Promoting Innovation in Albania

By
Hristos Giannopoulos
Artian Kica
Saraj Pirasmepulkul

Sponsoring Agency: Protik ICT Resource Center

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By
Hristos Giannopoulos
Artian Kica
Saraj Pirasmepulkul

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PROFESSOR PETER CHRISTOPHER, ADVISOR
Worcester Polytechnic Institute

ABSTRACT

This project, based in Tirana, Albania, aims to promote innovation through the creation of a makerspace community, a space where people with creative ideas for new products can find the tools to develop them. A makerspace provides its members with resources such as prototyping tools, and a collaborative working atmosphere. This is much needed in Albania, since we found that students there often mention a lack of hands-on experience in their education. We worked with our local sponsor, Protik ICT Resource Center, to establish the makerspace and to plan future projects. We developed recommendations based on our work mentoring students in the Young Innovators Club and participating in Startup Weekend Tirana.

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We would like to sincerely thank the many people who helped us through this project and contributed to its success. These people not only gave us many resources to develop the project, but also made our transition to Albania very easy and comfortable.

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AUTHORSHIP PAGE

Hristos Giannopoulos, Artian Kica, and Saraj Pirasmepulkul divided each portion of the project into equal amounts, which were written individually and later compiled. As a team, we then read through each section and performed edits together. This allowed us to be in agreement with the material that we submitted and ensure equal contribution of every section as we all worked together in each method of the project. Each member has participated in this project by having roles as the leader, organizer, writer, editor, and communicator.

TABLE OF CONTENT

TABLE OF FIGURES

EXECUTIVE SUMMARY

An important element in the innovative process is the ability to develop and improve upon an idea or product. In recent years, advancements in technologies have allowed for faster, more efficient, and newer ways in which one could realize and prototype their ideas. One example of such technology is the 3D printer, a type of automated rapid prototyping tool which creates three dimensional objects and is controlled by computer software. The benefits of 3D printing over traditional forms of manufacturing include speeding up and reducing the cost of the prototyping stage of a creating a physical product. However, since this technology is still in its early stages and is relatively expensive, there are still limitations that prevent a wider uptake of such tools. Makerspaces, or community run workspaces, try to address the barriers of entry associated with these tools by providing members with access to such resources to help prototype their ideas. The purpose of a makerspace is to bring people together to learn and collaborate on projects, although different makerspace communities may vary in their approach to the space and demographics of the members.

Protik ICT Resource Center (Protik) is a non-profit organization in Albania that is focused on promoting innovation and becoming a connection point for those seeking the latest and most innovative ideas, products, and services. Their goals include fostering innovation and entrepreneurship, helping increase demand for information and communications technology (ICT) sector, and promoting networking and partnership in Albania. Protik offers many programs and resources to the Albanian community. One of their programs is the Young Innovators Club, which allows for a selected group of middle to high school age students with skills in programming, electronics, or systems administration to gain more experience with advanced technologies through various self-guided projects. By observing and working with the students, we gained a better understanding of the tools and resources that are needed to develop and sustain a successful Albanian makerspace community in Tirana.

In order to develop the proposed makerspace, we laid out three main objectives:

1. Recommend appropriate tools and resources to create an effective working environment.

2. Develop guidelines to select skilled individuals to pilot and strengthen the makerspace community.

3. Observe and assist in projects with members of the makerspace to formulate recommendations used for improving and sustaining the makerspace in Albania.

Makerspaces help promote innovation because they provide the public with access to a wide array of equipment and tools that may be too expensive for most people to buy on their own. They also provide training programs to educate users in skills they may need to work on projects that use these tools.

A makerspace in Albania must be set in a convenient location while also containing the necessary resources to facilitate an inventor's creative process. We determined three steps to help us achieve this first objective:

a) Find a space for the makerspace.

b) Recommend rapid prototyping tools.

c) Recommend other required tools and software.

The space allocated needs to be suitable for setting up and storing necessary equipment in the makerspace including computers, work desks, rapid prototyping tools, electronics, and soldering irons. Extra space is also needed for projects in progress. We determined that the best location would be the Protik Technical Lab located at their site. The area already has sixteen computers and storage space. It is also very convenient for Protik that the working space is located within their office.

A main attraction of makerspaces is their ability to provide access to expensive rapid prototyping tools. Protik asked us to us recommend prototyping tools to purchase. We determined that two 3D printers would be suitable for the selected space because 3D printers have many useful applications and do not create much noise or waste. The third step was ensuring access to required tools and software. Basic hand tools were recommended because they will inevitably be used in projects at the space. Since 3D printers will be available in the space, 3D design software should also be available. We recommended AutoCAD as the software of choice.

Our second objective was strengthening the makerspace with interested and skilled individuals to pilot the Tech Crew program. The Tech Crew program would involve a group of students selected from local Universities to work with 3D printers on innovative and forward thinking projects. The Tech Crew program is similar to a makerspace but initially would not be open to the public. We developed criteria to help Protik select students as well as a senior technical advisor for the program. Some of these criteria included, experience with 3D modeling tools, electronics and the engineering design process. We made these recommendations based on our observations from the Young Innovators Club and our experience participating in Startup Weekend, Tirana. In order to generate awareness and explain the capabilities of 3D printers, we made a presentation for students at the Polytechnic University of Tirana. The position of technical advisor for the Tech Crew Program would involve guiding and mentoring students during the program. We recommend that the technical advisor have a background in 3D printing and the engineering design process to help the students and troubleshoot problems with the equipment.

We observed many of the Young Innovators projects to develop our recommendations. We also participated in Startup Weekend Tirana with members of the Young Innovators Club and took first place. Startup Weekend is a weekend-long event that is designed to encourage entrepreneurs to pitch and develop their ideas into a functional business. Our group's idea was called *Shumlist*, a platform where hobbyists and inventors can buy, share, or sell their unfinished or finished projects. The goal of Shumlist was to create a market to support the growing maker movement and its inventors. Shumlist took first place at Startup Weekend out of a total of fifteen teams. The final results were determined by a group of judges consisting of many successful Albanian entrepreneurs.

A common theme among Albanian students is a lack of practical experience with the theoretical concepts they are taught in school. Students often learn only in theory and do not get the chance to apply their knowledge. Our recommendations for a makerspace aim to serve as a way to allow these students to gain more insight and experience in working on real projects.

Based on our results and observations, we developed three main recommendations for Protik and the Tech Crew. The first recommendation is that Protik host a summer program to expose students to electronics and microcontrollers. We recommend that the program use the Arduino development board over other equivalents. The Arduino is used all over the world by students and hobbyists of all ages. Unlike other microcontrollers, it is not only targeted to engineers, but also to those without any prior technical background in electronics and programming. With the ease of use of the Arduino development environment coupled with the wealth of support for the platform, this summer program would be a good way to expose students to electronics and programming. We recommend Protik host two three-week-long summer programs based on the Open Source Hardware Group's Arduino tutorials. The first program would cover the basics of Arduino and the second program would cover more advanced topics.

We also recommended a four month work plan for the Tech Crew program. The work plan consists of three projects of varying team sizes and durations, simulating experiences they may encounter in industry. The work plan we developed incorporated time for the students to learn Arduino, as well as to have a review session on AutoCAD. There is also time allotted for the students to very carefully document their projects with pictures, descriptions and explanations of their decisions based upon the engineering design process.

The third recommendation is that Protik consider hosting a robotics competition, preferably the medium sized FIRST Tech Challenge competition that has teams competing internationally. We suggest a robotics competition as it allows for a hands-on project learning experience in various engineering disciplines, which Albanian students have expressed their interest in building. With students from the recommended Arduino course, the Tech Crew program, and the Young Innovators Club, we believe that there will be enough skilled and interested students to participate in the competition.

Our team concluded from our results and observations that Albanian youths are enthusiastic and ready to fully embrace innovation. By helping lay out the groundwork for makerspace communities in Albania, we expect that the movement will be able to expand and flourish. We believe that our recommendations will ensure that this makerspace community is sustainable, versatile, and improvable as new technologies are introduced. We expect this space to help prepare Albanians to invent, innovate, and become entrepreneurs.

CHAPTER 1: INTRODUCTION

This project deals with promoting innovation in Albania. Albania is a country located in Southeastern Europe that has begun to take steps to promote innovation and entrepreneurship among its people. This is because innovation has the potential to create new opportunities for work, stimulate a more sustainable economy, and utilize creative ideas to address pressing needs. Innovation directly stems from our natural desire to explore and solve the problems we experience in our own lives. According to *Innovation 101,* a journal article published in *The Creativity Research Journal*, there are three key concepts required for innovation to flourish. The first is the initial idea, which is created naturally based on our experiences and our environments. The second necessity is a culture that supports experimentation and free thought; a culture that sees failure as a learning experience instead of something to be avoided completely. The third aspect is the ability to create multiple iterations of a physical prototype to fully develop an idea (Innovation 101, Teaching Innovation).

In order to promote innovation, there are a few challenges to overcome. Creative ideas are never in short supply; it is in our nature to solve the problems around us. However, establishing a culture in which everyone is encouraged to develop their ideas without fear of failure can be difficult anywhere, not just in countries such as Albania. One issue that Albania faces in promoting innovation is the high barrier of entry for the tools and resources required to prototype an idea. Traditional prototyping methods can cost tens of thousands of dollars and require weeks of lead time (Rosochowski, 2010). Albanians usually do not have access to these powerful tools because of their high cost.

Recently, new advancements in technologies have brought forth the advent of versatile rapid prototyping (RP) tools that have been used in industry to make the prototyping stage of the innovative process much easier, faster, and cheaper (Bradshaw, 2010). Tools such as the 3D printer have opened up for more complex three dimensional parts to be manufactured. Even though the costs of many of these RP tools are lower than traditional prototyping tools, they may still too expensive for an individual to purchase. Furthermore, the software used to operate these new and powerful RP tools require training to use effectively. In order to make these tools available to as many people as possible, a number of organizations known as makerspaces have formed in the past few years in an attempt to address this issue of limited usage. Makerspaces not only provide anyone access to these tools, but also encourage people to see experimentation and failure as learning experiences. Introducing a similar program in Albania would promote innovation as it provides hands on platform for individuals with creative ideas (Barnikis, 2013).

Protik, an Albanian non-profit organization, is a leader in promoting innovation within Albania. Their aim is to become an Albanian ICT hub by being “a connection point for those seeking the latest and most innovative ideas, products, and services.” One of their most recent projects is the “Tech Crew Project” which aims to develop a makerspace community in Albania. Protik hopes to address many of the issues of promoting innovation through their makerspace. The space would contain many prototyping tools and hold educational workshops, solving the problem of access and learning curve. The makerspace would promote creativity and experimentation, a necessity in the innovative process.

Makerspace models within the United States vary greatly depending on their locations and target demographics. It would be unwise to assume that the program structure of any one of the American makerspaces would be directly applicable to Albania. Therefore, the makerspace community at Protik needs to be created with focus on the Albanian user demographic.

Our goal is to collaborate with Protik in developing the most effective makerspace for the Albanian people. To accomplish this goal, we laid out three objectives. For our first objective, we recommend appropriate tools and resources to create an effective working environment. We recommend 3D printers as well as CAD software for Protik. Our second objective is to develop guidelines to select skilled individuals to pilot and strengthen the makerspace community. We selected student members from local universities and helped interview the technical advisor for the project. Our final objective is to observe and assist projects with members of the makerspace to formulate recommendations used for improving and sustaining the makerspace in Albania. This allows us to assess and develop recommendations that were used to formulate future projects to improve and sustain this makerspace community.

CHAPTER 2: BACKGROUND/LITERATURE REVIEW

The information in this chapter describes how community run organizations known as makerspaces and the emergence of easy to use rapid prototyping tools can promote innovation. In order to understand the elements needed for innovation to thrive, we first need to look at the innovative process. Innovation can be divided into five stages, each of which is described further in chapter 2.1. With an understanding of innovation, we identify the use of rapid prototyping tools and makerspaces as two ways to promote innovation. RP tools allow for quick and easy production of a wide variety of parts. RP tools can be used to create prototypes, final products, or parts that cannot be created through traditional molding or machining. In this project, we put more of an emphasis on 3D printers than other RP tools. Makerspaces are community workshops that allow hobbyists and enthusiasts to have a place to gather and work on a wide variety of projects. Makerspaces provide a space to work, a wide variety of tools to use, and a sense of community. All of these aspects of a makerspace promote innovation. The remainder of this chapter discusses challenges that developing nations still face in the acquisition and assimilation of these tools. We focus on the work of organizations that seek to improve the innovation infrastructure in Albania and similar regions.

2.1 Exploring the Roots of Innovation

The idea of innovation is placed in high regard in media and business. Having seen companies like Apple and Samsung become extremely successful through their innovative ideas and various products, it is no surprise that most engineering companies treat innovation as “a type of currency” (Wright et al., 2012). Innovation can often be the most important part of a company. Any company that is not innovating or bringing desirable products to market will quickly stagnate and business will suffer. A company's success can be directly tied to how innovative that company is (Wright et al., 2012). While identifying innovative companies is simple, trying to define innovation formally is not as straightforward. To get a better understanding of what innovation is, we can look at the innovative process displayed in Figure 1.

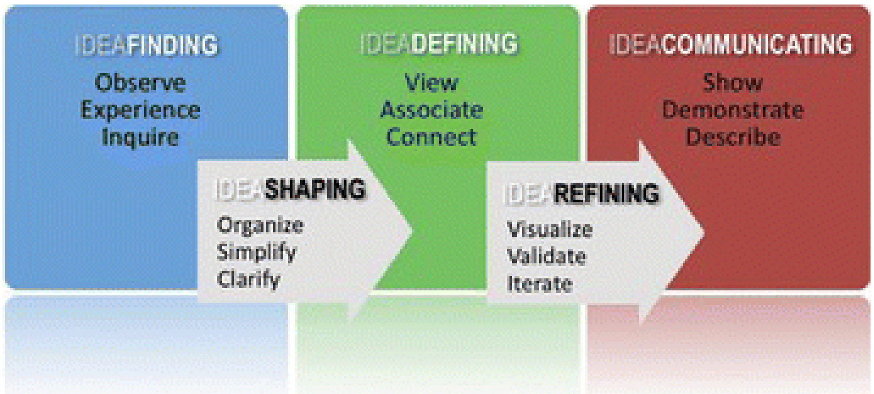

Figure 1: The Stages of the Innovative Process (West et al., 2012)

Innovation can be divided into five general components. (West et al., 2012). The first component is **idea finding** which involves identifying an idea, product, system or service to be developed. Some may describe this stage as the spark or the initial idea.

The second step is **idea shaping**. In this stage, various organizational tools are used to simplify and clarify the idea. Some have used the phrase "a problem well stated is half solved" to best describe this second step. In this stage, a problem statement is usually created (West et al., 2012). When working on products in this stage, one should experiment to find the best product experience for the end user (West et al., 2012).

Idea defining is the third stage and involves brainstorming possible solutions in order to further develop the idea. This stage can be broken into three ingredients: combining, associating, and reframing (Teaching Innovation). Combining takes two unrelated concepts and creating a new idea with them. Associating encourages the creation of connections between slightly related ideas or products. An example is combining the aspects of a hair brush, tooth brush, and a general cleaning brush to get a greater understanding of all three. The final aspect is reframing, which encourages the group to question prior assumptions and constraints of the innovative idea. For this stage in the process to be successful, there needs to be an environment conducive to brainstorming and creativity. There are no wrong answers in brainstorming and everyone involved should be open to any and all ideas (Wright et al., 2012).

The fourth stage, **idea prototyping** or **idea refining**, uses the ideas from the third stage to begin to create potential solutions to the problem at hand. In this stage, the product is validated and prototypes are taken through multiple iterations. A critical view of the product can help drive the creative process. Here, various scenarios for the idea are simulated and analyzed (West et al., 2012; Wright et al., 2012). The prototyping stage is where a majority of the innovative process takes place. Prototyping can be broken up into three steps. The first step is converting the idea of a solution into mock-ups while taking into account user experience and best design practice. In the second stage, the mock-ups or prototypes are reviewed and evaluated to determine what needs to be improved. The final stage is to modify or rebuild the prototypes to make them better. For an innovative idea to come to life, it typically takes multiple iterations of a prototype.

The fifth stage, **idea communicating**, begins when the idea is mature and involves communicating and demonstrating the possible solutions created. This stage should not just be a simple presentation of the data discovered or the product, but the idea should be "launched and exploited in a semi-real or actual situation or context" (West et al., 2012). Two examples of a launch of a product would be a Kickstarter campaign or placing the product in stores. The fifth stage in the development of Apple's first iPod was to reveal the product to the public and begin to market and sell the product.

2.2 Innovation in Practice

By examining how people in the real world have innovated, we can identify certain elements that lead to innovation. In this section, we examine somewhat unconventional innovators like Flip Video and Zappos to gain a perspective of other ways to innovate. We also analyze Apple's innovative strategies through the introduction of the iPod. The common theme between each of these examples is that the innovative idea was not immediately developed. Each idea built upon prior ideas and products and was refined and prototyped until the final innovative idea took shape.

When thinking about innovation, people often think of a single unique and new innovative product. However, innovation is not always a single spark of brilliance. Instead, it can also center on identifying product markets and adapting an idea existing to fit the needs of the customers (Laff, 2009). One article uses the example of the Flip Video camera as "a textbook case of innovation." The camera was a simple, single function video camera which allowed users to easily take and share videos with friends. Instead of reinventing the camera, Flip innovated through improving the user experience of their products. While technology tends to drive to more complicated and feature-packed products, Flip took market research and discovered that people wanted simplicity over an abundance of complex features. "That's the beauty of innovation. It's not just high tech, low tech or no tech. If the end consumer sees benefits and it's [a product] different from your competitors, then you've got a winner," says Thomas Kuczmarski, a consultant and faculty member at Northwestern University's Kellogg School. Flip is an excellent example of how innovative products do not need to be groundbreaking. Flip took an existing idea and found out the best user experience was an extremely simple one. They defined their idea, refined through prototypes, and finally communicated their product by bringing it to market.

A common misconception is that a physical product is needed to innovate. Netflix, Amazon, and Zappos all innovated without a physical product by identifying the gaps in the market and providing a new service. Zappos, an online shoe retailer, innovated through top tier customer support and generous return policies. Instead of creating a completely new idea, these companies innovated by creating the best iteration of their product in the eyes of the average consumer. They identified market trends and needs and evolved their products and services to meet them (Laff, 2009).

The multinational corporation Apple often comes to mind when talking about innovation. Despite their success, Apple is almost never the first one to market with a product. One of their most innovative products was the iPod released in October 2001. Apple was not the first manufacturer to release a portable MP3 player. Both the Compaq Person Jukebox and the Creative Nomad Jukebox, released in 1999 and 2000 respectively, were precursors to the iPod (Junko Yoshida, 2000). Apple was able to take the majority of the market share it has today not by packing more features and memory into their product, but by making it simple and easy to use. They took the idea of a portable music player, went through many prototypes refining each to better fit the customer's needs, and provided a better user experience.

Examining each of these companies provides a slightly different perspective on what innovation can be. Companies like Flip and Zappos prove that there is more than one way to innovate. These examples show how important the prototyping stage is to the innovative process. In the past, prototyping products was so costly it was not possible for an individual to prototype an idea on their own, preventing them from being able to innovate. However, new rapid prototyping tools have made developing prototypes much easier, faster, and cheaper. Makerspaces give anyone with a desire to innovate and create access to tools and a space to develop the idea.

2.3 Traditional Forms of Manufacturing and Their Limitations in the Innovative Process

Until recently, the process of prototyping parts has been extremely costly and time consuming, making this only affordable to large companies. To understand how RP technologies have been able to drastically lower the barrier of entry, one needs to look at the traditional methods of manufacturing and how they limit the innovative process.

Before the introduction of RP tools such as the 3D printer, injection molding was the predominant technique to create plastic parts. Because of the nature of the molding process, it is difficult to change a part once the mold is made. Material can only be added to the part by removing additional material from the mold. This problem makes the prototyping of parts using injection molding very time consuming because new molds need to be made for each part iteration. This drastically slows down the refining stage of innovation (Onuh & Yusuf, 1999).

In a research study on estimating the cost of injection molded parts, 75 real world parts ranging in size and complexity were quoted at a Massachusetts injection molding tooling company. The costs for the molds ranged from $14,000 to $143,000 and lead time for the molds ranged from 12 to 21 weeks (Fagade & Kazmer, 2000). In another study, researchers received a quote for $53,000 for tooling to create a simple terminal block through injection molding. The same report broke down costs for injection molding parts for automotive applications. They attributed almost 30% of the cost of the part to mold manufacturing and another 25% to the actual injection molding process. Only 25% of the cost of the part came from the actual plastic material (Mukherjee & Ravi, 2005). Subtractive manufacturing and molding are relatively inaccessible for anyone other than industry, where the volumes of products are large enough to offset the cost of tooling.

2.4 Technical Benefits of 3D Printing in Rapid Development and Innovation

This section examines RP tools and their role in the innovative process, as these tools allow for speedy and inexpensive creation of products to be tested and developed. New RP technology offers feasible alternatives to traditional, more expensive manufacturing techniques for prototyping and product development. Examples of RP tools include 3D printers, CNC machines and laser cutters.

Products are released twice as fast today as they were during the 1980s (Mukherjee & Ravi, 2005). As a result, products need to be developed faster and lead times for manufacturing tooling must be shortened while maintaining a stable, well-designed, and cost effective product. This acceleration in product development has been a self-perpetuating cycle. Since the first commercial RP tools were released in the mid-1980s, there have been competitive initiatives trying to make product development faster and more efficient. RP in manufacturing has the ability to speed up the visualization and verification steps in the design process (Onuh & Yusuf, 1999). “A prototype is worth a thousand pictures” is now being added to the traditional saying “a picture is worth a thousand words” thanks to how easily 3D printers and other RP tools can produce these prototypes. Although most parts today are designed in 3D CAD modeling environments, there can be great value in being able to examine a tangible object.

RP tools also aid in the verification phase of the design process. Due to pressure to get a product released, it is often not feasible to wait an extended period of time for the tooling of a single prototype. With 3D printers, physical prototypes can be produced in hours at a small percentage of the cost. With traditional tooling methods, only a handful of prototypes may be built due to long lead times and high cost for tooling. With 3D printing, hundreds of prototypes can be created in the same span of time. The ability to quickly build prototypes aids greatly in the prototyping process. This allows designers more freedom to take more radical approaches to the design problem with little risk. 3D printers have become standard in industry for these reasons.

2.5 3D Printers: What They Are and Their Limitations

A 3D printer is a computer-controlled additive manufacturing tool that creates three-dimensional (3D) objects by melting and extruding successive layers of material. A 3D printer lays down the material to build the model from a series of cross sections which correspond to the virtual cross sections of the CAD model. Because of the automated nature of a 3D printer's operation and the speed at which complex 3D objects can be created, 3D printers are classified as a type of RP tool. The advantage of additive manufacturing is the ability to create almost any shape or geometric feature. For example, 3D printers can print interlocking solid parts while molding cannot. Please refer to Appendix A for a breakdown of various manufacturing techniques and a more detailed explanation of how 3D printers work.

The sale of 3D printers has dominated the RP market so much that they account for 92% of all the RP products sold in 2007 (Campbell, Beer, & Pei, 2011). This is mainly due to the fact that 3D printers are often the least expensive RP tools. In addition to the lower purchase cost, annual maintenance costs for 3D printers can be as little as 20 percent of other RP tools. This explains why 3D printers have become a popular choice among small, micro, and medium-sized enterprises on a limited budget that are looking to have in-house RP capabilities (Campbell 2011).

2.6 Other Rapid Prototyping Tools

Other common rapid prototyping tools include the Computer Numerical Control (CNC) machine and laser cutter. A CNC machine is a computer-controlled cutting machine that is able to cut parts like a handheld router or mill. The cutting head's movements are generated based on a 3D model, similar to the 3D printer process. CNC machines often cut wood or metal and are often able to cut much larger parts than 3D printers can print. While 3D printers are mostly used in the prototyping stages, CNC machines can make prototypes and final parts alike, due to their high degree of accuracy (Onuh & Yusuf, 1999).

A laser cutter is mechanically similar to a 3D printer in that the tool head is able to move on a horizontal plane above the part. Instead of a tool head that extrudes plastic, the laser cutter has a high power laser able to cut through and engrave a wide variety of materials. Depending on the type of laser used, a laser cutter can cut wood, plastic, and metal of varying thicknesses (Onuh & Yusuf, 1999).

2.7 Challenges in Introducing Rapid Prototyping Tools

There are still several limitations to the uptake of many RP tools. The cost and experience required to use design software are often the two largest obstacles of introducing RP tools to the general public. Although 3D printers are becoming less costly over time, they are still too expensive for most individuals to practically own on their own. Two non-industrial and hobbyist-oriented printers include the $350.00 Printrbot Simple kit and the $6499.00 Makerbot Replicator Z18. Many of the least expensive printers are targeted to hobbyists, often requiring a large amount of tweaking and modifying to print correctly and consistently. These printers work well for those with advanced technical knowledge but may not be a good fit for someone looking for the plug and play experience of more expensive and professional 3D printers. Other limitations include: the limited variety of material that can be used, the strength of the objects that are printed, and the maximum size of a created object. These limitations vary depending on the specified printer. For example, the Printrbot Simple kit has a print volume (length x width x height) of 10 x 10 x 10 cm, while the Makerbot Replicator Z18 has a print volume of 30.5 x 30.5 x 45.7 cm.

Furthermore, the CAD software used to create 3D models for the 3D printer takes time and training to learn how to use effectively. This is an even larger issue in developing countries where access to the software is not prevalent. The steeper learning curve associated with some of the CAD tools used industry can "possibly detract them for a desired career in product development, and can be lost to other professions" (Campbell et al., 2011). This evaluation was based on a study introducing additive manufacturing to the Republic of South Africa. As Cackler states, "education is a fundamental issue that developing nations must address in order to take any sort of leading role in the high-tech world economy. If a nation has the financial resources to provide access to technology, this access is of little use without the appropriate training" (Cackler, 2008). Some organizations like Fab Lab and The Society of Manufacturing Bright Minds have begun to provide free access and courses on CAD tools for students. These programs have been relatively successful, but they are often localized. The problem lies in the fact that they are situated in urban areas and therefore not easily reached by rural communities (Campbell et al., 2011).

Despite the aforementioned limitations, 3D printing brings many advantages to the innovative process and to education. Makerspaces are community run workspaces where hobbyists, students, and enthusiasts can gather to work on a wide variety of projects. They provide a space to work, access to a wide range of tools, and the expertise of fellow makers. They foster the collaborative atmosphere required for innovation. Makerspaces allow public access to various tools that may not be practical for an individual to purchase on their own.

2.8 Anatomy of a Makerspace

In order to gain a greater understanding of what a makerspace entails, we began examining four organizations: the Milwaukee Makerspace, Technocopia in Worcester, Massachusetts, the Mt. Elliott Makerspace in Detroit and the Northeastern University 3-D Printing Lab. Each of these makerspaces takes a slightly different approach to the local "Maker" community in their area. Based out of the Church of the Messiah, the Mt. Elliott Makerspace has a very heavy focus on teaching children. This idea is reflected in their goal to "offer a sampling of experiences in various disciplines so that makers might discover and develop a passion...or multiple passions," as well as to "Ignite a lifelong love of learning" (Mt. Elliot Makerspace, 2014). Many of Mt. Elliot's programs cater directly to children. Two of their programs are called SprintShops and AwesomeShops. SprintShops are fifteen minute to three hour workshops designed to give children a taste of what goes on in a makerspace. Some popular projects include learning to solder and creating stop motion animation. AwesomeShops are more intensive workshops, meeting two hours per week for eight to ten weeks (Mt. Elliot Makerspace, 2014). These programs teach skills like microcontroller programming, CAD, screen printing, and basic electronic audio synthesis. With these programs, the Mt. Elliott makerspace aims to "create positive environments with our local families and youth" (Mt. Elliot Makerspace, 2014).

While the Mt. Elliott makerspace was founded to cater more to educating children, the Milwaukee Makerspace was founded as a collaborative space for people who already had many of the skills but may have lacked the needed equipment or space. The founders began the program as a robotics club mainly designed for people with already established set of technical skills. They described the space as a very informal and relaxed place where people came to tinker with robotics and work on other electronics projects. The founders then discovered makerspaces like NYC Resistor in New York and decided to adapt their space into something similar, catering not only to those with advanced skills but also to beginners. Many of the main members of the Milwaukee Makerspace are adults who are interested in much more advanced projects. While there was still a focus on teaching and learning, the makerspace was designed mainly for people who "had projects bigger than their houses." This mentality is really reflected in the projects at the makerspace. Some of the most notable projects include a DIY guitar fuzz pedal, an internet connected coffee pot, Jacobs's ladders, internet connected organ, electric cars, an 80 gallon biodiesel reactor, Ruben's flame tube, and the access control system designed to allow access to the space every hour of every day (Milwaukee Makerspace, 2014).

The Technocopia makerspace located in Worcester seems very similar to the Milwaukee makerspace in that the space caters more to skilled adults that lack the space or resources needed to complete their projects. Technocopia had all of the traditional makerspace tools including an abundance of hand tools, soldering irons, electronics parts, 3D printers, CNC machines, woodworking equipment, and a laser cutter. We were surprised that the space was more focused on woodworking than 3D printing. This shows that the makerspace model can allow for many different types of spaces (Technocopia, 2014).

An example of a unique makerspace community set in a library is the Northeastern University 3-D Printing lab that will be part of the school's newly opened Digital Media Commons at the Snell Library (Kornwitz, 2014). Unlike makerspace examples that we provided in earlier sections, this lab has the 3D printer as its only type of manufacturing tool. This lab focuses on providing all students with access to 3D printing, as provost and senior vice president Stephen W. Director said, "[the library is] not just a place where you store books, and information doesn't just come in 2-D physical forms. Information comes in all sorts of forms. Now, it's in 3-D" (Farrell 2014). The space will expose the students to fast-spreading technology that is becoming increasingly present in the American workplace. The 3D printing studio will address the need for greater access to educational technology, additional study spaces, and innovative opportunities for teaching and learning. It will also allow students to "find yet undiscovered career paths" (Kornwitz 2014). Northeastern is also developing lessons and workshops for the lab to provide the students with training on the printers and 3D modelling software used to design the objects (Farrell 2014). This space is unique in that it shows that one does not need a complete set of tools in a makerspace, all one needs is a community and a desire to create.

Even though each of the makerspaces varies in its approach to the space and the demographics of the members, each still has a heavy focus on collaboration and community involvement. The purpose of a makerspace is to bring people together to learn and collaborate on projects. Each of the four makerspaces reflects this as a core goal.

2.9 Makerspaces in Education

Makerspaces bring RP technology closer to everyday people. As we have discussed, RP tools provide a powerful way for anyone to prototype and develop their ideas. Furthermore, makerspace communities foster the “hacker” attitude of “adapting an existing something to fit one’s needs better” (Barniskis, 2013). This is especially important to education because it encourages people to tinker, fail, experiment, and improve. Barnikis believes that the lesson that “failure is no big deal is probably the most valuable” (Barniskis, 2013). Makerspace communities provide a platform that allows learning to become more hands-on and accessible to the greater public with the inclusion of RP tools. As Seymour Papert, an early pioneer of Artificial Intelligence stated, the real power of any technology is not in the technique itself or in the allure it generates, but “in the new ways of personal expression it enables, the new forms of human interaction it facilitates, and the powerful ideas it makes accessible to children” (Blikstein, 2013). Makerspace communities can act as a platform that allows its visitors access to the training required for a well-rounded education.

In order for a makerspace to be successful, it needs to closely mirror the curiosities of the local member community and have a series of different activities for students to explore and engage themselves. The purpose of this engagement is to expose students to types of literacies that extend beyond arts, literature, and media (Foote, 2013). Lastly, makerspace communities foster collaboration, teaching, and learning.

2.10 Albanian Innovation

After discovering what innovation entails in American society, it is helpful to see what innovation means to Albanians and to understand their efforts to improve their ICT infrastructure. During Innovation Week on 11 May 2014 in Tirana, Minister Milena Harito stressed how important innovation was in order to improve the lives of the Albanian people. Harito said, “The innovative technology offers transparency, thus creating a climate of trust between the citizens and the state.” During innovation week, the Vice Prime Minister Niko

Peleshi showed his desire to make innovation part of the government approach by adding that the new generation should be the main promoters of innovative technology (Urci, 2014).

Innovation Infrastructures Albania, a report on innovation published by WBC-INO.NET, began by introducing innovation as “activities resulting in the successful implementation of creative ideas that result in the improvement of technology, services goods, etc. with a positive impact on society” (Innovation Infrastructures Albania, 2011). The report’s goal was to map the Albanian innovation infrastructure and identify key stakeholders. The report continues by citing innovation as a key driver in the economy as well as a tool to increase productivity.

Traditionally, research institutions are considered the “main carriers of innovation” while industry takes over the implementation, commercialization as well as the marketing aspect of the ideas or products (aida.gov). Essentially, research institutions find and shape the ideas while industry defines, refines, and communicates them. Part of our goal is bringing innovation to a wider audience. We aim to supplement the innovation taking place by students and professors at universities with innovation by the general public through the use of makerspaces. Our sponsor Protik ICT Resource Center is already making steps towards this goal.

2.11 Protik ICT Resource Center

Protik ICT Resource Center, also referred to as Protik, is one example of an organization dedicated to promoting innovation specifically in the ICT sector. The Protik ICT Resource Center is an Albanian non-profit organization that was founded on October 10, 2012. It has support from many large sponsors including the Government of Albania, the United States Agency for International Development (USAID), the Albanian-American Development Foundation (AADF), Microsoft, Cisco, and Albtelecom. Protik aims to advance the ICT sector in Albania by educating and providing students with both networking and technical resources. The organization was founded on its values of integrity, excellence, transparency, collaboration, and cooperation. Protik aims to become a hub for ICT within Albania, becoming a connection point for latest and most innovative ideas products and services. In becoming an ICT hub, Protik hopes to foster innovation and entrepreneurship.

Protik offers many programs and resources to the Albanian community in order to progress the ICT sector. Conference rooms, technical classrooms, and computer labs can be booked for classes and special events. These labs and conference rooms are equipped with audio-visual equipment, wireless internet, and a number of computers. In addition to these facilities, Protik also hosts an internship lab in order to expose talented students to ICT businesses and technology. The program can accommodate between eight and twelve students at a time and places them in internships with partner companies.

One program that Protik has successfully organized was the Young Innovators Club, which is a group of talented students between ages eleven and sixteen with skills in programming, electronics, or systems administration. The club has worked on robotics projects such as Lego NXT, Arduino microcontrollers, and Raspberry Pi computers. The program allows these students to gain more experience with advanced technologies. The project hopes the exposure will influence the students to pursue a career in the ICT field.

Many of the tools used by the Young Innovators are similar to those most often used in makerspaces. Arduino microcontrollers and the Raspberry Pi are useful tools for electronics projects. The Arduino is an inexpensive electronics development board that can be used to develop interactive objects. It is able to take inputs from a variety of sensors and switches and control a variety of hardware including lights, motors, and other physical outputs. Microcontrollers like the Arduino have been used in industry for many years. Microcontrollers can be found in anything with an electronic “brain” including TV remotes, microwaves, cell phones, and stereos. The Arduino is unique since it is not tailored to engineers, but to hobbyists and makers. Easy development tools and lots of easy to read documentation make the Arduino a great prototyping tool to learn electronics and programming.

The Raspberry Pi is a small and inexpensive computer capable of doing almost anything a regular computer can and is roughly the size of a credit card. Like the Arduino, the Raspberry Pi can interact with the outside world and can be used for a variety of electronics projects. The Raspberry Pi is an excellent tool for teaching students programming and other advanced computer skills since it runs off an inexpensive SD card. If a student makes a mistake during software experimentation, it can be fixed by copying a new set of files to the SD card. Together, the Arduino and Raspberry Pi can be used in a wide variety of educational projects.

2.12 PITAGORA Project

Similar to Protik, the PITAGORA project aims to raise the level of technology in the ICT sector. PITAGORA stands for the Platform for the Information Technology Aimed at Getting Opportunities to reduce the ICT gap in the Adriatic area. The project promotes the use of new technologies and is encouraging a movement towards more modern electronics and information technologies. PITAGORA host seminars and talks that promote new and innovative tools in the ICT sector. PITAGORA has determined that “types of technologies are below the desired and appropriate level” and that “encouraging the use of [new technologies] will help the development of the ICT sector” (Kordha, Klodiana, Vela, & Rezarta, 2013, May). PITAGORA claims Albania is falling behind technologically and it is affecting other areas of development. They believe that by gaining a better understanding of modern technology and increasing its use, Albanian organizations will become more profitable and efficient.

2.13 Bridging the Gap

Technology develops and improves a country’s economy by allowing creative ideas to be expressed in manifested in new ways. The freedom to create and experiment allows for innovative individuals to strive. Rapid prototyping tools are gaining popularity because they offer many benefits over traditional manufacturing tools. They are able to speed up the prototyping process as well as make it easy for almost anyone to build any part they can design in CAD software. Instead of having to build a part by hand, a RP tool can create the object based on a digital design. This allows for makers to create a wider range of objects than they would be able to on their own.

However, one of the limitations that prevents a greater range of users from harnessing this powerful tool is the learning curve associated with using these tools. Various makerspace organizations have grown out of the effort to address this issue. Makerspaces allow a wider range of users to have access to such machines and tools that may be too costly for them to afford individually. Makerspaces typically offer workshops and programs aimed at educating members on the power of the tools they have, but they also nurture a collaborative atmosphere that allows for more skilled users to help orient their less-experienced peers. By working with Protik ICT Resource Center, a makerspace community can be established in Albania that would allow for its member to improve their technological literacy. This makes it easier for Albanians to become innovators and continually seek ways to expand their creativity.

CHAPTER 3: METHODOLOGY

The goal of this project was to work with Protik ICT Resource Center in developing a makerspace community that best fits Albanian needs in order to promote innovation in the Albanian society. To achieve this goal, we completed the following three objectives:

1. Recommend appropriate tools and resources to create an effective working environment.
2. Develop guidelines to select skilled individuals to pilot and strengthen the makerspace community.
3. Observe and assist in projects with members of the makerspace to formulate recommendations used for improving and sustaining the makerspace in Albania.

These objectives will further develop the makerspace at Protik into a facility that will foster the growth innovation and demand of the Albanian ICT sector. This will lead to more creative ideas that people will act upon and create technological progress in Albania.

3.1 Establishing a Working Environment

Objective 1: Recommend appropriate tools and resources to create an effective working environment

A reason why makerspaces help promote innovation is because they provide the public with access to a wide array of equipment and tools that may be too expensive for most inventors to buy or too difficult to operate on their own. Therefore, an effective Albanian makerspace must be set in a convenient location while also containing the necessary resources to facilitate an inventor’s creative process. We created three steps that helped us work towards achieving this first objective of setting up the tools and resources:

1. Find a space to set up and store the equipment.
2. Recommend rapid prototyping tools to be used in this makerspace.
3. Recommend other required tools and software.

A first step is to allocate a space that is suitable for setting up and storing the equipment in the makerspace. The space would need to support the setup of computers, work desks, and prototyping tools that we will have available for the members of this makerspace. This is because the recommended prototyping tools, such as 3D printers and Arduino boards, require extensive use of computers for CAD software and development environments. Therefore, these tools must be placed in a location that has direct access to computers. Secondly, the space must have an area for cabinets to safely store the electronics, soldering irons, hand tools, printer materials, and ongoing projects so that they may be quickly accessed by the members while working in the makerspace.

Upon consultation with the Protik executive boards, we determined that the Protik Technical Labs room would be a suitable facility for a makerspace. The room already has many computers, desks, and large storage cabinets. A corner of the room will be dedicated to the 3D printers. Keeping the makerspace at the Protik offices allows for the company to have more control over it. The layout for the makerspace is shown in Figure 2.

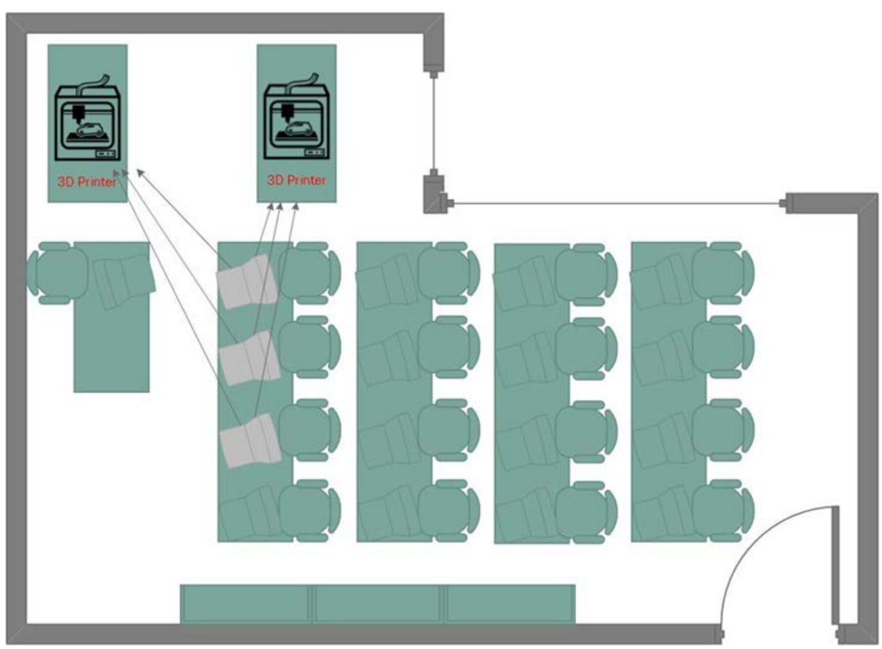

Figure 2: Top View Layout of Protik Technical Labs Room with Two 3D Printers.

Sketch provided by Protik (Kasaj 2014).

A second step is to recommend the RP tools to be used in this makerspace. This step involved researching the various RP tools that would be incorporated into this makerspace and writing a budget report to appeal to Protik's donors. We based our RP tool criteria on the decision that the makerspace would be located in the Protik technical labs at their site. First, we want the RP tool to be able to fit on the work desks that are provided, because the room is used for other workshops as well. Second, the tools must not produce a lot of noise, pollution, or vibration.

From our research, the most suitable RP tool for this makerspace is the 3D printer. Compared to other RP tools, 3D printers do not produce much noise or waste. A 3D printer would not disturb anyone in the office like a CNC machine or laser cutter might. The two selected 3D printers are the **Makerbot Replicator Fifth Generation** and the **Type A 2014 Series 1 3D Printer**. The reliability and the level of support associated with the printers were a major consideration when we were making our decision. Since there are few individuals in Albania with experience troubleshooting 3D printers, we made sure that both printers we recommended had reliable reviews, excellent customer support, and a large online community. Print volume and resolution were other considerations we made when selecting the printers. The Makerbot has a medium sized print volume (252 x 190 x 150mm) with a 100 micron layer resolution (Makerbot, 2014).The Type A 2014 Series 1 printer has a much larger print volume (305 x 305 x 305mm) and 50 micron layer resolution (Type A Machines, 2014). Having two printers would allow multiple parts of varying sizes to be printed at the same time. The information about these 3D printers was acquired from analyzing product specifications from websites and feedback in user reviews. We have listed the specifications of the two machines below.

Makerbot Replicator Fifth Generation

- Work volume: 252 x 199 x 150 mm
- Filaments price: $30
- Price: $4000

Figure 3: Makerbot Replicator Fifth Generation 3D Printer.

Image retrieved from http://eu.makerbot.com/shop/de/3d-drucker/replicator/?__shop=1

Type A Machines 2014 Series 1 3D Printer

- Dimensions: 765 x 571 x 459 mm
- Work volume: 305 x 305 x 305 mm
- Weight: 16 kg
- Filaments price: $40
- Price: $2800

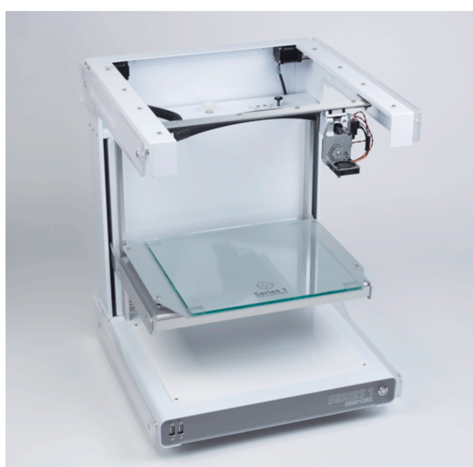

Figure 4: Type A Machines Series 1 3D Printer

Image retrieved from http://www.typeamachines.com/products/series1-3dprinter

Please refer to Appendix B for the full Tech Crew Implementation Plan that was sent to Protik donors. The document includes the layout of the makerspace, the specifications of the two 3D printers, the budget details, and the implementation phase schedule.

The third step is ensuring that the members have access to required tools and software used for prototyping their ideas. Tools that may need to be ordered include soldering irons, wire cutters, electronic components, and microcontroller boards. Protik already has two soldering irons, three different types of wire cutters and a few small boxes of various leftover electronic components and microcontroller boards. For the Tech Crew program, more tools will need to be ordered. The small tools that are available for use in the makerspace must be documented and stored methodically to ensure that they may be readily available and in good condition for users of the space.

To use the RP tools, the installation of 3D modeling software on the computers is also required. From our interview with the Tech Crew project manager Hatixhe Bilibashi, many universities in Albania use AutoCAD in their curricula. This suggests that it may be helpful to install AutoCAD as opposed to a different 3D modeling software. We recommend that Protik purchase three licenses so that multiple students can design parts at the same time. A commercial license of AutoCAD for one computer costs around $4000.00. It is possible to request educational discounts for AutoCAD and other similar commercial tools. Free student versions of AutoCAD may also be used by the students to practice and design three dimensional models on their own computers. Free alternatives to AutoCAD as CAD software include Blender. A limitation of Blender is that it is more difficult to specify dimensions for a three dimensional part, possibly increasing the learning curve for members. We strongly recommend AutoCAD for the space because of its use in schools and in industry. Other free tools may be viable options, but these tools are often not as refined or easy to use for three dimensional engineering designs as CAD software.

3.2 Increasing Awareness and Recognition

Objective 2: Develop guidelines to select skilled individuals to pilot and strengthen the makerspace community.

To increase awareness and recognition of the makerspace, we determined guidelines for selecting skilled individuals for a pilot group. Since makerspaces are still new in Albania and there are still many changes that could be made to our model, we do not advise opening the resources to the general public just yet. The first group of members would be fifteen students from the Polytechnic University of Tirana in engineering fields of Electrical, Mechanical, Mechatronics, and Informatics Engineering. We want to expose and build the skills of these students with the 3D printers and other tools so they can grow into mentors that offer peer guidance to future makerspace users.

To propose the project, we traveled with Hatixhe Bilibashi to the Polytechnic University of Tirana to give a presentation to the students. The presentation introduced the Tech Crew program and described some possible applications of 3D printing as it pertains to their field of engineering. According to discussions with students, we learned that there is a lack of hands-on learning at the university. Because 3D printers are one of the easiest ways to take a 3D model and physically reproduce it, we expect the Tech Crew project to interest many students. In order to further promote the program, we created a poster for the Tech Crew project. We collaborated with students from the Young Innovators Club to design the poster for the Tech Crew project. We want the poster to both promote the program and give the students a general overview they would be working on in the program. One of the Young Innovators Club student members, Margen Stepa, was one of the main students who helped us with the final design, featuring a stylized 3D printer and a flow chart of the design process when using 3D printers. The poster can be seen below.

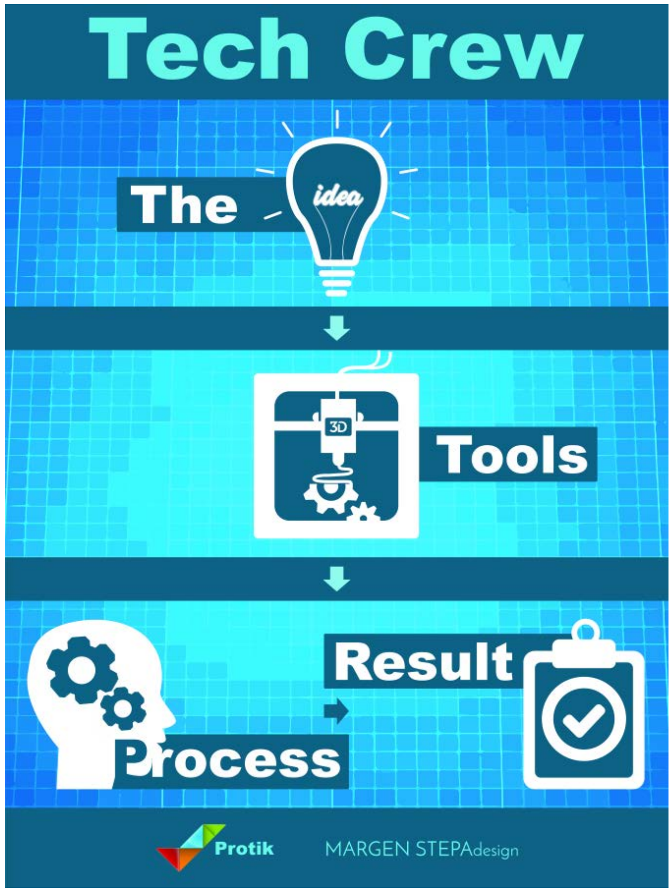

Figure 5: Tech Crew Poster Created by Margen Stepa

After we introduced the students to the project, we determined the key skills that students in the program should have. Some of the criteria include: experience with 3D modeling tools such as CAD software, experience with electronics like the Arduino or Raspberry Pi minicomputer, and a background in the engineering design process. We want students with varying backgrounds so that their unique strengths can combine to create more advanced and interesting projects. One example of a more advanced project that requires varying backgrounds is a completely 3D printed robot. Please refer to Appendix C for the Tech Crew Application form.

In addition to creating criteria for the students, we were also able to determine key traits a senior technical advisor for the project would need to be effective. This individual would be directly involved with the students throughout the duration of the project. Because the advisor would need to be able to provide technical assistance for the 3D printers and software, they should be familiar with 3D printing and modeling. Other desired traits include a background in information technologies, engineering, or computer science. In addition to technical skills, the advisor would need to be able to work with and successfully motivate the students to reach their full potential.

We hope that our recommendations for selecting personnel will help Protik build a solid base of members for the makerspace. We recommend that Protik create student teams with two student leaders in each, so that in case that one cannot continue the project, the team would still be able to function. With a strong group of students with overlapping skills and a knowledgeable technical advisor, it is possible for the makerspace to be self-sustaining.

3.3 Student Projects

Objective 3: Observe collaborative projects with members of the makerspace to formulate recommendations used for improving and sustaining the makerspace in Albania.

As WPI students, we believe that a good way to learn concepts is through practice in addition to theory. We observed and assisted many of the projects that the Young Innovators were working on to gain a greater understanding of their strengths and weaknesses. By observing a wide variety of projects, we were able to see how members of the group interacted and collaborated in different situations. The Young Innovators Club has been meeting and continues to meet at Protik on Fridays from 3 pm to 5 pm. They work on various projects at their own will and Protik provides them with the space and resources they need to carry out their projects. We decided to collaborate with the students from the Young Innovators Club on two projects. One was a wireless chessboard game and the other was a startup idea called *Shumlist* which we entered in the Tirana Startup Weekend 3.0. The event took place on the weekend of November 21st, 2014. The results and observations from these projects would then be used to create future recommendations to design new projects and workshops to be hosted in this makerspace.

Wireless Chess Project

The project that they started working on during our time in Albania was the Wireless Chess Project. The project goal is to create a chess board that uses magnets and sensors to move pieces without any effort from the players using an Arduino Uno microcontroller. The chess pieces would be attached with magnets, and moved using another magnet underneath the chess board using a set of X and Y axis racks and pinion gear drives.

Tirana Startup Weekend 3.0

To collaborate with the students on another project, we entered the Startup Weekend Tirana 3.0 when the opportunity arose. This provided a great platform for both the students and us to learn more about the innovative process by meeting with coaches and mentors who taught us how to execute our entrepreneurial ideas. Furthermore, it allowed us all to be exposed to different innovative ideas from other teams participating in the competition. While the Young Innovators mostly focused on creating physical projects, Startup Weekend exposed the students to the business aspects of a project. In addition to creating a website at Startup Weekend, the students needed to design a business plan and determine how their idea would profit.

The startup project idea that we collaborated with the students on was tailored to the student's skill level and interests based upon a group discussion on the first week. The project was one in which students can continue working on and improve by themselves, without relying on the skills we bring. Secondly, the project needed to challenge the collaborators enough, yet not too difficult that it discourages the students from continuing in the future. Thirdly, the project should require only the tools that are provided by Protik, since the project needs to be completed in the makerspace. In section 4.2, we will further examine our project and observations that we made at the Startup Weekend Tirana 3.0.

CHAPTER 4: RESULTS AND OBSERVATIONS

This chapter presents the quantitative results and qualitative observations that we obtained from completing our set objectives. It includes assessments of created deliverables, findings from discussions with students, and observations from collaboration on projects. We organized the results, observations, and suggested recommendations for Protik to improve the makerspace community and future programs. In addition to these results and observations, we discuss the final makerspace setup and the success that we experienced from our startup idea at the Startup Weekend Tirana 3.0. The results of the work we have completed provide a framework for us to develop recommendations to our sponsor Protik to continue promoting innovation.

4.1 Observations about the Young Innovators Club

During our time with students from the Young Innovators Club, we noticed a number of characteristics of the group. Officially, the Young Innovators Club program ended in September of 2014 but the students continue to meet. It is somewhat apparent that the program is over because their meetings seem informal and the students no longer seem to have a set project to work on. They often come in and log on to the computers to learn about programming, play games, and talk about general projects in small groups. One of the most integral members of the club had left to study in Germany in September. The students indicated that this member was the leader in many of the projects and was the only member with experience with microcontrollers and electronics. This was the same member who recommended that Protik should start a program using 3D printers. None of the other members of the group are familiar enough with microcontrollers or the Arduino to finish some of the remaining projects. From our observations we noticed that there was very little overlap in the skills of the members, especially with electronics.

The second observation we made about the group is that there seems to be no formal leader to help guide and motivate the group to complete projects. While letting students work independently on projects often leads to creative ideas, we believe that with a set leader recommending group projects the Young Innovators could be much more effective. We recommend that a technical advisor could take a leader role, making the projects more robust. If the student leader of the project left the program, the technical advisor would be able to step in and continue the project. The technical advisor could play a role in selecting projects, enforcing schedules, teaching skills, and keeping students on track.

4.2 Startup Weekend Tirana 3.0 Competition

The Startup Weekend Tirana 3.0 event has two components: formation of the idea before the event pitch and collaboration during the event itself. This section will include our observations and findings from the collaborative process involved in our idea's conception as well as the team dynamics of the students. Furthermore, the final results of the competition and the learning outcomes of the students are examined.

Forming an Innovative Team

The students were very passionate about forming a team for this competition because of the potential of creating and owning their own start-up company. They have great entrepreneurial spirit, and have many technical skills for programming and digital art software such as Adobe Photoshop and Illustrator. The students were composed of one businessman, two creative designers, and four computer programmers. Many project ideas were brainstormed and discussed during the meetings in Protik. However, because of the 54 hour time limit of the Startup Weekend and skill demographic of the students, projects involving web and graphic design were favored over hardware projects.

Earlier ideas that we discussed included a virtual paintball gun case connected to a smartphone. The case would allow user to emit infrared "bullets" and play a laser-tag-like game within a marked territory set by a map on each phone. All of the students were interested in this idea. After further brainstorming, however, the students decided against following through with the idea. The project would have involved more hardware design than the students were comfortable undertaking in a single weekend. They decided that a web design centered project would be much more suited to their skills. The students considered working on the infrared paintball-game project after the weekend but they still felt that they lacked many of the electronics design skills required for the project. From this observation, we believe that the Arduino tutorial we have laid out for Protik's future summer program would be a great skill builder for students in future Startup Weekend competitions.

Shumlist: A Success Story

The project that the student agreed upon is called Shumlist, which is a website that allows for hobbyists and tinkerers to spread their ideas through real projects. Because of the nature of the project, Shumlist shares our goal of promoting innovation. The website will allow the users to sell, buy, share, or trade finished or unfinished projects they worked on. Its purpose is to support the growing maker community by providing a service that currently is not available. This platform allows for various ideas and projects to be created, continued, and recycled. The final project can be viewed through the following website: http://www.shumlist.co/. Below is the logo for Shumlist.

Figure 6: The Official Logo of Shumlist

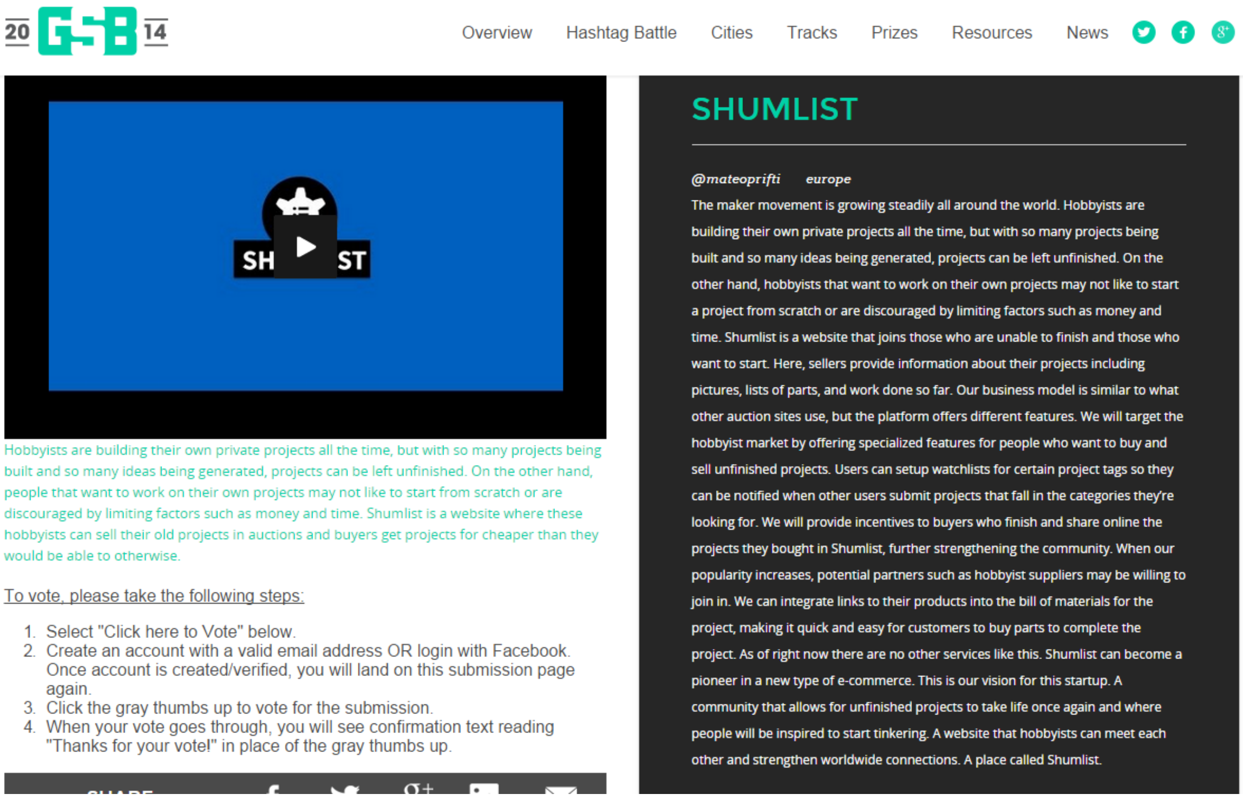

Figure 7: Shumlist Project Page on the Global Startup Battle Website

The following is the official project description of Shumlist that was submitted to the Global Startup Battle:

"The maker movement is growing steadily all around the world. Hobbyists are building their own private projects all the time, but with so many projects being built and so many ideas being generated, projects can be left unfinished. On the other hand, hobbyists that want to work on their own projects may not like to start a project from scratch or are discouraged by limiting factors such as money and time.

Shumlist is a website that joins those who are unable to finish and those who want to start. Here, sellers provide information about their projects including pictures, lists of parts, and work done so far. Our business model is similar to what other auction sites use, but the platform offers different features. We will target the hobbyist market by offering specialized features for people who want to buy and sell unfinished projects. Users can setup watch lists for certain project tags so they can be notified when other users submit projects that fall in the categories *they're looking for. We will provide incentives to buyers who finish and share online the projects they bought in Shumlist, further strengthening the community.*

When our popularity increases, potential partners such as hobbyist suppliers may be willing to join in. We can integrate links to their products into the bill of materials for the project, making it quick and easy for customers to buy parts to complete the project. As of right now there are no other services like this. Shumlist can become a pioneer in a new type of e-commerce."

The student-formed team Shumlist, led by Mateo Prifti from the Young Innovators Club, took first place at the Startup Weekend Tirana 3.0. After winning, they advanced to the next phase of the Global Startup Competition and had 48 hours to complete a video that showed off their idea. The video filming process took place inside Protik using the resources that Protik was able to provide, including video cameras, computers, and access to the students' previous robotics projects. If the students gained enough votes to place top two in Europe, they would be able to travel to Silicon Valley to present their ideas in the final stage of the Global Startup Battle. We acted more as coaches than members of the team, giving feedback and critiquing ideas where we felt necessary. The students valued our suggestions and feedbacks. From our observations, the element most essential to success in the Startup Weekend Tirana 3.0 was the high level of collaboration among the students enhanced by business, creative design, and programming. We used our observations from the Startup Weekend in recommending future programs for Protik including the Tech Crew work plan and the Arduino Curriculum.

CHAPTER 5: CONCLUSION AND RECOMMENDATIONS

In this chapter, we provide conclusions of the project based upon the key findings we discussed in the previous chapter. We also provide future recommendations and implementation plans for Protik so that they can continue improving and expanding the makerspace community that we created. Through our observations and hands-on collaboration with the students from the Young Innovators Club and Tech Crew, we gained a deeper understanding of possible barriers to innovation in Albania and initiatives that are being made to improve the innovative infrastructure. We analyzed these limitations and provide suggestions and educational material because our results show that a more hands on and user-tailored education is the key to establishing a more innovative society.

5.1 Summary of Key Findings

Students from the Young Innovators Club show strong computer skills including programming, modeling, designing, and video editing. The Startup Weekend Tirana 3.0 competition was a platform where these students were able to put their various computer skills to work by collaborating on a successful software project called Shumlist. The event allowed students to learn about the innovative process which includes brainstorming ideas, executing the design, prototyping using software, and dealing with team dynamics.

Through our observations and interactions with the students, we noticed that they are not as familiar with electronics and hardware as they are with software and design. As a result, they were unable to follow through and build some of their more hardware oriented ideas like an infrared paintball game or wireless chess board. To strengthen the students' electronics and embedded programming skills, we proposed that Protik host a summer program teaching students the basics of programming and circuits using the Arduino development board. The students will be able to use the Arduino as a prototyping tool to learn through hands-on projects. Additionally, we created a four-month-long implementation plan for the Tech Crew project with the objective of providing students with access and working knowledge of 3D printers. The work plan will allow students to realize their ideas through a physical prototype as well as potentially expanding the applications of 3D printing to a wider range of users.

The various lesson plans and project documentations that we have created will be a resource for Protik, as well as future groups looking to promote innovation, to continue expand the makerspace community. The aim is to create a makerspace that is scalable, adaptable, and engaging for all members.

5.2 Suggestions for Future Projects

FIRST Robotics Competition in Albania

We suggested to Protik the possibility of bringing the FIRST robotics competitions to Albania. By participating in a robotics competition, students will be exposed to and learn many skills including programming, electronics, mechanical design, and teamwork. There are many FIRST competitions in Europe in which Albanian teams can participate. One example is the CEESA Eastern Europe FIRST Tech Challenge which is hosted at the American International School of Bucharest in Romania. The website for this organization is http://www.easterneuropefirsttechchallenge.org/.

We recommended the FIRST Tech Challenge (FTC) because we believe that the format of the competition is large enough to allow up to 10 students from each participating school to form a team, but small enough for smaller teams to still enter the competition. Furthermore, the size of the robots in the competition is not too large, making it possible that the event be hosted in Protik's conference room. Lastly, the robotics kits could be reused after each year, which reduces the financial burden and possibly outreaching to a larger community. Please refer to the full documentations and implementation plan that we proposed to Protik in Appendix D.

Arduino Summer Camp Program

We designed an Arduino curriculum based off of the well-developed tutorials from the Open Source Hardware Group. The curriculum is divided into two separate three week long, or fifteen day, lesson plans corresponding to the available tutorials. The first course teaches all of the basics of Arduino programming and the second course moves on to more advanced topics such as interfacing with servos, LCD Displays, and a computer through a programming language called Processing.

Based on the length of each section and the number of sections to be covered each day, we recommend starting off with a four hour allotted class time and adjusting based on the rate at which students absorb the material. It is difficult to determine how quickly or slowly the students may absorb the material and we feel that a four hour class time would be a good starting point. In the beginner course, we have allotted one day just in case the students are running slightly behind. In the advanced course, we allotted four days not only for the students to catch up if they fall behind but also to allow for the students to complete a project on their own. We have seen that students in Albania rarely get enough real world experience with projects so we wanted to allow the students time to apply their knowledge to a project of their choosing.

In order for the students to gain as much as possible from each of the lessons, we recommend they follow a specific procedure to go through the material. First, the students should read the tutorial in the book attached to the curriculum. This will allow them to get a basic idea of what they will be doing in each lesson. Next, the students should watch the video to reinforce the concepts they read in the tutorial. The students should always complete the challenges at the end of almost every section. These challenges give the students a way to practice the material they learned through the video and tutorial. Finally, the students should watch any challenge videos to correct any mistakes they may have made in the challenge problems. The program can be seen in Appendix E.

In addition to going through the lessons in this order, we also recommend that the students hand type the code from scratch instead of copy and pasting from the lessons. Writing out the code helps greatly in the learning process and helps the material stay with the students. Many of the circuits apply to multiple lessons. We recommend that the students take apart and rebuild their circuits between each lesson. Similar to typing out code by hand, this repetition helps students to understand the circuits as much as possible. These recommendations are based upon our own experience in trying to learn Arduino, as well as recommendations from the Open Source Hardware Group.

We understand that learning something new, especially electronics, can be frustrating. This may cause the students to become discouraged at points. To prevent this, we recommend that the instructor for this course not only understand the material but also be able to act as an effective motivator for the students. They should be able to tell when it is best to push the students to continue and when to give the students additional help when they are struggling with a concept. The instructor of the program is essential to its success. Refer to Appendix E for a three week curriculum proposal.

Joint Project with Harry Fultz

This year, another WPI IQP team in Albania is working with the Harry Fultz Technical High School to implement a high school robotics club. We recommend that Protik work with student mentors from the Harry Fultz Technical High School robotics club to hold a robotics competition since these students will have more hands-on expertise from working with the WPI IQP team.

Mr. Enxhi Jaupi, an electronics teacher and the advisor for the robotics club at the Harry Fultz Technical High School, showed interest in the initiative from our discussion with him since this would allow for the continuation of the high school robotics program at the school. He expressed his concerns that the number of students eager to join the robotics club superseded their capacity for this year’s club. Therefore, a robotics competition was a platform that would allow the students to pursue their interests in hands-on robotics learning experience.

3D Printing Workshop for Value Added Products

After discussing with another WPI IQP team that is working to promote beekeeping products in Albania, we suggest that Protik hosts a workshop that allows for the greater public to know about the benefits and uses of 3D printing. For example, one area where 3D printing can be applied is printing candle molds, which is of interest to beekeepers. Traditional methods of creating molds are time consuming, require specific material and are often difficult to make reliably. 3D printing the molds would allow creation of new and more complicated three dimensional forms, adding greater value to candle products sold by beekeepers. Plastic 3D printed molds would be able to be used many times, adding to their value even more.

Continuation of the Tech Crew Project

We developed a four month plan for the continuation of the Tech Crew. The plan has a goal for eighty days of work with a flexible schedule to accommodate different commitment levels for the students. The plan begins by reviewing the engineering design process, AutoCAD tutorials, and an Arduino tutorial. A brief introduction on how to use the version control software Git would also help groups work collaboratively on coding projects. The entire plan is laid out in Appendix F.

There are three main projects scheduled for the four months. Each of the projects is set up in a similar way. First, students will brainstorm ideas for the project. Then, the students will form teams to work on the project that most interests them. Team size will vary depending on the project. Once teams are formed, the students will begin sketching their ideas on paper and begin modelling their projects in AutoCAD. About halfway through the projects, the students will spend one or two days documenting the project. This documentation process will teach the students technical writing skills as well as allow others to learn from the projects in the future. The documentation will be critiqued by both the advisors of the program as well as the other groups of students. Once the students are done with the project, they will have a show and tell day where they present their project to other teams as well as other interested parties such as parents, Protik employees, and professors.

The first project is introductory. The students will receive a refresher on AutoCAD as well as go through an Arduino training program we developed. The plan can be seen in Appendix F. In this project, students will work in teams of three to four. The second project has students working in much larger groups from six to eight students. This project should have at least the same complexity as the first project but should be completed in about half the time since there are more students and they should be more comfortable with AutoCAD and Arduino. The students should complete the third and final project in groups of two to three. This project will be somewhat less in depth than the first two as this project is only about half the time as the others.

Our reasoning behind varying the duration and number of students in each project was to recreate as closely as possible, a real world working environment. In industry, engineers and designers work on teams of varying sizes, therefore we want the Tech Crew's projects to mirror this as closely as possible.

5.3 Overall Project Conclusion

The goal of this project was to work with our sponsor Protik to promote innovation in Albania by developing recommendations to support a makerspace community that bridges the gap between people's ideas and their ability to realize those ideas using technology. To gain further insight into the innovative infrastructure in Albania, we observed and assisted students from Protik's Young Innovators Club on team projects. We participated together with the Young Innovators in the Tirana Startup Weekend 3.0 competition in which our group took first place. We observed that students in the Young Innovators Club had strong skills with web design and some programming, but lacked practical experience using prototyping tools for mechanical and electrical projects. To further expand their ability to innovate and realize their ideas, we laid out a series of recommendations, and future program outlines that will provide the students with hands on experience with new prototyping tools. By following these recommendations, Protik has the potential to further expand and strengthen the innovative infrastructure in Albania, thus empowering the nation with bright potential entrepreneurs.

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APPENDIX A: INTRODUCTION TO MANUFACTURING TECHNIQUES

There are three main ways to create a physical part. The first is subtractive manufacturing, or cutting shapes out of a block of material. (Bradshaw) Some examples of subtractive manufacturing include machining and woodcarving. These techniques involve using specialized tools to remove metal and wood, respectively, to create the desired shape. These methods are relatively inaccessible to someone without the proper training or tools, the methods take many hours of training to master.

The second way to make a solid object is molding, or “Forming material that is liquid or plastic into the required shapes then set.” (Bradshaw) This molding process is also inaccessible to someone without proper technical skills or financial resources. Injection molding is one example of a molding process, used to make plastic parts for a range of applications. (Fagade & Kazmer, 2000) Traditionally, to get an object injection molded, it would be necessary to send specifications and drawings to various injection molding companies, to quote the cost of designing a mold for that specific part. Mold costs vary with the complexity and size of the part.

The third and final method of creating a solid part is additive manufacturing. Additive manufacturing is any process where material is added to create the final product. Up until the advent of 3D printers and other specialized manufacturing processes for integrated circuits, one of the only additive manufacturing processes was bricklaying. (Bradshaw) The concept of 3D printing dates back to the 1970’s. Engineers often call 3D printing rapid prototyping because of the speed the technique offered and prototyping because the process was not viable for large production runs of parts. (Bradshaw) Many different approaches to additive manufacturing using rapid prototyping have been developed over the years. Some of these methods include Stereo lithography, Selective Laser Sintering, Fused Deposition Modeling and Fused Filament fabrication. (Rosochowski & Matuszak, 2000) Most 3D printers today used Fused Filament Fabrication, which was originally patented in 1979. At the heart of Fused Filament 3D printing there is an extrusion head which takes plastic filament, usually ABS plastic and heats it to almost melting point, similar to a hot glue gun. The head has freedom of movement on the x-y plane, and extrudes the plastic onto a height adjustable platform. The plastic is deposited layer by layer, with the platform slowly moving down until the final part is completed. To determine the path the extrusion head takes, computer software takes in a 3D modeled part, slices the part into 2D sections that stack on one another to form the part. It is these 2D sections that the extruder head follows to create the physical part.

APPENDIX B: TECH CREW PROJECT IMPLEMENTATION PLAN

"TECH CREW", IMPLEMENTATION PLAN

Project background

The "Tech Crew" project was proposed on_________and approved on________. The main goal of this project is the creation of young talented individuals' team within the age range of 17-22 years old. The primary focus will be generating and shaping innovative and productive ideas in electronics and robotics. Tech Crew will select University students who have the right background and/or potential for modeling in AutoCAD, 3D modeling objects, electronics, robotics and mechatronic

Based on analyzes and research about the three Tech Crew model proposed via email on 21 July 2014, Protik decided to implement option number two. In this option it is proposed to start the project only with 3D printers and allow the flexibility that if the expertise of the team, demand from the market or other unforeseen factors dictate and there is budget, we can look into the possibility of including a CNC machine or laser cutter.

Why only 3D printers?

While initially we envisaged a full project including CNC Machines and laser cutters along with 3D printers, we have realized that it would be very disruptive for Protik's day to day business to have all these machineries in house because:

1- Laser cutters and CNC Milling Machines are usually big
2- Laser cutters and CNC Milling Machines are messy, they generate a lot of scarcities, dirt and noise
3- They are expensive to repair and maintain
4- It is quite difficult to identify local experts on these machines
5- It would be very complex to introduce so many new machines and concepts to the team of students

Also 3D printers are now the latest in most maker spaces and other innovative structures around the world. For more on 3D printers please refer to Annex II.

Implementation team

Ms. Bilibashi will be in charge of this project for project management purposes. A part time consultant will be hired because most of the equipment are special purpose mechatronic devices. This consultant must have knowledge and experience in this field. His commitment will be needed for a total of 15- 20 days. It is difficult to find such expertise in Albania and Protik has already started to look for a consultant. Also Protik has identified a team of students from Worcester Polytechnic Institute (WPI) who have expertise in electronics, software development and robotics. The students are now working at Protik premises and are already contributing to the project. They will be here until December 18th 2014.

Implementation of the project with two 3D printers in Protik premises

The implementation plan sent on 21 July 2014, proposed the purchase of two 3D printers namely: Cubify CubeX Trio with high Resolution and Type A 2014 Series 1 3D Printers. In consultation with the robotics students from the Worchester Polytechnic Institute and after further research, Protik suggests to purchase a Makerbot Replicator 5th Generation instead of the Type A 2014 Series 1. The reasons for this switch are as follows:

1. the Makerbot brand is backed up with good online support and documentation, which is necessary for use in Albania, where there are less skilled individuals to help troubleshoot
2. the WPI students, who will assist with this project have seen it work in real life in the Makerbot showroom in Boston
3. This 3D printer would be shipped from the European distributor in Germany, and would take approximately a week to reach Albania, allowing for a prompt start of the project

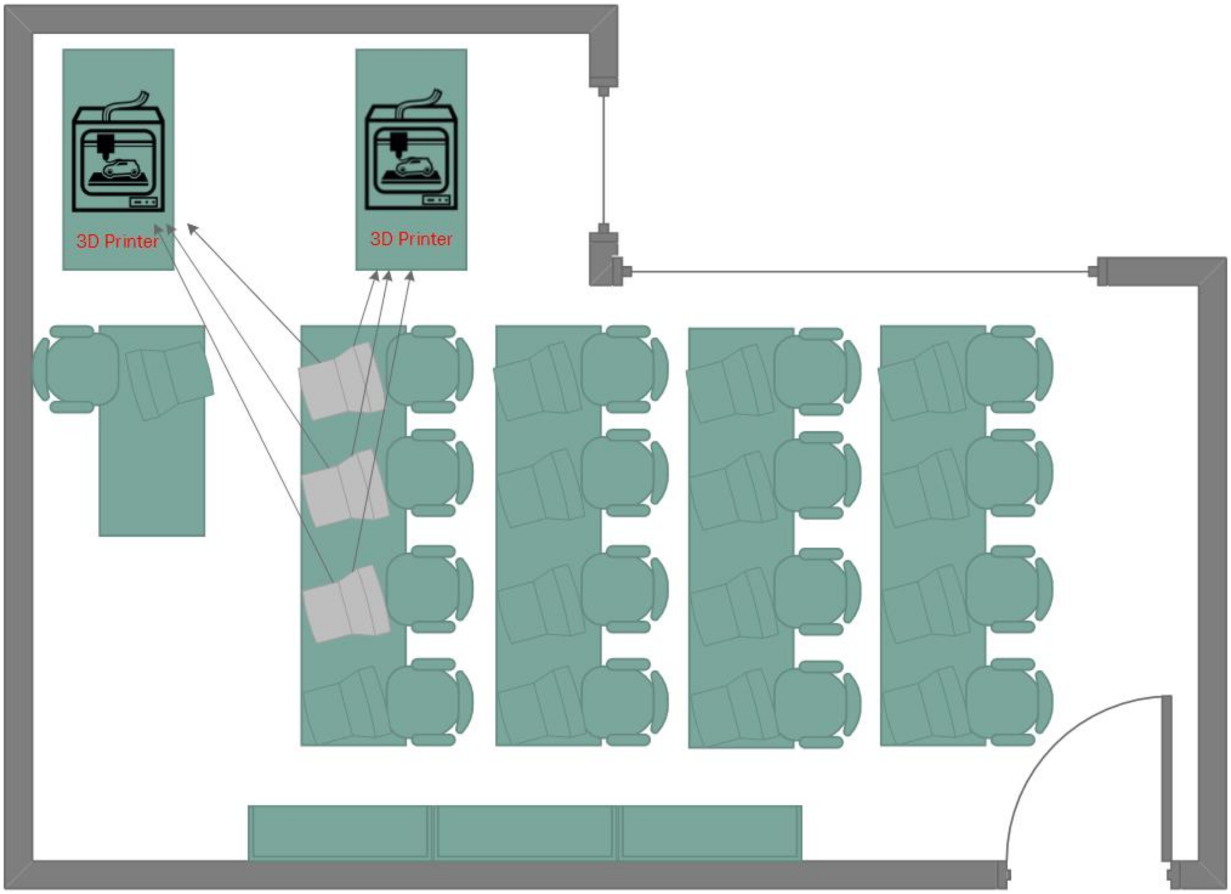
The above choice will allow the team to be able to print both high and low resolution 3D objects.
Finally the proposed 3D printers for this project are:

Makerbot Replicator Fifth Generation
Work volume: 252 x 199 x 150 mm
Filaments price: 22.9 Euros
Price: 3190 Euros
Web: http://eu.makerbot.com/shop/en/3d-printer/replicator/55/makerbot-replicator

Type A 2014 Series 1 3D Printer work with a large volume and has cheap parts.
Dimensions: 765 x 571 x 459 mm
Work volume: 305 x 305 x 305 mm
Weight: 16 kg
Filaments price: 40$
Price: 2800$
Web: http://www.typeamachines.com/products/series1-3dprinter

Assembly of electronic devices will be done not by given the basic electronic elements ,like diodes, sensors, resistance, integrated circuits, but using ready boards and assembling in electronic devices, which will increase the value of raw material and electronic pieces, from 5000 to 7000-8000$. Even in this case, as most of the equipment must be imported, then the budget should allocate a portion of Transport and Customs (approximately for a total of $ 5000-6000).

To create a proper work laboratory we have to use two of the Protik Technical Labs desks and computers in which the projects will be assembling and designed. A corner is required for the printers. This project is linked with the ongoing costs, which have to do with raw materials, equipment maintenance with additional and spare parts for equipment and cleaning. The lab usage from other groups of students versus a fee can cover the costs of materials. The implementation of the project will still be difficult because the lack of spaces in Protik Center.


3D Printer
3D Printer

The budget

Budget Details: Protik Tech Crew, Figures in US Dollars

Line Item	Budget Detail	Base of Calculation	Year 1		
	Object Class Categories/Staff	**Unit**	**Unit Cost**	**Qty**	**Total**
1. Travel & Transportation					
	Domestic travel				
	Travel	Month	50	12	600
	Subtotal Travel				***600***
2. Marketing					
	In House marketing				
	Workshops, presentations, conferences	Unit	100	4	400
	Online, written and visual media				
	Advertisement	Unit	1000	2	2,000
	Subtotal Marketing				***2,400***
3. Direct Program Costs					
	Materials and Supplies				
	Makerbot Replicator 5th Gen.	Unit	4500	1	4,500
	3D printer Type A 2014 Series	Unit	2,800	1	2,800
	Toolbox	Unit	250	1	250
	Hot glue gun	Unit	25	1	25
	AutoCAD design Suite	Unit	4,195	1	4,195
	Blender	Unit	-	5	-
	Microcontrollers	Unit	50	10	500
	Books	Unit	30	30	900
	Raw materials& electronics components	Lump sum	8000	1	8,000
	Consultancy	Days	200	20	1,090
	Other unidentified electronic gadgets	Unit	200	20	4,000
	Food and Beverages	Unit	10	30	300
	Contingency	Lump sum	2000	1	5,385
	Shipping / Transportation		1500	2	3,000
	VAT + Custom expenses	Lump sum	1440	1	1,440
Subtotal Program Costs					***35,000***
4. Other Operating Costs (Direct Administrative)					
	Management Fee/Overhead	Month	1000	12	12,000
	Subtotal Other Operating Costs				***12,000***
PROGRAM TOTAL					**50,000**

	Approved	50,000
	Rest	0

Implementation phases for the Tech Crew project:

Phases of project development	**Timeline**	
	Start	**End**
1- *Research and Preparatory Work.* a. Finalize research on 3D Printers and raw materials b. Buy the 3D Printers and raw materials c. Identify the software products that are necessary to buy d. Research the potential demand for 3D printing objects in Albania. e. Identify potential 3D objects to be printed by the team	Nov 2014	Nov 2014
2- *Agree on the start of the project* a. Sent a final implementation plan to the donor b. Agree on project implementation plan and start date	Nov 2014	Nov 2014
3- *Recruitment* a. Prepare a clear recruitment plan. b. Prepare selection criteria for students that will be part of the program. c. Prepare selection criteria for the technical consultant	Nov 2014	Nov 2014
4- *Project Awareness and Promotion*. a. Prepare a presentation to be held in universities to attract interest. b. Prepare posters for the Tech Crew project. c. Prepare a social media plan to promote the project. d. Prepare a plan on how to attract interest from the businesses. e. Continuously work on the promotion of the program	Nov 2014	Nov 2015
5- *Project Implementation.* a. Prepare a three month work plan for the students of the tech crew. b. Setup the printers and the softwares. c. Work with the students and the consultant on the 3D Printers.	Dec 2014	Nov 2015
6- *Project Follow Up.* Provide recommendations on how this project can continue. Provide recommendations on how we can involve universities more in this process and transfer knowledge	Sept 2014	Nov 2015

ANNEX II
Why 3D printers?
3D printing technologies have the potential to become one of the key innovation drivers for the decades to come. These technologies have a potential to be highly disruptive, as they will give rise to entirely new products and services and will force to rethink creation, production and distribution processes. Furthermore, 3D printing technologies are expected to lower the barriers to entry and enable new companies, with innovative business models, to compete with established firms.

3D printing is an innovative rapid prototyping technology where molten plastic is laid down (printed) layer by layer to produce a 3 dimensional object. This is known as “additive manufacturing” as material is added to form the model rather than being machined off as in normal (subtractive manufacturing) forms of production.
3D printing is a new technology in Albania country but it is currently undergoing a huge growth around the world and in many new fields of manufacturing.

This makes it a good time for educators and students to develop their skills in this form of technology and to follow the advancements currently being experienced in industry. Using 3D printer technology in schools will help equip students with the necessary skills to enter this rapidly moving technology.
3D printing provides new advantages that may revolutionize education. Many curriculum areas require students to think, to problem solve and to design. This technology will give the Albanian students the opportunity to test object modeling in the fields of:

- Mechatronic
- Electronic
- Informatic
- Information and Comunication Technology
- Graphic Design

and functional properties of their designs with a solid model rather than just a virtual model.

3D printing can be used to:

- help conceptualize/visualize a design in the development stage
- test functionality of design ideas during the development stages
- make low cost successive modifications to prototypes
- produce finalized designs for presentation to a client/audience
- produce short run manufacturing of a product

3D printing is a ground-breaking technological which offers novel advantages to assist in the fulfilment of a productive educational experience; it is only reasonable that schools begin utilizing 3D printers.

APPENDIX C: TECH CREW RECRUITMENT PLAN AND QUESTIONS

Tech Crew Recruitment Plan

1. Expose the project to students at local universities
   a. Prepare a presentation explaining the project and its importance.
      i. Present WPI and ourselves.
      ii. Why traditional methods of manufacturing are limiting.
      iii. Describe 3D printers and why they can help.
      iv. Plans for the project.
2. Create an application that interested students can use to apply for the Tech Crew program.
   a. Example application/questions shown below.
3. Interview Applicants
   a. Interview questions TBD.

Tech Crew Students Recruitment Application Questions

1. Skills
   a. What is your Major?
   b. Have you worked with any design projects?
      i. If so, can you briefly describe the field of the project?
      ii. The length of time spent on the project?
      iii. Was it a personal or school project?
      iv. Did you work individually or in a group?

   c. What experience do you have with CAD or other 3D modeling software? I.e. AutoCAD, Solidworks, Inventor, Blender, 3DMax, etc.
      i. Please list any programs you have worked with.
         1. How long have you worked with the software?
         2. What have you designed?
   d. What would you be interested in designing? i.e. renewable energy products, automotive related parts, fashion / clothing accessories, robot parts
   e. How familiar are you with 3D printing? Have you worked with one before?
   f. Please describe the extent of your understanding of electronics, if any.

APPENDIX D: BRINGING FIRST ROBOTICS INTO ALBANIA

A robotics competition is a good future project for Protik to increase innovation in Albania. We suggested to Protik the possibility of bringing the FIRST robotics competitions to Albania, where Protik could be the host. This is because by participating in a robotics competition, students get to learn and apply knowledge in fields of mechanical engineering, electrical engineering, and computer science through a hands-on, interdisciplinary project. Furthermore, a robotics competition is a great platform that allows participants to gain more experience in problem solving, management, and teamwork. An organization that has a strong robotics competition foundation is FIRST. We recommend Protik hosting a FIRST robotics competition because of the advantages it offers. This includes having many grant opportunities, a new competition designed every year by FIRST, and the great number of teams competing internationally if Protik wants to increase the scale and competitiveness of robotics in Albania to international competitions. One has to be registered on FIRST to be able to use the name FIRST robotics competition.

FIRST Robotics Competition is an international high school robotics competition organized by FIRST, which is an acronym for **I**nspiration and **R**ecognition of **S**cience and **T**echnology. There are three different FIRST robotics competitions that we believe could be brought to Albania; FIRST Robotics Competition, FIRST Tech Challenge, and FIRST Lego League. These competitions are abbreviated FRC, FTC, FLL respectively, and target different demographics of students, require different budgets, and thus the competitions have a different scale.

Their mission is to show students of every age that science, technology, and problem-solving are not only fun and rewarding, but are proven paths to successful careers and a bright future for all. For more information about FIRST, including registration, please visit the website: http://www.usfirst.org/

FIRST Robotics Competition (FRC)

The FRC is the largest competition of FIRST, and includes the largest robots physically. It is an opportunity for **high school** students and their mentors to work together to solve a common problem, in which they have six weeks to design and build a robot using a standard "kit of parts" and a common set of rules. Each year, the challenge is designed by Dean Kamen, FRC staff, and a committee of engineers and other professionals.

We will need adult mentors with technical expertise, high school aged students, sponsorship, a meeting place, space to design a build a robot and access to tools. A FRC team is generally 25 students, but there is no limit.

The cost to participate in FIRST, as well as details on how to apply for grants can be found in the following links. It seems that the most expensive registration fee so far is $6000.

FIRST Tech Challenge (FTC)

FTC is a mid-sized robotics competition. Teams are made up of students between grades 7-12. FTC recommends a team size of about 10 students, with a limit of 15 from your school and/or community. http://www.usfirst.org/roboticsprograms/ftc/start-a-team

Teams participating in the FTC use a kit of parts to construct their robots. The difference between this kit of parts and the one in FRC is that they are reusable from season to season. There are two kits that are authorized for use, which is the TETRIX building system from PITSCO, and the Matrix Robotics kit. Teams are also allows to build their robots out of raw materials. A LEGO MINDSTORMS NEXT robotics controller is required for competition, and may be purchased as part of a kit, or individually, depending on the kit we get. The programming language can either be through LabVIEW or Robot C. For more information: http://www.usfirst.org/roboticsprograms/ftc/registration

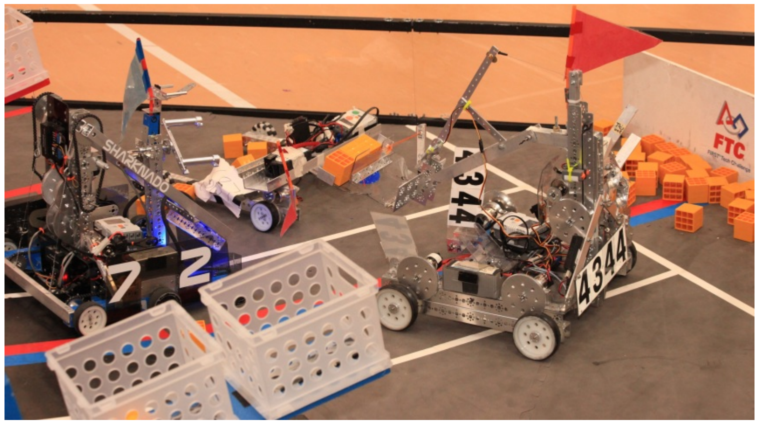


Figure 1: A FIRST Tech Challenge Competition. Image retrieved from: http://www.nasa.gov/sites/default/files/7110_ftc.jpg

FIRST Lego League (FLL)

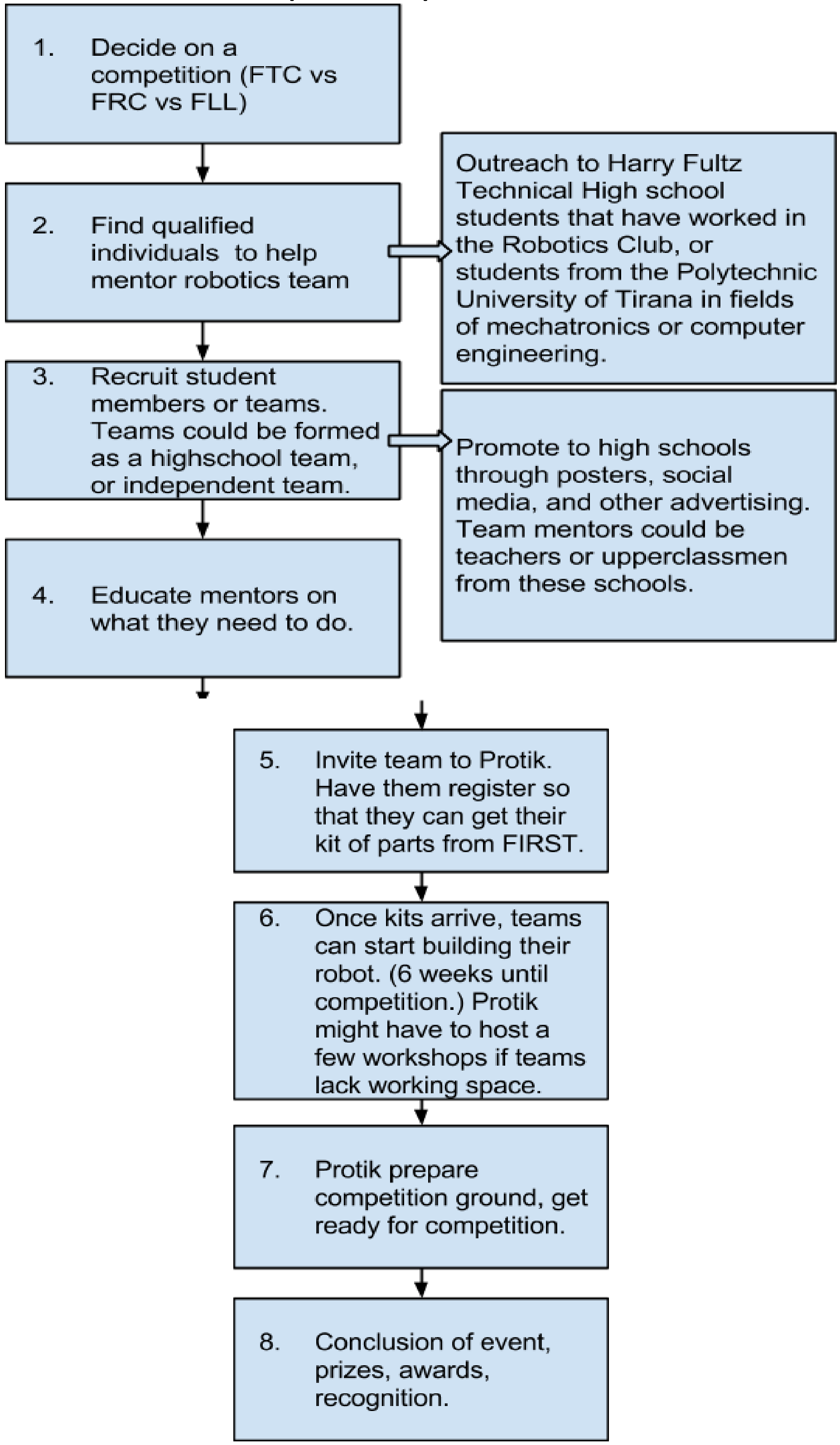
This is the smallest of the three robotics competition created by FIRST, which is targeted for elementary to middle school aged students (9-16 years old for countries outside of North America) to build LEGO-based robots to complete tasks on a thematic playing surface. Each year, FLL releases a new challenge for our teams, which focuses on a different scientific topic of question, such as biomedical robots. The Challenge has three parts: The Robot Game, the Project, and the FLL Core values. The teams are up to 10 members. We would need a meeting space that has room to set up the 4x8 feet playing field, a computer, and internet access. http://www.firstlegoleague.org/challenge/startateam

The cost for a FLL kit is approximately $883 ($225 for Team Registration, $88 for Field Setup Kit, $570 for EV3 Robot kits with DC battery). Further detail and pricing could be found in the following link: http://www.usfirst.org/roboticsprograms/fll/pricing-and-payment-terms

Recommendation

We personally believe that an FTC Competition is the best choice among the three because it offers a good balance of size, competitiveness, and student demographics (Grades 7-12). FLL is targeted towards a young student group, so if we want to outspread this competition to high schools, it might not work as well as FTC. However, FLL would be easiest to set up in Protik and in many schools, and does offer a good educational experience as well. FRC requires a lot of space and resources, plus costs a lot more money, therefore fewer teams in Albania would be able to adopt it. FTC is our first recommendation, then FLL, then FRC.

FIRST Competition Implementation Outline



APPENDIX E: ARDUINO SUMMER CAMP PROGRAM

We designed an Arduino curriculum based off of the extremely well developed tutorials from the Open Source Hardware Group. The curriculum is divided into three week, or fifteen day, lesson plans corresponding to the available tutorials. The first course teaches all of the basics of Arduino programming, and the second course moves on to more advanced topics like interfacing with servos, LCD Displays and a computer through a programming language called Processing.

Based on the length of each section and the number of sections covered each day we recommend starting off with a four hour allotted class time and adjusting based on the rate at which students absorb the material. It is difficult to determine how quickly or slowly the students may absorb the material and we feel that a four hour class time would be a good starting point. In the beginner course we have allotted one day just in case the students are running slightly behind. In the advanced course we allotted four days not only for the students to catch up if they fall behind but also for the students to complete a project they complete on their own. We have seen that students in Albania rarely get enough hands on, real world experience with projects so we wanted to allow the students time to apply their knowledge to a project of their choosing.

In order for the students to gain as much as possible from each of the lessons we recommend they follow a specific procedure to go through the material. First, the students should read the tutorial in the book attached to the curriculum. This will allow them to get a basic idea of what they'll be doing in each lesson. Next, the students should watch the video to reinforce the concepts they read in the tutorial. Then, the students should always complete the challenges at the end of almost every section. These challenges give the students a way to practice the material they learned through the video and tutorial. Finally, the students should watch any challenge videos to correct any mistakes they may have made in the challenge problems. In addition to going through the lesson in this order we also recommend that the students hand type the code from scratch instead of copy and pasting from the lessons. Writing out the code helps greatly in the learning process and helps the material stay with the students. Many of the circuits apply to multiple lessons. We recommend that the students take apart and rebuild their circuits between each lesson. Similar to typing out code by hand, this repetition helps students to understand the circuits as much as possible.

We understand that learning something new, especially electronics, can be especially frustrating. This may, at points cause the students to become discouraged. To prevent this we recommend that the instructor or supervisor for this course not only understand the material, but should also be able to act as an effective motivator for the students. They should be able to tell when it is best to push the students to continue and when to give the students additional help when they are struggling with a concept. The supervisor of the program is essential to its success. Below is an overview of the program.

Day	Module	Unit	Description / Topics Covered
0	1	1 - 3	Some Friendly Administration Details
1	2	1 - 5	Installing / Setting Up IDE
2	3	1 - 3	Blink LED
3	3	4 - 7	digitalRead and analogRead / Serial Communications
4	3	7 - 9	analogRead Challenges
5	3	10 - 12	PWM
6	4	1 - 4	Prototyping process for code
7	4	5 - 6	Prototyping process for Hardware
8	5	1 - 4	If statements and for loops
9	5	5 - 7	Arrays and Control
10	5	8 - 12	Switch Cases and While loops
11	6	1 - 4	Advanced Blink LED and Buttons
12	6	5 - 8	State Changes and Debouncing
13	7	1 - 4	Analog IO
14	7	5 - 8	Callibration and data smoothing / Wrap UP
15	N/A	N/A	Extra Day
Advanced Ciriculum			
1	1	1 - 2	Multi Dimensional Matrices
2	2	1 - 4	LCD Displays
3	3	5 - 6	GUI with Buttons
4	3	7 - 8	GUI with Potentiometer
5	3	1 - 4	Servos Part 1
6	3	5 - 7	Servos Part 2
7	4	1 - 4	Functions
8	5	1 - 4	Creating Libraries
9	5	5 - 8	Creating Libraries
10	6	1 - 4	Processing Intro
11	6	5 - 8	Processing Continued
12	N/A	N/A	Extra Days / Group Project
13	N/A	N/A	Extra Days / Group Project
14	N/A	N/A	Extra Days / Group Project
15	N/A	N/A	Extra Days / Group Project

APPENDIX F: TECH CREW PROGRAM FOUR MONTH PLAN

We developed a four month plan for the continuation of the Tech Crew. The plan has a goal for eighty days of work with a flexible schedule to accommodate different commitment levels for the students. The plan begins by reviewing the engineering design process, AutoCAD tutorials, and an Arduino tutorial. A brief introduction on how to use the version control software Git would also help groups work collaboratively on coding projects.

There are three main projects scheduled for the three months. Each of the projects is set up in a similar way. First, students will brainstorm ideas for the project. Then, the students will form teams to work on the project that most interests them. Team size will vary depending on the project. Once teams are formed, the students will begin sketching their ideas on paper and begin modelling their projects in AutoCAD. About halfway through the projects, the students will spend a day or two documenting the project. This documentation will teach the students technical writing skills as well as allow others to learn from the projects in the future. The documentation will be critiqued by both the advisors of the program as well as the other groups of students. Once the students are done with the project, they will have a show and tell day where they present their project to other teams as well as other interested parties such as parents, Protik employees, and professors.

The first project is very introductory. The students will receive a refresher on AutoCAD as well as go through an Arduino training program we developed. In this project, students will work in teams of three to four. The second project has students working in much larger groups from six to eight students. This project should have at least the same complexity as the first project but should be completed in about half the time since there are more students and they should be more comfortable with AutoCAD and Arduino. The students should complete the third and final project in groups of two to three. This project will be somewhat less in depth than the first two as this project is only about half the time as the others.

Our reasoning behind varying the duration and number of students in each project was to recreate as closely as possible, a real world working environment. In industry, engineers and designers work on teams of varying sizes, therefore we want the Tech Crew's projects to mirror this as closely as possible. A section of the plan is listed below.

Day	Agenda	Other
1	Introductions / Begin review of the Engineering design process	
2	Continue Engineering Design Process / Begin Brainstorming Initial Projects	http://www.nasa.gov/audience/foreducators/plantgrowth/reference/Eng_Design_5-12.html#.VH2YYovF-
3	Continue Brainstorming / Look at Thingiverse, Instructables, Hackaday for inspiration	
4	Continue Brainstorming / Look at Thingiverse, Instructables, Hackaday for inspiration	
5	Form teams of 3 - 4 to begin work on an idea / Begin Planning idea	
6	Begin Sketching Ideas on Paper	
7	Begin Sketching Ideas on Paper	
8	AutoCAD Basics Tutorial	https://www.youtube.com/watch?v=-JbXqesOUyM
9	Begin Practicing with Autocad	
10	Begin Drawing Project in AutoCAD	
11	Continue Drawing Project in AutoCAD	
12	Continue Drawing Project in AutoCAD	
13	Continue Drawing Project in AutoCAD	
14	Continue Drawing Project in AutoCAD	
15	Journal Project: Include Inspiration, Obstacles, Solutions and design constraints	
16	Arduino Tutorial	
17	Arduino Tutorial	
18	Arduino Tutorial	
19	Arduino Tutorial	
20	Arduino Tutorial	
21	Arduino Tutorial	
22	Arduino Tutorial	
23	Github Tutorial	try.github.com and https://www.youtube.com/watch?v=0fKg7e37bQE
24	Finish Up Drawing Parts in AutoCAD	
25	Finish Up Drawing Parts in AutoCAD	
26	Finish Up Drawing Parts in AutoCAD	
27	Finish Up Drawing Parts in AutoCAD	
28	Start Printing / Writing code / Designing Electronics (If Applicable)	
29	Start Printing / Writing code / Designing Electronics (If Applicable)	
30	Start Printing / Writing code / Designing Electronics (If Applicable)	
31	Start Printing / Writing code / Designing Electronics (If Applicable)	
32	Start Printing / Writing code / Designing Electronics (If Applicable)	
33	Start Printing / Writing code / Designing Electronics (If Applicable)	
34	Start Printing / Writing code / Designing Electronics (If Applicable)	
35	Start Printing / Writing code / Designing Electronics (If Applicable)	
36	FUN DAY! Each Person draws a small part to print and keep	
37	FUN DAY! Each Person draws a small part to print and keep	
38	Begin to finalize project	
39	Begin to finalize project	
40	Begin to finalize project	
41	Begin to finalize project	
42	Document Project (Formal Drawings, Document Code, Lots of Pictures)	
43	Document Project (Formal Drawings, Document Code, Lots of Pictures)	
44	Document Project (Formal Drawings, Document Code, Lots of Pictures)	
45	Document Project (Formal Drawings, Document Code, Lots of Pictures)	
46	Make Sure ALL Code and Drawings are on Github	
47	Project Show and Tell	
48	Next Project Brainstorming	
49	Next Project Brainstorming	
50	Next Project Brainstorming	
51	Form Diffrent teams of 6 - 8	This project should be completed twice as fast because there are 2x as many people
52	Sketch Ideas On Paper	
53	Sketch Ideas On Paper	
54	Start Drawing in AutoCAD / Start Arduino	
55	Start Drawing in AutoCAD / Start Arduino	
56	Start Drawing in AutoCAD / Start Arduino	
57	Start Drawing in AutoCAD / Start Arduino	
58	Start Drawing in AutoCAD / Start Arduino	
59	Start Drawing in AutoCAD / Start Arduino	
60	Start Drawing in AutoCAD / Start Arduino	
61	Document Project (Formal Drawings, Document Code, Lots of Pictures)	
62	Document Project (Formal Drawings, Document Code, Lots of Pictures)	
63	Finalize Project Design / Start printing and building	
64	Finalize Project Design / Start printing and building	
65	Finalize Project Design / Start printing and building	
66	Show and Tell with Projects	
67	Next Project Brainstorming	
68	Next Project Brainstorming	
69	Next Project Brainstorming	
70	Form Diffrent teams of 2 - 3	
71	Sketch Ideas On Paper	

What is Thingiverse?

Their website: http://www.thingiverse.com/explore/featured

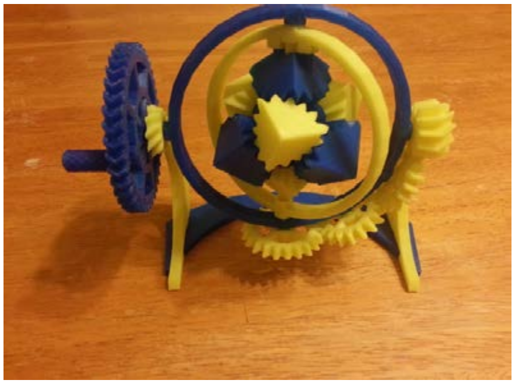
"MakerBot's Thingiverse is a thriving design community for discovering, making, and sharing 3D printable things. As the world's largest 3D printing community, we believe that everyone should be encouraged to create and remix 3D things, no matter their technical expertise or previous experience. In the spirit of maintaining an open platform, all designs are encouraged to be licensed under a Creative Commons license, meaning that anyone can use or alter any design."

Essentially, this means is that Thingiverse is a website where you can share and download parts to 3D print. Parts on Thingiverse range from toys, to robot parts, to extremely useful accessibility parts, like braille dice, or tools to help people with arthritis turn keys.

Example Parts from Thingiverse ready for 3D printing:

Low Poly Alligator Head

The Amazing Gyroscopic Cube Gears

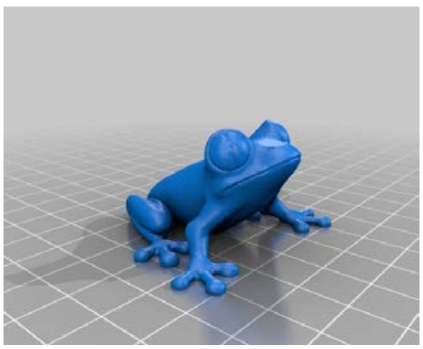


Martian Pyramid

Splashing Pen Holder

Treefrog

Noisemaker

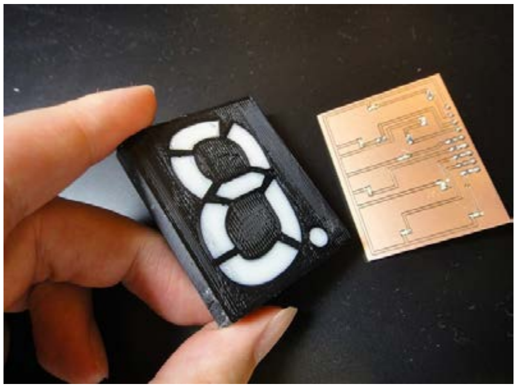


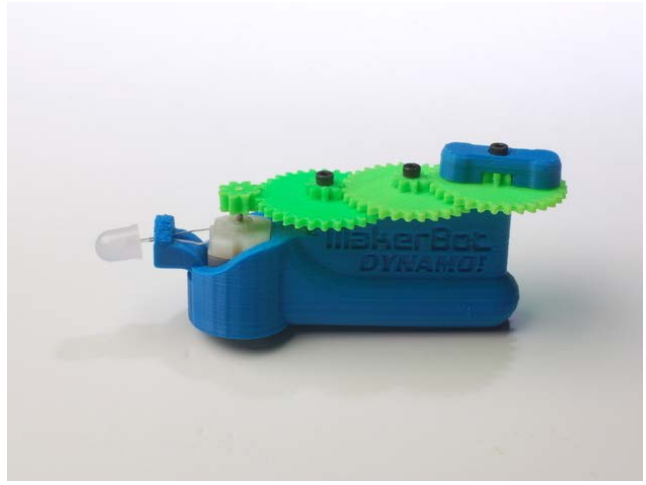
Flexy Hand

S-carabineer

Custom 7-Segment Display

Makerbot Dynamo





Images retrieved from: http://www.thingiverse.com/

Ponoko and Shapeways Description

Shapeways Video: https://www.youtube.com/watch?v=8equ02z-s8U

Ponoko and Shapeways are two online companies who offer 3D printing services. They offer printing in a number of different materials, some of which include: precious metals, stainless steel, nylon plastic, frosted plastic and even full color plastic. These sites allow clients to upload drawings for their parts. The sites also allow clients to sell their design, some of the money goes to the company and some of the money goes to the client.

We believe that Protik could benefit from this type of business model. It could be a valuable service for local Albanians, allowing anyone to 3D print any parts they may come up with. Ponoko and Shapeways are both located abroad so Protik could offer this service to Albanians at a cheaper rate. This model could allow Protik to utilize the 3D printers during off hours as well as recoup some of the cost of the printers and materials.

http://www.ponoko.com/make-and-sell/how-it-works

http://www.shapeways.com/create?li=nav

The process in which an individual can get their design printed is as follows:

Design It: In this stage, a potential client designs their own product. They can use Solidworks, AutoCAD, Blender or any other 3D modelling program.

If a client is unable to design their own product in CAD or other modelling software, some companies offer an additional service to draw a part based off of pictures or sketches.

Upload It: Next, the client would upload their drawings to the website. The company would then quote the design based on design complexity, material, and time required to print the part.

Choose it: In this step, the client would be able to choose the material they would like the part printed in.

Make It: In this step, the company would print the product.

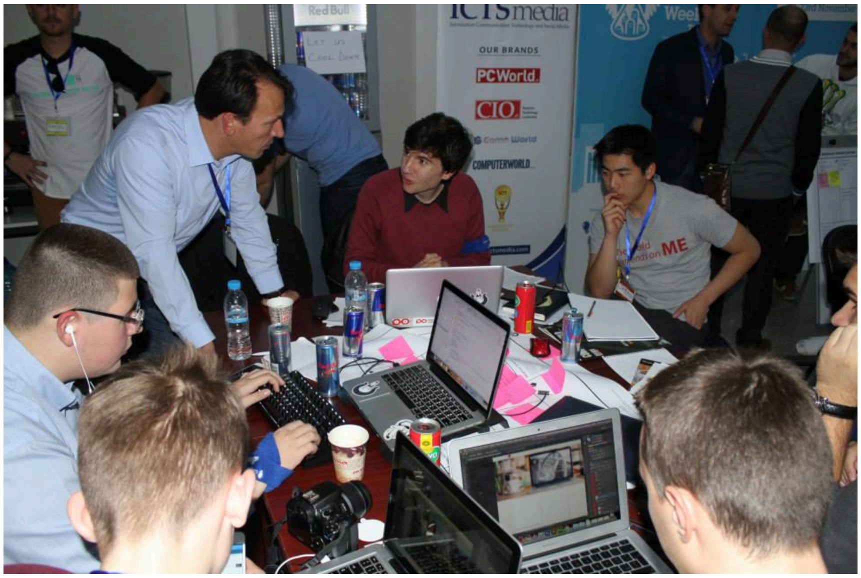
Ship It: In this step, the company would ship the part to the customer.

APPENDIX G: PHOTOGRAPHS OF YOUNG INNOVATORS CLUB WORKING ON COLLABORATIVE PROJECTS

Photograph of our team with students from the Young Innovators Club, working on the Wireless Chess project.

Photograph of our team with students from the Young Innovators Club, working on filming the video for Global Startup Battle.

APPENDIX H: PHOTOGRAPHS OF TIRANA STARTUP WEEKEND 3.0

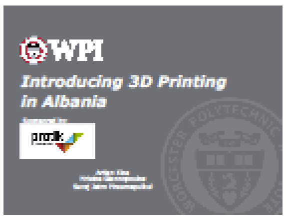


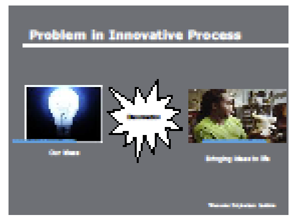
Photographs of our team working and presenting, and our startup idea that were taken at the Startup Weekend Tirana 3.0 on November 23rd to 25th, 2014.

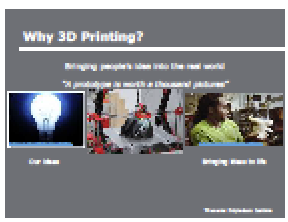
APPENDIX I: TECH CREW PROJECT PRESENTATION

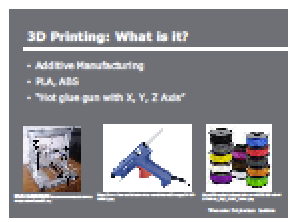
Photographs of the presentation our team and the Tech Crew project manager Hatixhe Bilibashi made at the Polytechnic University of Tirana on December 3, 2014.

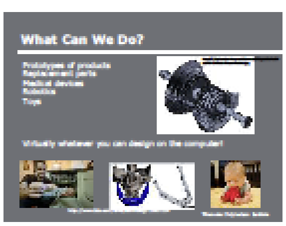
APPENDIX J: TECH CREW PRESENTATION SLIDES

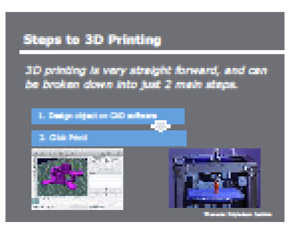












WPI

Introducing 3D Printing in Albania

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ICT Resource Center

Artian Kica
Hristos Giannopoulos
Saraj Jetro Pirasmepulkul

Who We Are

Worcester Polytechnic Institute

http://odk.org/wp-content/uploads/2014/05/worcester-polytechnic-institute2.png

http://upload.wikimedia.org/wikipedia/commons/thumb/f/f5/Massachusetts_in_United_States.svg/2000px-Massachusetts_in_United_States.svg.png

Worcester Polytechnic Institute

Problem in Innovative Process

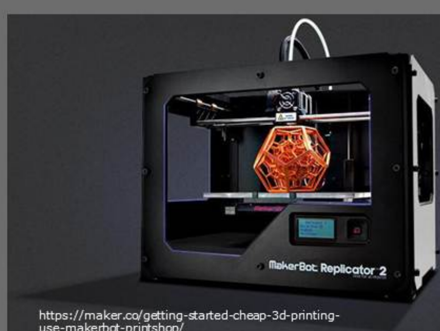
Our ideas

Disconnection

Bringing ideas to life

Worcester Polytechnic Institute

A Solution: 3D Printing



https://c2.staticflickr.com/8/7045/6777645024_791c22b463_z.jpg

Worcester Polytechnic Institute

Why 3D Printing?

Bringing people's idea into the real world

"A prototype is worth a thousand pictures"

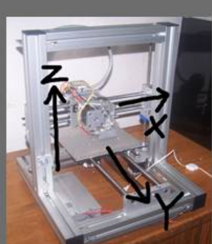
Our ideas

Bringing ideas to life

Worcester Polytechnic Institute

3D Printing: What is it?

- Additive Manufacturing
- PLA, ABS
- "Hot glue gun with X, Y, Z Axis"



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http://www.howardelectronics.com/steinel/images/WGF-3002L.jpg

http://thumbs2.ebaystatic.com/d/l225/m/m9ZFSnhUL_lhjF_5387_bWw.jpg

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What Can We Do?

Prototypes of products
Replacement parts
Medical devices
Robotics
Toys

http://i133.photobucket.com/albums/q63/agustianhadinata/CADModelofSteamTurbine.jpg

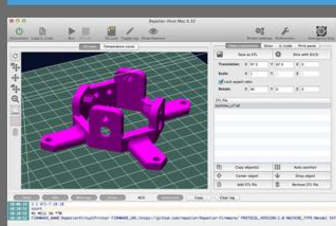
Virtually whatever you can design on the computer!

http://www.bbc.com/news/technology-16907104

Steps to 3D Printing

3D printing is very straight forward, and can be broken down into just 2 main steps.

1. Design object on CAD software
2. Click Print!



Worcester Polytechnic Institute


Thank You Very Much
Questions?

APPENDIX K: GLOSSARY

3D printer - An industrial robot that creates three dimensional objects through additive manufacturing techniques.

Additive Manufacturing - A technique of creating three dimensional objects by adding successive layers of material.

Arduino - A microcontroller board intended for hobbyists and students. Arduino is an open-source electronics platform based on easy-to-use hardware and software.

CAD - Short for Computer Aided Design. The use of computer systems to assist the creation, modification, analysis, or optimization of a design.

FIRST - An acronym for **F**or **I**nspiration and **R**ecognition of **S**cience and **T**echnology, FIRST is an organization focused on robotics competition founded by Dean Kamen,

ICT- Short for information and communications technology. Integration of telecommunications, computers as well as necessary software, middleware, storage, and audio-visual systems, which enable users to access, store, transmit, and manipulate information.

Makerspace - Community run workspace where hobbyists, students, and general enthusiasts can gather to work on a wide variety of projects.

Protik - Short for Protik ICT Resource Center. Our sponsor for the IQP.

Prototype - An early sample or model product built to test a concept or process.

Rapid Prototyping – Abbreviated as RP. A group of techniques used to quickly fabricate a scale model of a part or assembly using CAD data.

Raspberry Pi - Credit card-sized, single-board computers.

Tech Crew Project – Protik's current program aimed at promoting innovation through the use of 3D printers.

Young Innovators Club – Protik's previous program aimed at promoting innovation among Albanian youths.