Interviewee:

Interviewers/Roles:

Interviewer A: Questioner

Interviewer B: Note Taker

Interviewer C: (if applicable) Note Taker/Follow-up Questions

Introduction Script:

Hello, we are students at WPI conducting research in collaboration with the WPI STEM Education Center. XXXXX gave us your contact information because they felt that your perspective would be beneficial to our project. Our team is designing a pilot externship program for secondary school STEM educators. We define an externship as a professional development opportunity, which will connect educators with a STEM-related company to gain first-hand experience about what it is like to work in the industry. They can then use these experiences to further develop their curricula to stimulate their students' interest in STEM subjects and to provide insight into what it is like to work in STEM-related careers. The interview is intended to take less than thirty minutes.

Confidentiality Protocol Questions:

- Do you mind if we record this interview?
- Are you comfortable with us using your name(s) and/or position(s) in our final report or would you prefer to remain anonymous?
- Is it okay if we quote you in our report? If yes, you will be allowed a chance to review the quote before it is added to the final report.
- Would you like a copy of our final report?

*The confidentiality protocol questions will be asked at the beginning of the interview as well as at the end of the interview to verify that the interviewee is still comfortable with the use of their information.

Ice Breakers:

- How long have you been working at Company X, and what is your position at the company?

Project-specific questions:

1. Are you familiar with the idea of an externship program?
    a. We define an externship program as a learning opportunity for teachers focused on providing business or industry experience to those who participate. The goal would be for the teachers to use that experience to increase student interest and awareness in STEM career opportunities. One example from the Army Corps of Engineers brought a group of teachers to participate in their projects; in one specific example, the teachers collected water samples at different depths for testing in efforts to preserve local ecosystems. Another program by the Cape Cod Regional STEM Network brought teachers into a museum to observe hands-on preservation work. In both cases, the teachers created a deliverable such as a project, assignment, or presentation at the end of the program that reflected on what they learned.
2. Does your company currently offer any professional development or community outreach programs (internships, co-ops, etc.)?
    a. If yes, what are their parameters (duration, compensation, logistics)?
    b. If yes, how are these programs advertised?
3. What projects have your company been working on recently? How do you feel teacher externs could be involved in the completion of these projects?
4. One of the goals of an externship program is to increase interest in STEM fields in the classroom. What outcomes would you expect of teachers at the end of the program that could help to increase interest in your industry?

5. What outcomes at the end of the program would you expect from teachers to contribute to your company?
6. Do you feel your company would benefit from hosting an externship program for educators? Why or why not?
7. What would be the ideal duration for this program? For the preliminary design of the program, the duration being considered is 3 to 6 weeks. Should this duration be longer or shorter? By how much?
8. Sometimes teachers receive stipends for professional development experiences such as internships. Do you think your company would be open to paying a weekly stipend?
    a. If yes, does $500 per week sound feasible?

Externship Organizer Interview Protocol

Date:

Location:

Type of Interview:

Interviewee:

Interviewers/Roles:

Interviewer A: Questioner

Interviewer B: Note Taker

Interviewer C: (if applicable) Note Taker/Follow-up Questions

Introduction Script:

Hello, we are students at WPI conducting research in collaboration with the WPI STEM Education Center. XXXXX gave us your contact information because they felt that your perspective would be beneficial to our project. Our team is designing a pilot externship program for secondary school STEM educators. We define an externship as a professional development opportunity, which will connect educators with a STEM-related company to gain first-hand experience about what it is like to work in the industry. They can then use these experiences to further develop their curricula to stimulate their students' interest in STEM subjects and to provide insight into what it is like to work in STEM-related careers. The interview is intended to take less than thirty minutes.

Confidentiality Protocol Questions:

- Do you mind if we record this meeting?
- Are you comfortable with us using your name(s) and/or position(s) in our final report or would you prefer to remain anonymous?
- Is it okay if we quote you in our report? If yes, you will be allowed a chance to review the quote before it is added to the final report.
- Would you like a copy of our final report?

*The confidentiality protocol questions will be asked at the beginning of the interview as well as at the end of the interview to verify that the interviewee is still comfortable with the use of their information.

Ice Breaker Questions:

- How long have you been working at X organization? What parts of the organization enticed you to join?

Project Related Questions:

1. What motivated the creation of the externship program through your organization?
2. How is your program advertised or publicized to both teachers and employers?
3. How does your organization incentivize companies to partake in the externship program?
4. How did your program go about certifying the content with your state's department of education in order to make the program equivalent to standard professional development offerings?
    a. If they don't know, explain the PDP requirements for MA and the content areas teachers are expected to partake in each year.
5. How did your organization determine the parameters of the program when it was being designed?
    a. First with respect to teachers (working hours, time of year, work cite, deliverables at the end of the program)
    b. Second with respect to host companies (Wages, time of year, educational outcomes, timeframe)
6. How does your organization measure the success of the participants at the end of the program?
    a. Are there certain deliverables that help in measuring this success (survey, implementing projects/curriculum changes, post-program interviews)?
7. What is something a participant from your program would say was most beneficial to them after completing the externship?
8. What are some things that have been successful for your externship program?

9. What are some things that did not work well for your externship program?
10. Do you have any other contacts that you think could provide useful information to our team and would you be willing to forward their contact information?

Appendix B: Content Analysis Method Description

Maykut-Morehouse content analysis description

The first step in our content analysis method was to inductively categorize the data so that we could break down the interview transcripts into recurring themes and concepts. For educator interviews, the categories were *Parameters*, *Experiences*, and *Advertising*. The questions related to *Parameters* were designed to provide information regarding the logistical design of the externship program (duration, location, etc.). The questions categorized under *Experiences* were designed to gain information related to the specific activities that an educator would participate in and what would be the desired outcome(s) of the program. For *Advertising*, the question aimed to provide information regarding the most effective method for teachers to discover the externship. For the educator interview questions, our categorization is shown in the following table (questions numbers aligned with interview questions in *Educator Interview Protocol* in Appendix A):

Category	*Parameters*	*Experiences*	*Advertising*	*n/a**
Question Number	1, 6, 7, 8, 9, 10	1, 4, 5, 6	2	3, 11

*Questions under "n/a" will not be analyzed, question 3 serves to clarify the idea of an externship, and question 11 serves to expand our pool of interviewees.

For the employer interviews, the categories were *Parameters* and *Employer Benefits*. As with the educator interview questions, the *Parameter* category focused on information related to design details of the externship program. The questions under the *Employer Benefits* category were designed to provide insight into how an externship program could benefit the host company and what characteristics of the program would be most desirable to the company. The categorization of the employer interview questions is shown in the following table (questions numbers aligned with interview questions in *Employer Interview Protocol* in Appendix A):

Category	*Parameters*	*Employer Benefits*	*n/a**
Question Number	2, 4, 5, 7, 8	3, 4, 5, 6	1

*Questions under "n/a" will not be analyzed, question 1 serves to clarify the idea of an externship.

Once we conducted a sufficient amount of interviews, we refined the categories and redefined them into groups that could be most effectively analyzed. In this step, we determined criteria amongst the data that allowed us to interpret the information. We reviewed the notes and transcripts from each interview and organized the responses from educators and company representatives into a spreadsheet to facilitate the identification of common themes and disagreements. To maintain consistency during this process, the content analysis guide shown in the next section of this appendix was used. This guide broke down the interview questions into categories based on whether the responses would be a set of keywords or phrases, a numerical response, or a yes or no answer. The outcome of this step was to have the educator and employer desires and requirements specifically defined in a list of categories that could be cross analyzed. Through this analysis, descriptive statistics, such as the percent of interviewees that provided a certain response, were compiled and presented to our sponsors at the WPI STEM Education Center in order to prepare for the follow-up interview process.

The next step of our content analysis process was to explore relationships and disagreements across the educator and employer *Parameters* category. The last step was to design the pilot externship program and provide basic information about the most effective form of advertisement. We used the information gained from the analyzed parameters to design a structure that was desirable for all stakeholder groups in the program. We used the *Experiences* category to determine the general types of worksites that teachers wanted to attend (factory floors, labs, office spaces, etc.). The *Advertising* category was used to determine the best way to promote interest in both educators and employers. The *Employer Benefits* category was used to incentivize companies to host educators for this program. The results collected in the Externship Organizer Interview Questions had a small sample size and were not analyzed using the previously described content analysis.

Interview Data Collection Guide

INTERVIEW DATA COLLECTION GUIDE
WPI STEM EDUCATION CENTER STEM EXTERNSHIP PROGRAM

Educator Personal Interviews:

Question 1: Break apart their response into one or several keywords for further analysis
Potential Keywords: Online, Abroad, College, 3rd-Party, Research, Job, hands-on, Project, PBL, Certification, Accreditation.

Question 2: Break apart their response into one or several keywords for further analysis
Potential Keywords: Online, School, Colleague, Family Member, Word of Mouth, College.

Question 3: Record a yes or no answer as Y for yes or N for no.

Question 4: Break apart their response into one or several keywords for further analysis
Potential Keywords: Curriculum, Activities, Project, Presentation, Knowledge, Professionalism, Workplace Experience, Connections, Interest, Student.

Question 5: Break apart their response into one or several keywords for further analysis
Potential Keywords: Activities, Project, Presentation, Interest, Experience, Expertise, Perspective.

Question 6: Record 'Hands-on' or 'Observer' based on the interviewee response

Question 7a: Break apart their response into one or several keywords for further analysis
Potential Keywords: Factory, Lab, Office, Research, Tech, Engineering, Accounting, Robotics, Construction, Outdoors/Outside.

Question 7b: Break apart their response into one or several keywords for further analysis
Potential Keywords: Factory, Lab, Office, Research, Tech, Engineering, Accounting, Robotics, Construction, Outdoors/Outside, Classroom, School, Online.

Question 8: Record 'Summer' or 'School year' based on the interviewee response

Question 9: Record numerical inputs with values ranging from 3 to 6 based on the interviewee response.

Question 10a: Record response on a range of Unimportant, Slightly Unimportant, Neutral, Slightly Important, Important.

Question 10b: Record numerical inputs based on the interviewee response

Employer Personal Interviews:

Question 1: Record a yes or no answer as Y for yes or N for no.

Question 2a: Record a yes or no answer as Y for yes or N for no.

Question 2b: Break apart their response into one or several keywords for further analysis

Potential Keywords: Workshops, Community Service, Coaches, Guest Speaker, Webinar, Shadowing, Conferences, Online, School

Question 2c: Break apart their response into one or several keywords for further analysis

Potential Keywords: Online, Flyer, Word-of-mouth, Commercials, School Districts, Internal

Question 3: Break apart their response into one or several keywords for further analysis

Potential Keywords: Hands-on, Shadowing, Independent, Project, Management, Organization, Training, Learning.

Question 4: Break apart their response into one or several keywords for further analysis

Potential Keywords: Curriculum, Presentation, Connections, Experience, Recruitment, Outreach, Exposure, Project.

Question 5: Break apart their response into one or several keywords for further analysis

Potential Keywords: Deliverable, Project, Independent, Management, Organization, Training, Learning, Feedback, Perspective.

Question 6a: Record a yes or no answer as Y for yes or N for no.

Question 6b: Break apart their response into one or several keywords for further analysis

Potential Keywords: Exposure, Interest, Career, Diversity, Workplace, Morals, Values, Perspectives, Culture, Background, Inclusion, Representation, Talent.

Question 7: Record numerical inputs with values ranging from 3 to 6 based on the interviewee response.

Question 8a: Record response on a range of Unimportant, Slightly Unimportant, Neutral, Slightly Important, Important.

Question 8b: Record numerical inputs based on the interviewee response.

Appendix C: Follow-up Interview Protocol & Presentation

Follow-up Interview Protocol

Date:

Location:

Type of Interview:

Interviewee:

Interviewers/Roles:

Interviewer A: Questioner / Presenter

Interviewer B: Note Taker

Interviewer C: (if applicable) Note Taker/Confidentiality Questions

Introduction Script:

Thank you for agreeing to partake in the follow-up portion of our personal interviews. We hope to use this follow-up interview as an opportunity to evaluate the proposed designs that were created using the information gathered in our first round of interviews. We plan on presenting a short description of the findings from our interviews and then presenting two models that we created based on these findings. We will then ask you some questions about your thoughts on them. Similarly to the last set of interviews, this interview is planned to take 30 minutes.

Confidentiality Protocol Questions:

- Do you mind if we record this interview?
- Are you comfortable with us using your name and/or position in our final report or would you prefer to remain anonymous?
- Is it okay if we quote you in our report? If yes, you will be allowed a chance to review the quote before it is added to the final report.

*The confidentiality protocol questions will be asked at the beginning of the interview as well as at the end of the interview to verify that the interviewee is still comfortable with the use of their information.

Presentation: (Shown below)

Ask after each model is presented:

1. Based on the description of this model, do you feel that you have a good understanding of what the program is designed to accomplish, and who it is for?
2. What information would you need to know before attending this program as proposed?
3. What would make you want to participate in this program?
4. What would deter you from participating in this program?
5. How relevant is this program to your current role and the work you do?
6. Do you feel that this type of work experience is achievable in this timeframe?
7. How likely would you be to participate in a program like this?

Ask after both models are presented:

If you were to choose one of these programs to partake in, which program would you choose and why?

Follow-up Interview Presentation

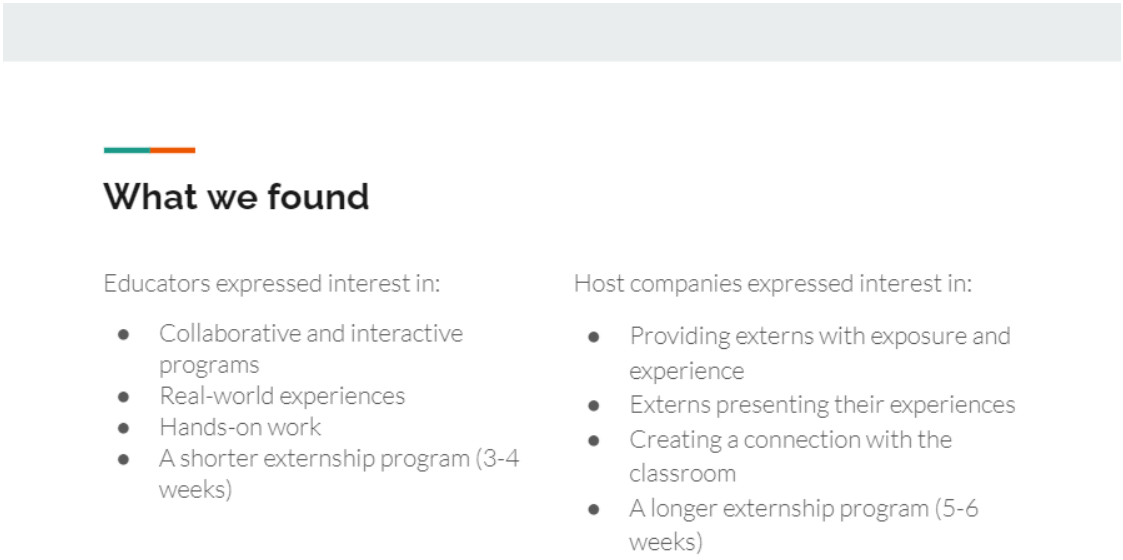

Figure C.1: Key Findings Slide from Follow-up Interviews

Presenter Notes:

We performed interviews with twelve educators and five company representatives to give us information to inspire our externship program design. A few of the recurring themes from our interviews are seen here.

- Educators wanted an externship that:
    - Inspired collaboration and interactive programs.
    - They wanted a sort of activity or project that was applicable to real-world experiences and allowed for them to perform hands-on work.
- Host companies wanted:
    - The externs to gain exposure and experience through an externship.
    - Companies specifically mentioned that they wanted externs to be able to present their experiences or findings back to the company, so that the company could hear what the externs specifically learned.
    - Additionally, the companies stressed that they wanted to create a connection between the classroom and workplace.
- The preferred length of the externship program for educators was between 3-4 weeks and

the preferred length for employers was 5-6 weeks.

- The reasoning behind these preferences is that educators value their summers greatly, and over a month of work would be a huge commitment, especially considering that many educators have part-time positions over the summer such as tutoring.

On the other hand, employers prefer at least a 5–6-week program because they feel that any less time would make it difficult for the extern to be effectively immersed in the industry and meaningfully contribute to the overall company.

Table C.1: Model A/B Program Designs

<table>
<tr><th>Model A</th><th>Model B</th></tr>
<tr><td colspan="2">4 days a week, 8 hours each day during the summer</td></tr>
<tr><td colspan="2">Weekly stipend of $500-$1,000, provided by companies</td></tr>
<tr><td colspan="2">Half-day, virtual, weekly meeting with STEM Education Center</td></tr>
<tr><td colspan="2">Externship experiences shared with company through end-of-program presentation</td></tr>
<tr><td>4 weeks</td><td>6 weeks</td></tr>
<tr><td rowspan="2">Moving to different aspects of the company each week, performing collaborative, hands-on work</td><td>2 weeks of shadowing, 4 weeks of self-directed project work</td></tr>
<tr><td>Remain in same department for entirety of program</td></tr>
<tr><td>Curriculum created based on holistic experience in industry</td><td>Curriculum created based on their self-directed project</td></tr>
<tr><td></td><td>Single-day activity sponsored by the company with the classroom</td></tr>
</table>

Presenter Notes:

We have two models for a program design with defining features shown in this chart. We'll let

you give us feedback on each model individually and then we'll let you give us feedback comparing both models.

Both programs:

- 4 days per week, externship program that runs during the summer.
- Externs work four days a week and eight hours per day.
- The fifth day of each week will be a half-day session with the STEM Education Center, working from home, on creating high quality curriculum.
- Externs would be paid through a weekly stipend between $500 and $1,000.
- The extern would present a presentation to the company to demonstrate what they learned and how they will incorporate the knowledge into the classroom at the end of the program.

Model A:

- 4-week duration
- This model would allow for externs to tour the multiple parts of the industry site to gain a holistic industry experience.
- The educator would be taught several skills from each section of the industry by shadowing industry professionals and doing hands-on work.
- The educators would work collaboratively on hands-on projects throughout the company in teams
- Ultimately, the teachers will be able to work with the STEM Center to use their experiences and knowledge to create a module of curriculum at the end of the program.

Model B:

- 6-week duration
- Externs would shadow industry professionals for training purposes for 2 weeks
- The remaining four weeks of the program allows the educator to work on a self-directed project that benefits the company
- The deliverable at the end of the program is a collaborative project with the company that encapsulates all the experience they've learned
- This project would then be turned into a module that can be used in the classroom by working with the STEM Education Center
- After the program is completed, there would be an opportunity for some form of activity such as a field trip to the host company, a mini project, or activity that the company would do to impact the classroom.

Appendix D: Externship Case Studies

Case 1: The Cape Cod Regional STEM Network's Teacher-in-Residence Program

Founded in 2004, the Cape Cod Regional STEM Network, in association with Cape Cod Community College and Woods Hole Sea Grant (a non-profit organization), created the Teacher-in-Residence Program. This two-week summer externship program was created in 2015 to connect K-12 STEM educators to relevant worksites in the area to provide real-world, hands-on marine science experience that participants can implement into the classroom. During the program, teachers get the opportunity to work on site at one of nine STEM-rich settings for a total of approximately 40 hours over the span of the two-week program, while the remainder of the time in the program is given to design effective curriculum lessons based on the experiences gained through the program. The program is primarily advertised through communications from the Cape Cod Regional STEM Network, which includes emails, social media posts, and professional networking.

Teachers that participate in the program are able to experience a blend of hands-on project work that benefits the worksite as well as shadowing industry professionals to gain experience on how their subject of interest is practiced in the field. The Teacher-in-Residence Program measures the success of its participants through helping teachers create an end-of-program curriculum module that teachers are able to directly implement into the classroom. This module consists of 3-4 lessons that capture what was learned during their time at the worksite. This module is able to be approved by the program director, Bridget Burger, who is a PDP provider in the state of Massachusetts.

Additionally, Cape Cod Community College, which is associated with the Cape Cod Regional STEM Network, is a PDP provider in Massachusetts and is able to provide credit for STEM mastery by completion of the work in the program. Teachers who partake in the program receive a 1000-dollar stipend for attending and spend their two weeks at a worksite where they are able to perform a blend of hands-on project work and shadowing industry professionals. In addition, teachers are granted a 500-dollar transportation stipend upon completion of the program that enables students to travel to the host institution for a field trip or relevant activity in

their subject. Former participants have noted that the Teacher-in-Residence program was able to effectively build on their exposure about what is really happening in the field (*2021 News: Cape Cod Regional STEM Network at 4Cs Looks to Pair Pre-k-12 Educators with "Teacher-in-Residence" Opportunities*, n.d.).

Case 2: Iowa Governor's STEM Advisory Council Externship Program

The state government of Iowa first ran a STEM educator externship program in the summer of 2009. The program ran independently for 2 years until the Iowa Governor's STEM Advisory Council (IGSAC) was formed in 2011. IGSAC has since assumed responsibility for the STEM educator externship program and has continued to run it annually for the last 10 years. The mission of the IGSAC Externship Program is to provide educators with the necessary experience to answer their students when they ask, "When will I ever use this?" in their STEM classes. The goals of this externship program are to:

- Create lasting partnerships between workplaces and local schools.
- Connect the teacher extern experience with STEM content and 21st century skills identified in the Iowa Core.
- Give students real-world career information about career possibilities in Iowa.
- Give teachers the opportunity to see and use the latest real-world applications of STEM disciplines in a local business or industry.

The IGSAC Externship Program has maintained steadily increasing participation from both educators and employers over the 12 years that the program has been carried out. This turnout can be attributed to the advertising methods used by the organization when promoting the externship opportunities. The main strategies used to advertise the program are direct emails to STEM educators and publications in regional STEM newsletters and email chains. Emails and publications provide surface-level information about the program as well as a link to the IGSAC website, which contains more in-depth information regarding requirements, benefits, the application process, and other details of the externship program.

The funds necessary to run this externship program were found through a mix of National Science Foundation (NSF) grants, Iowa state government educational grants, and grants from

private educational organizations. The Iowa governor's office played a large role in facilitating the pilot run of this externship program, and an NSF grant of 1.2 million dollars, shortly after the IGSAC was formed, allowed for the program to expand even further. With government and private grants being used to cover the stipends offered to educators, host companies saw little initial cost of participating in the externship program. The program found success in following years, as companies were eager to return as hosts after seeing the benefits of the externship program first-hand with minimal risk. Many returning companies also elected to adopt a cost-sharing model where the host company funds a portion of the overall stipend paid to the educator externs. The cost-sharing model has allowed the externship program to remain sustainable while also maintaining incentive for companies to participate.

The specific parameters and characteristics of the IGSAC externship program were determined through consideration of both educator and company preferences and requirements. Since its pilot run, this externship program has been held during the summer to accommodate the schedules of educators so they do not miss time in the classroom. Holding the program during the summer is also preferred by companies because it aligns with internships and other temporary employment programs that they may have. The standard format of the program is a 5 or 6 week duration in which externs work 5 eight-hour days each week, resulting in a cumulative 200-240 hours at the workplace. Although this is the standard format, there is flexibility depending on the host company and the schedule of the extern. For example, some externs have worked 6-day weeks while others have adopted a 4-day weekly schedule where they work 10 hours each day. It was decided that the 5–6-week duration is ideal using participant feedback based on other similar programs. Educators reported that a shorter duration of 2-3 weeks resulted in the program ending right as they began to feel comfortable in the industry environment. Similarly, host companies reported that a 3-week duration was too short for the externs to complete meaningful work at the company. In terms of compensation for the externs, the IGSAC Externship Program offers payment of 20 dollars per hour worked at the host company, which results in 4,000-4,800 dollars total for the industry work performed in a full week. In addition to the time at the host company, educators are also offered 2 paid days of professional development. The sum of compensation for participating educators is up to 5,000 for the whole

program. As previously mentioned, this stipend is partially funded through grants, and many returning host companies also contribute to the stipends through the cost-sharing model.

To ensure that the IGSAC Externship Program meets state educator professional development standards, educators create a project or problem-based learning module during the program. This module incorporates the workplace experience of the teacher and includes involvement by the host as a guide or evaluator as students progress through the module. As a result of the module development portion of the program, educators receive graduate credit certified through the University of Northern Iowa.

Case 3: Idaho STEM Action Center Externship Program

The representatives of the Idaho Teacher Externship Program were John McFarlane, who works with educator relations, and Matthew Thomsen, who works with employer relations. This externship program, which launched in the summer of 2019, began with a coordinator partnership between the Idaho STEM Action Center and the Idaho Workforce Development Council. The initial motivation for the creation of the program came from the former executive director of the Idaho STEM action center, Angela Hemingway, who noted that teachers go from college to the classroom without immersing themselves in the industry where their subject is applicable. Before the pilot program began, the Idaho STEM Action Center applied for a grant through the Office of Naval Research. Currently, the program finds funding through money set aside by the Action Center and through grants provided by the Idaho Workforce Development Council. These funds have been used to cover the teacher stipends and other program expenses for all 3 iterations of the program to date. Through this funding model, host companies see very little financial risk in participating in the program. This is done in hope that the employers will see the impact that they are able to make on the community and contribute to the teachers stipend either partially or in full for future iterations of the program.

The structure of the program includes 200 total hours of on-site, experiential learning over a 6-week period during the summer that is intended to expand the skill-set of teachers and advisors so that they can better prepare students for life outside of the classroom. The structure of their program was initially modeled from a STEM teacher externship program in Iowa,

discussed in case 2, but the Idaho STEM Action Center also conducted interviews with teachers and companies to determine their interests and ideas. They additionally opened their program to include all educators and advisors rather than confine their model to STEM teachers. To compensate for their time and efforts, teachers and advisors are provided a 5,000-dollar stipend as well as professional development credits if applicable. This amount was chosen because it equates to 25 dollars per hour, which is one dollar more than the local average hourly rate in Idaho. During the program, the externs are required to keep a journal of their experiences that must include a weekly report with an on-site photo for self-reflection. This was implemented so that teachers could reflect on their experiences after completion of the program to have a reminder of the material that they are presenting to their students. Furthermore, if the teachers want to receive professional development credit for their experiences, they are able to create a lesson plan that relates what they accomplished or observed in the field to what they teach in their classroom. A template that provides both a summary of the lesson and its learning objectives can be submitted to a local college for graduate credits.

In respect to outcomes, the program received the best feedback when matching educators with broad experiences because they were able to see several aspects of a company. One example of this was the Clif Bar and Company, which allowed the extern to see the entire manufacturing process from start to finish. For this specific example, the externs were able to see portions of the company including food science, manufacturing, supply chain management, talent development, and human resources. This holistic experience allowed teachers to see modern professional skills such as communicating clearly, workload or stress management, and time management, which are essential skills that are not typically taught in public education.

Appendix E: Authorship

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Paragraph 2	Hunt	Berwanger, Tomer	All
Paragraph 3	Tomer	Berwanger, Biando, Hunt	All
Paragraph 4	Biando	Berwanger	All
Paragraph 5	Berwanger	Hunt, Washock	All
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2.1.1	Biando	Berwanger	All
2.1.2	Biando	Berwanger	All

2.2	Hunt	Washock	All
2.3	Berwanger	Biando	All
2.3.1	Berwanger	Biando	All
2.3.2	Berwanger	Biando	All
2.4	Tomer	Berwanger, Washock	All
2.4.1	Tomer	Berwanger, Washock	All
2.4.2	Biando, Washock	Berwanger	All
2.4.3	Biando, Washock	Berwanger	All
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5. Recommendations and Conclusions			
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5.2	Berwanger, Biando	N/A	All
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Appendices			
Appendix A: Interview Protocols			
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Employer	All	N/A	All
Externship Organizer	All	N/A	All
Appendix B: Content Analysis Method Description			

Description	Biando, Hunt	Berwanger	All
Guide	Berwanger, Hunt	N/A	All
Appendix C: Follow-up Interview Protocol & Presentation			
Protocol	All	Berwanger	All
Presentation	All	Berwanger	All
Appendix D: Externship Case Studies			
Case 1	Berwanger	Biando, Hunt	All
Case 2	Hunt	Berwanger	All
Case 3	Biando	Berwanger	All