Lessons Learned in the Labyrinth: Navigating Campus Resources to Bring a Student and Faculty Smart Gardening Startup to Life

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Abstract

Many universities have technology transfer offices, entrepreneurship centers, and small business development centers to help faculty, staff, and students with the process of creating value from their ideas. While access to all these resources is a benefit of being a part of the university ecosystem, it can also be difficult to know where to start. Additional complications arise when faculty and undergraduate students, who are typically governed by different intellectual property policies, form a joint venture. This paper is written as a case study to describe the process of forming a startup by one such faculty and student team. The smart gardening technology being developed utilized a range of resources offered at the university. It enabled student learning through completion of sub-projects during summer research, internship, and technical electives. Finally, this paper covers strategies that other faculty and student teams in the same situation might follow to help them climb the entrepreneurship learning curve faster than we did.

Entrepreneurial Ecosystem

With the onset of the Bayh-Dole act in 1980, many universities established technology transfer offices to comply with the obligation to pursue intellectual property protection and commercialization. More recently, universities have established entrepreneurship centers that offer everything from academic programs to proof of concept funds to help students, staff, and faculty create value based on their ideas. Additionally, each state has a federally-funded Small Business Development Center (SBDC) that provides free business consulting and low-cost training services. The SBDC is often located at or near a university, and often works closely with the corresponding university technology transfer office and/or the entrepreneurship center. What follows is a brief summary of the services and resources often offered by each [1].

Technology Transfer Office

The main thing the Bayh-Dole Act did was allow transfer the ownership of inventions resulting from federally-funded research from the government to the university. This stimulated many universities to create offices of technology transfer (often referred to as tech transfer) tasked with licensing or otherwise facilitating the commercialization of inventions, particularly ones resulting from federally-funded research. An invention disclosure that describes the idea or intellectual property (IP) is usually the way to initiate a conversation with the tech transfer office. Although this typically only applies to *employees* of the university (faculty, staff, and graduate students), not undergraduate students, the division is not always obvious. For example, a non-tenure track faculty member might be involved in IP generation while under contract with the university, but develop it over a summer without federal funding or significant use of university resources. So, while the activities (employment and IP generation) happened simultaneously, the faculty member might not be required to file an invention disclosure. On the other hand, an

undergraduate student might be employed as a research assistant in a faculty-led lab supported by federal funding, and therefore may be required to follow the same policies as other employees of the university. To figure out if you are contractually obligated to disclose, you can refer to your employment contract and/or university policies.

Once an invention disclosure is made, the tech transfer office will decide if that IP meets the three criteria for a patent: novel, useful, and non-obvious. If not, the employee is typically free to pursue commercialization without IP protection (but trademarks, trade secrets, open source licenses, etc. may still offer enough incentive to pursue the idea). If so, a provisional patent will typically be filed. The university is obligated to advertise the invention at this stage, and the employee has two options: 1) license the technology to an interested company, or 2) form a company and license the technology from the university. Although technically the university does not need to let the employee license the technology if other companies would be more suitable, they typically will offer favorable licensing terms (often an exclusive license) to encourage and reward invention disclosure in the first place.

Entrepreneurship Center
While the tech transfer office often handles the legal side of this process, the entrepreneurship center often handles the practical side. Just because you form a company on paper and execute a licensing agreement does not mean your company that now exists only on paper will ever be a living, breathing organization with employees and revenue and all the other things we typically associate with a company. In fact, most companies at this stage are not companies in the practical sense at all. They are startups. A startup is defined as a temporary organization in search of a scalable business model [2]. Entrepreneurship centers have programs and curriculum available to faculty, staff, and/or students designed to foster the process of taking an idea from this startup phase through to commercialization.

Examples of entrepreneurship centers include the Horn Program in Entrepreneurship at the University of Delaware [3], the Innovation & Entrepreneurship Institute at Temple University [4], and the Center for Entrepreneurial Studies at Stanford [5]. The backbone of most of these programs is the literature on evidence-based entrepreneurship [6], [7] that drives the creation of programs, workshops, curriculum development, and other activities. These might be developed and implemented in house, executed through regional or national programs such as NSF I-Corps, or through some combination.

Small Business Development Center (SBDC)
Each state has at least one federally-funded SBDC. These centers are resources for every resident of the state, not just the university. However, since the pace of business development tends to be relatively high in and around universities, it is common for the SBDC (or one of several in a state) to be located at a university. For example, on Delaware's SBDC website [8], it states that

the SBDC is a unit of the University of Delaware's Office of Economic Innovation & Partnerships (also known as the tech transfer office). However, it takes some work to find which of the offerings will be appropriate for your startup. For example, we were once advised to attend an appropriately named "How to Start a Business" workshop, but the material was more appropriate for someone starting a restaurant or shoe store (as indicated by the presenter) than an internet of things hardware startup. At the same time, we know faculty who have had tremendous success working with the SBDC and their other resources.

Money and Time

Money and time are required in an evolving ratio during the startup phase and beyond. Luckily, many universities have programs that enable access to both at least in small amounts. Even a lean startup will likely need some funds to travel for customer discovery work, attend conferences, host a website, and pay fees associated with registering a company. Here are some things to look for in and around your campus.

Funding your venture

The first type of funding is non-dilutive grant funding, a.k.a. free money. Pitch competitions and business plan competitions are common and can serve as an early source of funding. On-campus programs like NSF I-Corps Sites offer a small amount of money ($3,000 as of now) to get started with customer discovery work that can lead to a $50,000 NSF I-Corps Teams grant at the next level. Some universities also have a proof of concept fund or other ways of accessing capital for equipment, prototyping, and product design work. As we move outside of the university, many federal agencies participate in the small business innovative research (SBIR) and small business technology transfer (STTR) programs, which offer phase 1 awards up to $225,000 and have been re-branded recently as "America's seed fund". VentureWell offers several programs geared toward growing inventors, innovators, and entrepreneurs [9]. Of these programs, the E-Team program targets multidisciplinary student groups and provides funding, up to $20,000, and guidance for teams who have a technology innovation that solves real-world problems [10]. These options are non-dilutive because you do not need to trade equity in your company for the money.

The second type of funding is dilutive funding, where you are offered capital in exchange for ownership of a percentage of your company. This is where angel investors, venture capitalists, and some of the startup incubator or accelerator programs come in. In general, it is wise to hold off on accepting dilutive funding unless a large infusion of capital is required early on to build the company.

Time and timing

Sometimes if you have money, you can buy time – in the form of compensating yourself, co-founders, and/or other early employees with cash. However, there may be other ways to access

time, particularly student time, for early research and development work in a mutually beneficial arrangement. Many universities have undergraduate research and/or service learning programs that pair qualified students with interested faculty members and pay students a stipend for a summer or semester of their time. There may also be centers or institutes on campus that offer internships with member faculty for students interested in working on projects that advance the goals of the center [11]. Many universities allow (even encourage) faculty to use up to 20% of their time or the equivalent of one day per week to work on consulting or startup-related activities. For faculty, it is wise to look up your university policies on such things and/or talk to your department chair or dean to make sure you document any conflict of interest.

Forming a Company
There are several types of companies (LLC, C-Corp, S-Corp, etc.) and your SBDC probably has resources to help explain the differences. An LLC is quick and easy to form either through your SBDC, online via sites like LegalZoom.com, or through a startup-friendly lawyer, and can be converted to a C-Corp later. However, if you plan to take on venture capital early, you may want to start with a C-Corp. Some incubator and accelerator programs facilitate this process, and other useful startup sites have templates to help with the paperwork [12].

If you are a solo founder at this point, the paperwork is straightforward. However, if you have co-founders, you will likely want to set up an operating agreement early on and divide equity in your company. There is no right answer to how to divide equity in the company evenly, but the wrong answer is usually to split it evenly without thinking through it. We found the founders' pie concept and calculator [13] helpful in quantifying the contributions of our three co-founders. Others have used Slicing Pie [14], a similar concept. In either case (single founder or multiple co-founders) it can be wise to leave a portion of the equity in your company in the range of 5-10% unassigned to entice early employees and/or board members.

Ownership vs. Management
While equity agreements describe ownership, the people that have equity may or may not be the ones involved in day to day management. Most companies are managed by a board. All types of companies require boards, but requirements on size and composition vary depending on the type of entity [15]. A board for a startup might consist of the founder or some or all co-founders, early stage investors, and/or advisors. Members of the board who are not founders may be given a small amount of equity as compensation for their time and involvement. The management of the company is typically appointed by the board, and tends to be made up of individuals with titles everyone is familiar with: Chief Executive Officer (CEO), Chief Operations Officer (COO), and Chief Financial Offer (CFO). Although these titles are not required, they help explain who does what in a startup with a common vocabulary [16].

Sage Smart Garden
Now that we've shared the general process, we'll dive into the specifics of our startup in roughly chronological order.

In the spring of 2015, DR wanted to build a garden on the roof deck of her urban townhouse to grow vegetables and herbs, but knew nothing about gardening and did not have many resources

(time or money) to get there easily. She wanted something that could water itself automatically with just occasional manual check-ins that led to fresh tomatoes and basil that could be harvested at leisure on the weekends. She proposed this as a project to UD's summer scholars program, and identified three students interested in helping. The project was funded, and along with a team of students, they got to work on the design process. By the end of the summer of 2015, the team had completely rebuilt the roof deck, built nine 3'x3' modular raised beds, arranged them in a U-shape on the roof deck, threaded sub-surface drip irrigation throughout the beds, filled the beds with a custom soil mix, started seeds and seedlings, attached an electronically actuated solenoid valve, and began prototyping a smart garden system that could remotely activate the solenoid valve. However, the system relied on an inconsistent wi-fi connection and was not yet weatherproof. Future plans were made to use an alternative communication protocol and ruggedize the system for the outdoors.

The following summer in 2016, an alumnus and donor to UD's College of Engineering (CoE) began funding a program which would come to be known as the CoE Fellows. This 10-week internship, led by faculty director DR, was implemented to bring engineering students into the world of entrepreneurship through weekly mentoring and coaching sessions throughout the duration of a hands-on project. After being selected to join the program, Trevor Stephens (UD mechanical engineering student), Ben Mazur (UD electrical engineering student), and a Stanford computer science/product design student formed a team and began a problem-finding exercise under advisement from DR and the donor to the program. The team moved quickly through the areas of applications for inexpensive cameras, wireless underwater communication, drone networks, internet of things, and smart home technologies. The team narrowed in on a product opportunity gap [17] in availability of smart home products for outside the home, particularly for gardening. The idea was simple: use solar powered sensors to put garden vital signs at the fingertips of gardeners, while providing a system that automates watering. Coincidentally, the team had stumbled upon an idea very similar to what DR had been working towards in her roof deck garden project the summer before.

The team charged forward with development, using XBee radios, Arduino, Raspberry Pi, and many other open source technologies that enabled rapid prototyping. They also purchased several competitor products, which provided invaluable benchmarking information. As the summer approached its end, the team had cobbled together a semi-functioning prototype of the early system. It was comprised of two water valve modules, with built in moisture sensors, that could be toggled remotely from a rudimentary app created with Blynk [18]. Soil moisture data was graphed within the app, and the valves could (sometimes) open and close remotely. The modules were largely battery operated, but had solar panels to allow recharging of a portion of the battery. Like many first prototypes, it was buggy and looked very different from our current prototype. However, it was a successful proof of concept and the team was able to monitor and water a garden remotely. The team called the system Eve.

On numerous occasions the team faced "mid-project crises", questioning the validity of their project and the problems they were solving. Around this time, DR introduced them to colleagues at UD's Horn Program in Entrepreneurship. The team met with a mentor from Horn and were introduced to the world of evidence-based entrepreneurship. They were advised to hypothesize whom their target customer might be, and then go find and interview potential customers that fit

that description. The team generated a survey to collect contact information as well as gardening habits from hundreds of individuals, then set up phone interviews with those who most closely fit their customer archetype. As they would learn, the customer discovery process would have been extremely beneficial to perform at the *beginning* of an endeavor. Nonetheless, the handful of interviews they performed supplied new hope and much needed course corrections.

Based on the success of this and other projects that needed more support, DR applied for and was awarded a $30k VentureWell faculty grant to create a bridge program for continued development of student projects outside of senior design and other coursework. Part of this grant funded the development and implementation of a new class, Prototype to Product, that was piloted in the spring of 2017. Trevor enrolled in this class and used the time to advance the system prototype. Towards the end of the courses, he began work to launch a crowd-funding campaign on Kickstarter to help build a customer base and fund development through pre-sales. Ben and Trevor filmed a campaign video with the help of a third-party videographer, and Trevor generated many of the graphics necessary for the campaign and website landing pages for the project being called Evergreen (a change from Eve) at the time. Unfortunately, Kickstarter mandates that projects cannot sell prototype versions of their product unless the product is basically finished already. Evergreen at the time was too early for Kickstarter, as the team was not in any position to promise delivery of commercially ready devices within the timeframe backers expect from a campaign. Many backers sent messages asking how they could pre-order the system, since there was no such option on the rewards list. This was encouraging, but ultimately the decision was made to terminate the campaign. It is likely that crowdfunding via Kickstarter is still in our future after further prototype development.

At the end of the spring 2017 semester, the team (now DR, Trevor, and Ben) was accepted into NSF I-Corps Sites in the early summer 2017 cohort. NSF I-Corps Sites provides $3000 in funding, workshops on evidence-based entrepreneurship, and access to mentors and advisors. Through the program, we started building out our business model canvas [7] around initial hypotheses, which were systematically de-risked by repeated customer interviews. By the end of the program, we had completed roughly 30 customer interviews and decided to apply for Ud's newly formed proof of concept fund for $75k of development funding. However, our initial application was rejected, and we were told to make sure with talk with tech transfer to unravel the legal issues around our student/faculty startup. So we did. As a non-tenure track faculty member working with undergraduate students, it was unclear if the university had claim to the IP. However, we decided together that it would be beneficial to file for a provisional patent and pursue commercialization in parallel. We discarded the idea of licensing the technology as an option and decided to form a company to license the technology from the university.

In preparation for filing for an LLC to then license the technology back from the university, we hired a branding specialist and graphic designer. This was a surprisingly lengthy process of reviewing and rating a list of hundreds of garden/tech/plant sounding words and syllables. Personal preference, search engine optimization (SEO), trademark, and domain and social media handle availability were all factored into the decision. Finally, we settled on Sage Smart Garden, LLC, which is now registered in Delaware. Through conversations with other faculty who have done this before, we identifed a startup-friendly lawyer at a boutique law firm who agreed, as

some do, to let us defer payment until we had secured more capital. We worked with him on an operating agreement and a licensing agreement that we are just now putting the final touches on.

In the fall of 2017 after these conversations with tech transfer took place, we gain applied to the proof of concept fund. This time we are finalists, and invited to pitch to a panel of internal and external judges. Although we still didn't get the award this time around, we got some good feedback from the judges and were clearly making progress. Since then, we have been iterating on the operating agreement and licensing agreement and managing some changes in the core team. One of the student co-founders that graduated in May 2017 was offered a full-time job at another startup, and we decided to revisit the founders' pie to reallocate equity based on his capacity for future contributions. Additionally, DR took a job at a different university, and is in the process of working with some of the new resources available to the team because of her new role. We are currently applying for a VentureWell E-Team student grant, an NSF I-Corps Teams grant, and pursuing early stage seed funding to get a small batch of prototypes in the hands of early adopters this spring.

Conclusion
There is no one correct path and founders will receive different advice from different stakeholders in the process. There have been times that we wished we had some sort of case manager to guide us through the process and sort fact from fiction and good advice from bad. However, navigating this process has led to an amazing amount of professional development for the whole team over a relatively small amount of time that would not have been accessible if we had been simply told what to do. The most valuable lesson we have learned is to listen to Steve Blank: get out of the building. However, when Steve Blank says it, he is referring to customer discovery. We recommend it as a more general strategy. We're now connected to world-renowned faculty, directors of entrepreneurship and product design institutes, seasoned entrepreneurs, and others who would not have been accessible to us had we not reached outside of our comfort zone for advice. More often than not, the people that advised us have been incredibly generous with their time, and the success of Sage Smart Garden, LLC will be heavily influenced by this network.

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