Transitioning International Development Projects to Sustainable Businesses: the Challenges in Commercializing a Research Project and the Engineer-Entrepreneurs Behind the Product

by

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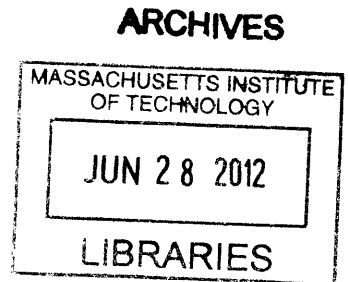
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ABSTRACT

Professionals that work on designing products and developing businesses for the
developing world experience challenges unique to international development in addition
to common challenges in product design and business development. However, there are
far more professionals working in product development than in business development.
Majority of international development projects come from research in academic
institutions and the number of research-based spin-off start ups working on
commercializing the technologies is significantly less than the number of other research-
based spin-offs. This study looks at the characteristics of founders that transition
products from research projects to companies, their motivations, the challenges they
face, and how they overcame the challenges through a case study method.

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TABLE OF CONTENTS

LIST OF TABLES

1. INTRODUCTION

The gold at the bottom of the pyramid refers to the world's 4 billion people, the largest untapped consumer market on earth according to Allen Hammond and C.K. Prahalad (2004). Although these 4 billion people individually have insignificant purchasing power, Hammond and Prahalad reasons that the collective purchasing power of these 4 billion people is huge. What renders this rosy picture unrealistic is the lack of infrastructure in developing countries that makes it extremely difficult to aggregate those individual purchasing powers into a market large enough to attract new entrants. Most parts of the developing world do not have paved roads. There is no city planning. There is no postal address. There is no source of reliable electricity. This lack of infrastructure, common in the developing world, imposes a significant barrier to entry and deters companies from rushing to the gold at the bottom of the pyramid.

Not only are there barriers for new businesses, but also there are significant barriers to new product development in developing countries. Most product development teams are based in industrialized nations, which makes field visits too costly and many teams do not spend enough time in countries with their users as much as they should. And this lack of user interaction is apparent in resulting products, which are unfit for users' environment. A foot-operated micro-irrigation pump designed for small-scale farmers in East Africa was attractive, extremely inexpensive, and required low effort. But this product failed to sell because the product placed its female users, 80% of the target market, in a socially unacceptable position. It should be noted that this is a product being used out on the field in plain view of the public. This cultural mishap could have

been easily avoided had the development team conducted more comprehensive prototype testing with their users (Donaldson, 2002).

Another common design challenge for development teams is designing durable products for extremely low selling price. If a product is to be sold for $20, it needs to be manufactured at a fraction of that price. Hence, the development team works under great constraints to deliver a product that meets users' needs at a price point they can afford. Unfortunately, more often that not, development teams produce a bare bones design that either uses low quality materials or is a minimum viable product to meet the cost requirements. A low-cost wheel chair designed with a lawn chair and bicycle wheels can be mass manufactured at very low costs. This minimum viable product provides mobility to disabled users at the cost of their physical discomfort and safety (USA TODAY, 2006). Development teams need to be wary of falling into the trap of trading in great design for the lowest-cost design.

Although businesses are not rushing for the gold at the bottom of the pyramid, there are many organizations cashing in their gold to develop products for the developing world. One such organization of interest is academic institutions. Many academic institutions have research laboratories dedicated to solving global challenges and offer product development classes with international development focus. Every year, great ideas come out of universities. There are so many great ideas, in fact, that there is a nonprofit organization called Design that Matters that was founded to serve as the "institutional memory" and capture these ideas from each year to allow successive teams to build on previous work (Prestero and Cantor, 2004).

Many students participate in development projects but very few continue beyond the course or beyond graduation. This paper is interested on the few that do continue. The challenges in product development and business development are difficult enough to deter seasoned professionals and wealthy firms from entering developing markets. So what drives inexperienced students and recent graduates want to take on the challenge? This paper attempts to uncover motivations of students who transition their academic projects into commercial products and provide a description of the challenges they faced and how they overcame those challenges.

2. Literature Review

2.1 Common Characteristics of Founders

Early research on entrepreneurship had focused on finding common personality traits among entrepreneurship (Brockhaus, 1980; Brockhaus & Horwitz, 1986; Sexton & Bowman, 1983). Studies were conducted to observe any correlation between successful entrepreneurs and the following personal traits: need for achievement (Johnson, 1990), locus of control (Begley and Boyd, 1987; Pandey and Tewary 1979; Shapero, 1982), and risk taking propensity (Brockhaus, 1987; Hisrich and Peters, 1995). Although some found positive correlation, majority of these studies have failed to present conclusive evidence of how these personal traits manifest themselves differently in founder and non-founding managers. Researchers have concluded that these personal traits were wrong traits for empirical study (Brockhaus 1980; Carsrud and Krueger, 1995; Gartner, 1989; McClelland, 1965; Sexton & Bowman, 1986). Other demographic information such as having entrepreneur parents (Roberts & Wainer, 1971; Shapero, 1971) have been shown to have a positive influence on the likelihood of a person's entering an entrepreneurial career track.

Later studies have shifted the focus to understand the common traits among successful entrepreneurs. Leadership researchers have claimed that passion for work is a common characteristic of successful business leaders (Bass & Stogdill, 1990; House & Shamir, 1993, Locke, 2000). Researchers agree that passion is relevant in entrepreneurial setting as well because it drives entrepreneurs to face extreme uncertainty, work through financial barriers, challenges to their new products, and resource shortages (Locke,

2000; Timmons, 2000). Bird (1989) noted that entrepreneurial behavior is "passionate, full of emotional energy, drive and sprit."

Douglas and Shepherd (2000) found that individuals enter entrepreneurship based on utility comparisons given their attitudes toward risk, independence, and work. Studies on why founders entered entrepreneurship indicate that desire for independence and financial gain are strong drivers (Roberts & Wainer, 1971). Further in depth interviews revealed that 30% quit their previous jobs with no specific plans for the future, 13% had to leave because of factors such as plant closing, and an additional 40% said they would have left their previous positions even if they had not become entrepreneurs (Cooper, 1971). Both theory and empirical evidence support the claim that individuals are more likely to start a new firm the lower the opportunity cost (Amit et al., 1995; Iyigun & Owen, 1998).

Among successful rapid growth ventures, studies have shown that founder's resourcefulness—higher education, relevant industry experience, entrepreneurial experience, and broad network—is a strong indicator of venture performance. Evidence supports the theory that entrepreneurial skills are enhanced through higher education (Sapienza and Grimm, 1997; Watson et al., 2003). And studies show that founders in successful technology oriented start-ups have a bachelor's degree or higher, usually in engineering (Roberts, 1969; Susbauer, 1969). Founders with experience in the same industry as their new venture have a more established professional network (Fesser and Willard, 1990; MacMillan and Day, 1987; Siegel et al., 1993). The founder's broad personal and professional network is particularly advantageous to young firms because a broad network indicates founder's ability to access additional knowhow, capital, and

customer referrals (Birley, 1985; Hansen, 1995). If the previous experience is also in entrepreneurship, the firm benefits from the founder's management experience and ability to avoid costly mistakes (Cooper et al., 1998; Duchesneau and Gartner, 1990; Stuart and Abetti, 1987).

The author was unable to find any existing literature on characteristics of people who found start-ups with an international development focus. Existing literature in design for development focuses on design challenges and market failure and rarely focuses on teams. Malkin and Anand's 2010 article is the only one the author has come across that emphasizes a need for a product champion and their importance during crucial transition periods in the product development process.

2.2 Challenges in Designing Products for the Developing World

Products designed for developing world go through essentially same stages—needs finding, abstraction, design, and testing—as products designed for the developed word. The crucial difference that makes designing for the developing world much more difficult is that designers working on products for the developing world are often separated from the user by language, culture, and thousands of miles (Malkin and Anand, 2010).

Because of the geographical distance, remote design teams must maintain continuous feedback loops and interact with potential users throughout the product development and implantation stages (Donaldson, 2002). Unfortunately, it is very rare to see comprehensive user need finding and market research in design for developing

countries. Comprehensive need finding and market research should be able to answer questions such as: who is/are the target group(s)? What are their characteristics? What are their requirements? How diverse are these requirements? What would be the potential value of a "solution" to the user? How are the users addressing the need now? (Donaldson, 2002)

Donaldson (2002) emphasizes the need for great design, something most development teams forgo in favor of low cost solutions, because technology that is poorly designed and unsuited to the user and or the environment is detrimental to users with no financial safety net to take risks. To ensure great design, development teams must work with early adopters in the field and conduct extensive prototype testing (Malkin and Anand, 2010)

Not only do products have to be useful to the target group and be appropriate, but products also need to be sustainable (Donaldson, 2002; Free, 2004). Developing nations seldom have necessary supporting technologies such as reliable source of energy and clean water and skilled human resources needed for operating and maintaining a porduct. To address these concerns, designers must think carefully about product's use of consumables, the price and availability of those consumables, ease of use and instruction, robustness, and availability of repair services.

Furthermore, the people that use the products are often different from people who choose the product and pay for the product (Free, 2004). It is important for development teams to realize this distinction during market research in order to design products that are both usable and saleable. Free (2004) also notes that working with key gate keepers early on increases successful commercialization since these influential

figures will use their networks to spread the world if they believe in the benefits of the product and feel that they have a stake in its success.

2.3 Challenges in Creating Businesses for the Developing World

Many great products designed for the developing world have not become commercially viable and have remained in the archives of design studios and academic institutions. A study conducted by Chesbrough et al. (2006) found that successful deployments focused first on the design and implementation of a business model that commercialized the technology and only second upon product design. This study also found that implementing effective business models took 5 years or more primarily because of the lack of infrastructure in many developing countries. Additionally, product adoption in developing countries is much slower than in developed nations due to lack of existing distribution channels and lack of telecommunication technologies that would accelerate the spread of world of mouth. Because most for-profit ventures prefer not to operate under slow growth over a long time frame, Chebrough et al. (2006) advocates early stage firms to partner with NGOs who already have done much of initial business model infrastructure to facilitate commercialization of the product.

Obtaining patents and other protective measures for the firm's intellectual property is important because this facilitates creating advantageous partnerships and alliances to manufacture, market, and distribute the product (Free, 2004). However, obtaining patents is a lengthy and costly process and in most developing countries, there is a lack of infrastructure to enforce intellectual property laws.

Besides Chesbrough et al.'s 2006 study of firms that successfully commercialized products in developing countries, the literature on common attributes of successful firms with an international development focus is sparse—partially due to the lack of firms that attempt to commercialize products in developing countries. Research in general entrepreneurship often sites firm's commitment to growth (Cooper and Artz, 1995; Davidsson, 1991; Sexton, 1989) and exemplary recruitment (Barringer et al., 1998; Braggs, 1999; Harrison and Taylor, 1997; Rich, 1999) as a necessary precursor for successful rapid growth.

3. METHODS

Three founders of nascent start-ups with an international development focus, all less than one year old at the time of interview, were identified within the author's network of international development professionals (Full disclosure: the author is a co-founder of one of the companies). Founders agreed to be interviewed on a condition of anonymity. Each founder was asked to create a timeline of his or her company from the time of idea conception, and to mark time periods where important milestones occurred in product or business development. Alongside this timeline of events, founders were asked to identify active team members, funding used, and funding awarded for this time period. During the first round of interviews—conducted in person whenever possible—each founder was asked the same set of questions aimed that understanding where the idea came from, what motivated them to continue, and what were the hardest challenges. Interviews were conducted in an open manner with the prepared set of questions guiding the flow of the conversation. Each interview was recorded and transcribed afterwards. After compiling all the notes from each interview, author followed up with each founder to delve deeper into certain issues and ask their opinion on an interesting topic that came up in conversation with another founder. Authors and founders kept email correspondences throughout the duration of the study for times when further clarifications were needed.

4. CASE OF COMPANY A

Company A makes a low cost medical device called Product A designed for primary health clinics in resource poor settings. Product A's unique value proposition is its integrated training module and capability to validate the success of tasks being performed. Product A uses a household good commonly found all over the globe and attached a modular sensor and a modular cycle monitor that essentially transforms the household good into a medical device. The cycle monitor talks to the user in his or her native language about the progress of the task and at the end of the cycle gives them an indication of whether or not the task's requirements were met. Also the cycle monitor has an integrated training module that trains new users about the importance of the task and how to use the product by speech and visual guides on the cycle monitor.

Founder A, a graduate student in mechanical engineering, came up with the concept after working on another project. When Founder A started his graduate studies, he was looking to get involved in research addressing global health needs. Founder A studied mechanical engineering as an undergraduate, was a pre-med student, and had worked on a number of medical device designs. He found a team of researchers working on building a medical device (in the same product family as Product A) powered by solar energy and the team happened to be looking for an engineer to help them design the solar collector.

While working with this group for three months in the fall of 2010, he learned about the drastic difference in adverse health effects of not using the medical device between developed and developing nations; the current state of this technology in developing

nations; as well as an idea of what types of resource constraints the primary health clinics were operating under. However, at the end of the fall term, Founder A decided not to continue because he lost interest in building a solar collector.

Founder A spent his winter vacation thinking about whether or not a low cost design of such medical device would be feasible when he thought of using a common household good to replace the main component of the device that is the hardest to manufacture. Tinkering around with various sensors and operating conditions of the medical device, he found that the household good meets the required specifications for the medical device.

Founder A became excited about the idea and started discussing the idea with friends, peers, and advisors. He knew that for the idea to gain traction and for him to design a product that fits within the developing world setting, he needed to find people with the cultural context. He found two Nepali students who thought the idea was really interesting and wanted to help. They brought in knowledge of conditions in primary health clinics in Nepal. Most importantly, they informed Founder A that the household good is actually easily obtainable in Nepal and that most people used one regularly in their daily lives.

A competition for innovative solutions to global problems sponsored by the university had begun accepting applications and Founder A began putting together a team quickly. From the beginning, Founder A knew that to achieve a scale at which a product like this could have a measurable impact, he needed to set up a business. From experience he saw that an academic project can only go so far. Founder A started to actively seek out students from the business school to join the team to complement his engineering

expertise with business knowledge. He found a classmate in the product design class he was taking at the time who came from a management and engineering background to join the team. This person would later become Co-founder A (and referred to as Co-founder A for the remainder of this paper).

Most of March and April 2011 was spent on working with the Nepali students to come up with a concept design and conducting feasibility analysis. A new feature that came from a team brainstorm was to attach a monitor that would let the user know the progress of the task and to let them know if the required specifications were met— indicating successful completion of the task. The team thought this was an exciting idea that would improve usability of the product. Founder A spent the two months leading up to the competition's judging rounds prototyping the cycle monitor and conducting biological tests to ensure that the prototype was performing at the same level as commercial medical products.

The team won a $10,000 award from the competition in mid May and spent the next 4 weeks making 20 prototypes to bring to Nepal for the summer. Founder A recalls this preparation period with great distress. It was a tough time for the team. The Nepali students rushed to schedule the 2.5 months in Nepal and to contact doctors and health clinics in their family network. Meanwhile, Founder A, Co-founder A, and 2 undergraduate volunteers, set up an assembly line to produce 20 prototypes. The novelty of designing the prototype had worn off as he grimly faced a large pile of parts that needed to be assembled.

The summer field trial in Nepal was a great learning experience for the team. They came back with a much better idea of how clinics performed tasks without the medical device,

what types of health services were performed at what volume, what current process the medical device would replace, and who potential users of Product A were. Personally for Founder A, he came back with a stronger determination to take the project further because he related to the people he met at a personal level during the trip. He realized that these people were not any different from him; they had rights to go to a hospital to receive quality care and not be exposed to unnecessary health risks because they were receiving care at hospitals without the medical device.

With the field research findings, Founder A designed a second version of the Product A with even more modular components so that shipping would be more convenient— several of the prototypes were damaged during transit. And with the second version, he incorporated a set of voice instructions to go with the visual progress monitor as well as a training module, because he wanted to replicate the experience of having an instruction from a training session always on site.

In December 2011, Founder A, Co-founder A, and one of the Nepali students were each awarded fellowships to spend the month of January 2012 in Nepal and India to study the dissemination of the product. The focus of this field trip was to understand how medical devices were distributed to these clinics, who were the people involved in the decisions making progress, and understanding what their motives were.

The team returned from this trip with excitement about the positive reception Product A received from government officials, NGOs, distributors, and manufacturers. They also returned with constructive criticism and a real understanding of how many more hurdles they will need to jump through. The team reassessed what each member's realistic commitment levels will be in bringing the product to market and starting a

company. The two Nepali students were in the middle of their undergraduate studies and wanted to support the project as alumni of the team. Founder A and Co-founder A were both in their last year of graduate studies and agreed to keep on working on the project for another year or until the summer after graduation depending on availability of funding.

Founder A and his co-founder found it hard to create a convincing business plan for a company with one product. After getting feedback from couple of investors, the team productized a feature they planned on incorporating into the third prototype as its on product line and positioned the company as a design firm. The two founders leveraged their experiences in product design, business development, and working in the developing world context to come up with a design philosophy for the firm that differentiated itself from other product design firms.

The co-founders kept moving at the same pace and spent the two months following their return from the field applying to more design competitions and business plan competitions, various social entrepreneurship grants, and fine tuning the business plan. As both founders struggled to maintain the pace while finishing up their degrees, their personal lives took a toll. In an effort to put less strain on their personal lives, the team started recruiting actively and brought on three medical students, a graduate student already in the field, and a grant writer.

The process of recruiting a team was also a huge burden on the co-founders. Not surprisingly, they found it hard to convince others to put in as many hours as they did while not being able to financially compensate them. Uncommitted team members came and went—putting additional strain on the team because tasks did not get finished on

time or up to the quality that the co-founders have been used to. The co-founders reassessed their team and cut ties with uncommitted members and devoted more time on helping committed members develop necessary skills. They also put a halt on all recruiting activities since the time spent brining a new member on board has had a significant negative impact on efficiency of the team's time.

For Founder A, this was his turning point. Previously, his career goal was to go to medical school and be a practicing physician as well as an entrepreneur designing medical devices with global impact. Seeing how much time and work it took to find a team, bring in investors and advisors, and set up and grow a company, he became dissuaded from pursuing an entrepreneurial career:. "This experience made me realize that I do not wish to do this for a living. I would like to raise a family one day and have a stable career and personal life and the disruptive life style of an entrepreneur does not allow for that."

Founder A and his co-founder will be primarily focused on fundraising for the summer of 2012 to be able to fund a year's worth of operating expenses. During this year, the team aims to produce 100 commercial grade Product As, generate evidence of impact, generate sales, and at the end of the year find a firm or bring in a CEO to continue to grow the company as the founders plan to phase out. At the end of next year, Founder A will be attending to medical school and his co-founder will be attending business school.

5. CASE OF COMPANY B

Product B is an assistive device with a proprietary feature that allows Product B to out-perform all other similar products in the market in certain environments that are prevalent in developing countries. Product B is an assistive device unlike any other assistive device available. It is made from cheap parts available in most parts of the world, has a unique design that allows Product B to out-perform other products and provides higher utility to the user in certain environments, and has a flexible design that allows Product B to perform as well as other products in average environments.

The initial idea for the unique design was formed by a graduate student (who is now on the board of advisors of Company B and will be referred to as Advisor B for the remainder of this paper) in the fall of 2007 based on his experience and expertise in assistive technology for the developing world. Advisor B had been working to improve the state of assistive technology in developing countries since 2005. In spring of 2007, Advisor B taught an assistive device design course. A group of students from this course continued on with the project and spent the following summer conducting field research in East Africa with Advisor B and an assistive device company. Upon the group's return from the field and Advisor B's conception of two levers, the group of students began to work on what would be an early prototype of Product B as undergraduate researchers for Advisor B's lab which was founded around the time of idea conception.

In March 2008, two of the students who had continued with the project entered a design competition and was awarded first place. The award funded the development of first generation of prototypes. Since then, the team had been focused on developing the

prototype, conducting various mechanical testing in the lab as well as usability testing in the field, and iterating. Product B continued to win more competitions and grants, was the topic of several research papers, and received press coverage from international, national, and local media throughout 2010.

By September 2010, all of the core members of the project had graduated. Advisor B finished his PhD and was planning on conducting his post-doctoral work in India. In India, he would be working on preparing the Product B for commercialization and conducting necessary pre-production trial and biomechanics testing. Two undergraduate members continued to support Advisor B post graduation on a part time basis.

By April 2011, the team had been steadily receiving product requests and purchase interest from various individuals and organizations from the spillover effect of having been in the media spotlight, and Advisor B's work in India to prepare for commercialization had a strong footing. In the coming months, the team members began discussing about the future of Product B. The team realized that the project was no longer an academic project. More specifically, the product was nearing the end of its development stage. Product B was at a stage where it was getting ready to ship and the team anticipated facing a completely different set of challenges as they prepared to commercialize the product. The business challenges that came with commercialization of the product was not something anyone in the team had skills to face. The three core team members all had mechanical engineering backgrounds with no previous experience in business development. Advisor B was taking a faculty position in the upcoming year and was not in a position to be heading a business and they needed to

find someone fast who could transition Product B from an academic project to a commercialized product and would run the daily operations of the business full-time.

Founder B, one of the two undergraduate students who have been involved with Advisor B's research efforts and development of product B from very early on, stepped up to the challenge. She explains that this decision was natural given her involvement with the project and the timing. At this time, she had been out of school for about a year working as a health policy analyst for the U.S. Department of Health and Human Services and was looking for a change. There was a small amount of funding available to support her full time salary from an affiliate group which made the decision to take the leap much easier: "I would not have left my old job and picked up my things and moved to a different city had I not known that there was funding available to support me when I started."

The motivation for her to stay with the project all through her undergraduate studies and to stay involved post-graduation came from her time spent on the field interacting with users and technicians. She found the project idea compelling but what really made her stick with the project was being on the field and seeing how badly people needed a product like Product B. This was no longer an abstract problem she learned about in a classroom setting. This problem had a face and a name.

The opportunity for learning and growth had also kept her involved. Founder B came to MIT wanting to be a doctor. She was a pre-med student shopping for a major that would be most beneficial for her career goals when she came across Advisor B's assistive device design class. Quickly, she realized how she enjoyed spending time in lab and solving design challenges than organic chemistry problem sets. Although Founder B's initial

involvement with the project was that of an engineer, she became interested in ethnography research as she spent more time on the field with the users. She eventually completed her degree concentration in Anthropology. The project had created many opportunities for her and she had gained a diverse set of skills. Founder B was confident that the project would continue to create learning opportunities for her. She did not feel that she had made sacrifices on behalf of the team or that she was pressured to take on a position she did not want. Founder B was excited about heading an organization and welcomed the challenges that lay ahead.

The biggest challenge she faced starting out was managing expectations and figuring out the organizational structure. Advisor B was now playing more of an advisory role and the team now consisted of Founder B and two engineering graduate students. Both students have been involved with the project extensively since the early stages and they have been working together for several years up to this point and had a history of good teamwork. Nonetheless, conflicts started forming because of the lack of clear definition of roles and allocation of tasks. Founder B was working on the project full time, getting paid, and trying to form a company. The other two members were working on the project part time as their graduate research work, funded through their research assistantships, and were confused about their roles during this transition period.

As the team struggled to develop an organizational structure, Founder B was juggling developing relationships manufacturers identified by Advisor B during his time in India, applying to grants and social entrepreneurship focused competitions, learning about different types of corporate structures, and working for the affiliate partner organization that was funding her. Founder B remembers these 3 months as the roughest time of her

involvement with the project. What made this time so rough was not the heavy workload but the feeling of loneliness. She had felt that she was making these important decisions for the organization on her own, presenting it to the team, having a discussion and going back to the drawing board alone. She imagines the process would have been much more effective if the team had envisioned the larger picture for the organization together and had her execute the finer details.

The feeling of loneliness was exacerbated by her lack of confidence in her decisions. At times she felt panicked and found herself asking, "Am I doing this right?" Given the lack of previous experiences, she sought out mentorship and advice from other social entrepreneurs working in the international development space. But the time she put in to network and find potential mentors was not commensurate with the quality of advice she received. Unfortunately, there is a great lack of organizations that have been successful in commercializing a product based technology solution in the developing world. Throughout the process of her deciding on a corporate structure and strategy for the organization, she felt absolutely confused and alone, wondering why there were not more recent graduates who had founded non-profit organizations and could give her relevant advice.

Luckily for Founder B, she graduated from a university with a thriving community of entrepreneur alumni with diverse set of skills. She found a group of alumni who were willing to provide her with whatever support she needed. Although these advisors were entrepreneurs from different sectors, they were able to give her applicable managerial advice that was helpful for Founder B in leading and organizing her team. She received advice on what corporate structure was best fit for the long-term goal of the

organization—the guidance and confirmation she had been seeking. Most importantly, if the advisors could not provide her with support, they knew someone who could; the organization received pro bono legal support for all the paper work required for applying to be a 501(c)3 non profit organization with tax exemption status.

During this rough transition period, what motivated Founder B to push forward was the new vision for the organization. The scope of the organization had become much larger than that of Product B. Leveraging its experience in commercializing Product B, the new organization will build a portfolio of academic projects with potential for global impact and commercialize them. And Company B, was born.

This bigger idea was one that Founder B could get behind fully because she saw a long term career path within the organization. Since her long forgotten pre-med days, Founder B had developed a passion for international development work and STEM education for girls. With this bigger vision, the organization was no longer limited to improving wheelchair technology in developing countries and it opened up the door to work on other exciting technology based projects with global impact.

Her enthusiasm for this new organization with a big vision made her work harder but it actually ended up distracting her away from the goal of the organization. She was so excited about the idea that she wasted no time in contacting promising academic project groups and trying to design a process for on-boarding new projects and teams. Naturally, developing manufacturer relationships and managing field trial outcomes took a back seat and Product B related activities basically came to a halt. At which point Founder B realized that Company B's ability to attract new talent and interesting projects depended on the success of commercializing Product B, which would be used as

evidence of Company B's winning strategy. Founder B is currently dedicating all her awaking hours to make Product B commercially available globally.

Founder B is a daughter of two entrepreneurs and she believes that this has something to do with her jumping on to found Company B. The experience of setting up and running and organization made her realize that she still has a lot to learn and plans on going back to school for an MBA and return to Company B.

6. CASE OF COMPANY C

Company C, is in the business of selling an affordable and portable microbial drinking water testing kit to universities, local NGOs, and larger intergovernmental agencies that execute rural water projects. The microbial drinking water test kit was developed by Advisor C, a leader in the field of household drinking water treatment. Advisor C founded an initiative for brining clean water to people in developing countries in 1999 and has been working on innovative, low-cost water and wastewater treatment technologies for developing countries ever since.

Advisor C had been working on a low cost microbial drinking water test kit for the developing world that is simple and easy to use, can be carried in the field, and include everything needed to execute and interpret test results. One of the main values added to the kit was a portable incubator that used body heat and replaced the bulky, costly, and electricity dependent incubators. In 2009, one of her students conducted field research in the Philippines and published results that showed the kit's accuracy was comparable to those used by the EPA. From 2009 to 2010, Advisor C and her graduate students began distributing these kits at cost to other small academic groups.

Founder C, joined Advisor C's lab in September 2010 as part of her Master's program. Founder C also began working on the kit and realized how this filled many of the needs in developing countries. Seeing how that need was validated by peer groups who were placing orders for the kits, Founder C told Advisor C that this product had a great market potential. In November 2010, Advisor C received a request from a large international NGO for 60 kits, which was far larger than the regular orders of 4 to 5 that

Advisor C had been receiving. At this point, Advisor C realized that there was a real demand in the market for this product and that meeting these demands that were steadily increasing went far beyond her capacity as a researcher. Advisor C suggested to Founder C that she would be willing to support Founder C if Founder C had wanted to create a company around this product.

Founder C spent the following January in Ghana conducting field tests of the kit and returned back to the lab with even more enthusiasm for the product and the possibility of starting a business. Upon her return from Ghana, Founder C began to seriously think about setting up a business and discussed the idea with another graduate student (who will be referred to as Co-founder C for the remainder of the paper), a peer in Founder C's Master's program and a friend whom Founder C had worked with in the past on a variety of projects, both academic and professional.

Founder C's reasoning for bringing a co-founder on board was not purely based on finding someone with necessary skills she lacked. In fact, Founder C and Co-founder C share a similar set of skills--both have a strong technical background, professional experience in product design, acknowledged leadership skills, and an entrepreneurial inclination. Founder C recalls that every person she had spoken to about start ups said that sole founders are less attractive to invest in because they are not as strong as teams. One of her main reasons for wanting to get a co-founder was that she did not want to face questions from investors such as "could you really not convince another present that this was a good enough idea to work on?" And another reason was that she needed someone to share the sheer amount of work that goes into setting up a business and from experience knew that she enjoyed working much more when she worked in teams.

In the following March, Founder C and Co-founder C entered a design competition. This was an important milestone for the team because the application cycle had given them time to discuss and design a business plan and implementation strategy. In May, the team won a $5,000 award, which served as a third party validation of their idea. However, the momentum and enthusiasm from this award slowed as the academic semester came to an end and both founders took most of the summer off doing internships and taking vacations.

The team regrouped in the fall of 2011 and had a serious discussion about the future of the venture and what to do with the award money—the award money had restrictions about how it could be spent and the general focus was reimbursing development costs. One of the challenges in creating the big picture was that the team just could not envision a big picture for a firm with one product with not enough team members and not enough funding to continue to invest in R&D. At this point, Founder C had been meeting with a graduate student from a neighboring university who had been developing a chemical purification kit. She was on board after Founder C met with her a few more times in September as the third co-founder and the team applied to various funding opportunities.

During this time, Founder C worked hard to regenerate the forward momentum the team had before the summer because she was graduating at the end of the fall term and wanted to have a solid direction for the company and her career. All the while the team was continuing to take small orders from various NGOs and academic groups. The team was realizing that they could not continue to work on the project on a part time basis if the company was going to grow and bring in sizeable revenue. Given that the other two

team members were in the midst of their PhD programs, it was unlikely that the two would take on a full time position.

In middle of fall 2011, a good news cam from [Foreign Country]. The team had applied to a start up accelerator in [Foreign Country] and they have been admitted. This meant a member of the team would have to go to [Foreign Country] for 6 months starting in January 2012 to work on the project but in return would be provided with $40,000 USD of equity-free capital, office space, and mentorship. This news came timely with Founder C's pending graduation in December 2011. She reckons that without this opportunity, she probably would have gotten a full time job upon graduation and the company would have become a second priority.

An adventurer at heart, Founder C did not have to think twice about working and living in a foreign country. During her time as a student she had spend 1 to 3 months in various countries such as France, India, Peru, and Ghana. But she did reach out to everyone in her personal and professional network who had ties to [Foreign Country] to get help with securing housing, finding a laboratory at a local university to partner with, and developing a personal network in [Foreign Country].

The best part about joining the accelerator other than the obvious financial benefit was the community of startups. Founder C was working in the same building as 100+ likeminded entrepreneurs who were facing similar challenges of setting up a company. The accelerator had provided her with a large community of entrepreneurs with diverse backgrounds with whom she can brainstorm ideas with, learn about tax laws, and discuss branding and website design. She recalls that even coffee chats in the break area were extremely resourceful. While Founder C was taking advantage of working in

proximity to her peers and utilizing the community's knowledgebase, she was having trouble communicating with her team back in the States.

Before Founder C came to [Foreign Country], the team had met and agreed on big milestones for how the next 6 months pan out. But as Founder C was making big progress in [Foreign Country]—getting incorporated, working on the business plan, working with a design team to create a polished, commercial version of the kit, contacting manufacturers, and creating a database of potential sales leads—it became apparent that communicating her progress and what she learned was not a good use of her time or the team's time. Her progress updates became longer and longer and was cutting into the limited meeting time the team had for discussing next steps. If the team had been with her, they would have been working on these milestones and learning with her—eliminating the need to write up lengthy progress updates that did not quite include all the information.

Managing the team's expectations and work loads also posed a big challenge in the beginning. Because the other two members were still full time students, their prioritization of the company's needs fluctuated depending on their academic responsibilities. Meanwhile, Founder C's commitment to the company increased from seeing the progress towards the bigger picture and she started to pick up increasing amounts of work. To address the lack of communication about what the other members were doing, the team began sharing a document that tracks each person's working hours and short blurbs about tasks that were completed. This still required individual team members to spend time writing up their progress and reading others' progress but it was

the most efficient way for the team to communicate in the least time consuming manner about each member's progress.

Despite the challenges in team communications, Founder C believes that coming to [Foreign Country] was a gift for the company. She had 6 months to focus and work hard to meet her sales and product milestones and made most of the resources available to her. At the end of the 6 months in [Foreign Country], she hopes to have the manufacturers and distributers on board and have everything set up so that the team from that point and on can focus on sales. She will be joining another start up accelerator in the Fall with her friends from college and hopes to continue working on Company C on a part time basis making sales calls and placing orders to the manufacturers.

Before Company C, Founder C knew that she enjoyed working in teams and taking the leadership role and thought that she could be a successful entrepreneur. Company C gave her an opportunity to test out the waters and understand the types of work and work conditions an entrepreneur faced. Given her track record of working on multiple projects at once, she believes that she probably will pursue a career path of a serial entrepreneur—only being involved in the early stages of the start up continuously.

7. DISCUSSION

7.1 Founding Team Formation

The formation of these research-based start-ups with a distinct international development focus (ID start-ups) are not too different from how other academic spin-offs are formed. All founding team members of each company came from the same university: founder A had taken a design course with his co-founder, founder B had been working on the project with her co-founder for several years, and founder C had worked on several different projects with her co-founder. Like other academic spin-offs, the transition from research project to founding of a company occurred with the goal of commercializing the technology. However, the ID start-ups were motivated by the need to scale and increase the global impact of their technology unlike other academic spin-off whose main motivations were new career opportunities and financial gains.

For company B, the formation of the founding team was a natural transition from their existing core project team. Co-founders had a history of good teamwork and brought complementary skill sets to the team. For company A, was team formation was more forced and similar to many other start-up teams. The founder actively sought after people with skills the founder lacked and were deemed essential for project's success. In contrast, founder C did not seek out people with complementary skill sets because she came from a strong technical background and was confident in her ability to learn whatever soft skills that were necessary for running a business. Instead, she had specific individuals in mind when she initially thought about starting a business and they were all friends and co-workers with whom she had previously worked on team project.

Table 1: Company Profile

Industry	**Medical Devices**	**Assistive Technology**	**Water**
Business Type	B2B	B2B	B2B
Business Model	For Profit / -	Non Profit / 501(c)3	For Profit/C-Corp
Incorporation Date	-	December 2011	March 2012
Time of Founding	March 2011	December 2007	March 2011
Time of Product Conception	January 2011	Fall 2007	2007

Table 2: Founder Profile

	Founder A	**Founder B**	**Founder C**
Age	Mid 20s	Mid 20s	Mid 20s
Gender	Male	Female	Female
Education	MS, BS	BS	MS, BS
College Major	Mechanical Engineering	Mechanical Engineering	Civil Engineering, Public Policy
Previous Work Experiences	Consulting, Business Strategy, Marketing	Assistive Technologies, Health Policy	Development Policy, Water, Energy
Title	CTO	Executive Director	CEO
Career Goals	Medical Doctor	Entrepreneur	Entrepreneur
Field Experience	Yes	Yes	Yes

Table 3: Co-Founder Profile

	Co-Founder A	**Co-Founder B**	**Co-Founder C**
Age	Mid 20s	Mid 20s	Late 20s
Gender	Female	Male	Male
Education	MS, BS	MS, BS	PhD, MS, BS
College Major	Management Science, Mechanical Engineering	Mechanical Engineering	AeroAstro, Public Policy, Mechanical Engineering
Previous Work Experiences	Product Design, Product Strategy, Business Development	Assistive Technologies, Robotics	Engineering Services, NGOs
Field Experience	Yes	Yes	Yes

7.2 Founding Team Characteristics

One of the characteristics of high growth ventures (see table 4) is existence of founding teams rather than sole founders. Each of the ID teams had different reasons for forming a founding team. Founder A's reason for wanting a team with a diverse set of skills is most in line with the belief that firms with a founding team rather than a sole founder is more likely to achieve high growth rate given that a team possess more talent, resources, and professional contacts (Johannisson, 1990). Nonetheless, it is interesting to note that founder C had explicitly started looking for a co-founder because she knew that investors were more attracted by founding teams and she needed to attract investors to raise the capital needed to fund start up costs of a company. Whereas founder A's motive for forming a team was directly in line with investors' interests of a strong team well positioned for growth, founder C's motive was indirectly in line with investors' interest in a sense that her motive was to match investors' expectations.

Unlike other academic spin-offs where the founders usually lack industry experience and have a strong research focus, between the founder and the co-founder, all founding teams had relevant industry experience (see table 2 and table 3). Relevant industry experience is thought to have an impact on entrepreneurs' ability to successfully launch and grow a firm, because founders with relevant industry experience have larger network of industry contacts and a better understanding of the subtleties of their industries (MacMillan and Day, 1987).

Additionally, all founders and co-founders had shared entrepreneurial spirits (see table 2 and table 3). During interviews, all the founders said that they were interested in

starting a company because it fell in line with their career plans. Both founders B and C thought starting their ventures would have direct benefit to their goals of becoming entrepreneurs. Founder A thought that the experience of starting a company would be good for personal development, given that he was interested in exploring entrepreneurship as a career option. All founders were correct to assume that their initial foray into entrepreneurship will help their career later down the road. Singer (1995) had shown that prior entrepreneurship experience is one of the most consistent predictors of future entrepreneurial performance.

What all these founders lacked in experience, they tried to make up for it with their enthusiasm and support from their personal and professional networks. Founders with broad social and professional networks have potential to access additional knowhow, capital, and customer referrals. All founders described their professional network, expanded by attending conference and competing in design or business plan competitions and alumni network, as diverse and large. Their networks had provided them with an eclectic mix of mentors and advisors with diverse skill sets and experiences who gave them advices with different perspectives.

While the founders' broad social and professional networks certainly is certainly an advantageous resource as a start-up, founders still had a difficult time finding good advice relevant to starting a business in the international development space. A common complaint among the founders was the lack of a large network of entrepreneurs in the international development space. All had invested many hours into reaching out to various individuals who had relevant experiences in international development but advices varied widely and most were not relevant to their respective companies.

Table 4: Founder Characteristics

	Company A		Company B		Company C	
	Founder	**Co-Founder**	**Founder**	**Co-Founder**	**Founder**	**Co-Founder**
Relevant Industry Experience	Yes	Yes	Yes	Yes	Yes	No
Higher Education* *Graduate and Professional Degrees*	Yes	Yes	No	Yes	Yes	Yes
Entrepreneurial Experience	No	Yes	No	No	No	Yes
Broad Social and Professional Network	Yes	Yes	Yes	Yes	Yes	Yes

Table 5: Firm Attributes

	Company A	Company B	Company C
Founding Team vs Sole Founder	Team	Team	Team
Founding Team's Long Term Commitment	Weak	Strong	Moderate
Focus on Growth Oriented Strategies	Strong	Strong	Moderate
Recruitment Activity	High	Low	Moderate
Interorganizational Relationships	Strong	Strong	Strong
Buyer Concentration	High	Moderate	Moderate
Focus on IP	High	High	High

7.3 Founder's Role in Setting up a Company

All of the founders interviewed are technology-oriented founder with no previous experience in running a business. They have been primarily focused on product development up until the transition period. Wasserman (2003) indicates that founders with only technical skills may not be the best fit once a company begins making sales and the range of tasks required to be successful expands. Founder A dealt with this issue by finding a co-founder with business experience and handed over the CEO title. Founder B plans to acquire these skills necessary by going to business school and replacing herself with a professional CEO in the meantime. Founder C, current CEO of the company, in confident in the skills she has developed over the transition period to continue to grow the company.

The founders' decisions are also reflected on the company's long term growth strategy. Co-founders of company A hope to be succeeded by a professional CEO soon (their recruitment strategy is to hire people who win with them). They understand that they may not be the person with skills necessary to grow the company and made this decision early on. Their ultimate goal is to ensure that the company will grow so that the product can be produced at a scale large enough to create the impact on global health the founders were working to achieve. Company B also has a strong long term growth strategy and founder B sees a long term career within a company. This was her reason behind wanting to go back to school. She wanted to develop skills that were necessary to grow her company. Company C on the other hand has a weak long term growth strategy. Founder C certainly sees the company existing over a long time frame but does not necessary see the need for the company to grow at a rate that would require a

professional management team. She plans keep the company's operations at a fairly autonomous level so that the daily operating activities are manageable between her and her team of 3. It is also interesting to note that the two founders who decided to stay with the company and has no near term exit plan also displayed need for control during the interviews. When asked what they liked best about their job, each mentioned "being in charge" and "running my own show."

Interestingly, founder A was the only one who showed emotional attachment to his product, referring to it as "my baby" several times during the interview. This type of behavior hints that founder A may be the type of Founder-CEOs with strong attachment to the firm and less willing to give up control of his company (Wasserman 2003). However, founder A was the person most willing to give up control and has articulated that he is not going to be part of the firm's long term growth strategy. This may be explained by founder's long term vision for the company and his commitment to making the company grow. He feels that a professional CEO will be better suited for the task and has no problem with stepping aside in the interest of the company's growth.

7.4 Challenges in Designing Products for the Developing World

Because all of the ID start-ups interviewed for this paper were all nascent firms all less than 1 years of incorporation at the time of the interview, they did not have large sales figures to indicate successful product adoption. However, the fact that all three ID start-ups all have been funded through competition awards, fellowships, and research grants during the early product development stages indicate that several independent third

Table 6: Common Challenges in Achieving Appropriate Design

	Company A	Company B	Company C
Comprehensive need finding	Carried over from previous research project; additional study conducted via two field observations and interviews with users, doctors, and policy makers	Carried over from advisor's research and reports put forth by international agencies; additional study conducted via field observations and interviews with users and local engineers in the same industry	Carried over from advisor's research and reports put forth by international agencies
Extensive prototype testing	Mechanical and biological testing of all prototypes were conducted in lab. 23 Prototypes have been field tested for 5-11 months	Mechanical testing was conducted in lab. Over 60 working prototypes have been co-manufactured with local engineers and are currently in use	Prototype tested in Philippines and Ghana. Results of the efficacy of the product were published in a peer-reviewed journal
Working with early adopters	Worked with both early adopters and late majority groups to improve product attractiveness and to ensure appropriateness of design	Worked extensively with local engineers to improve manufacturing process and users to gather usability feedback	Worked with early adopters to gather usability feedback
Working with gate keepers	Started consulting policy makers and government procurement offices from the early stages	Consulted with the incumbent firm in the industry about potential licensing in the early stages and continued to work together	Received support of established researchers in the field

Table 6: Common Challenges in Achieving Appropriate Design (Continued)

	Company A	Company B	Company C
Understanding the conditions under which the product is expected to operate	Conducted ethnographic research prior to distributing prototypes to understand the environment and available resourced	Conducted an extensive study of the state of the technology in East Africa	Founder experienced for herself what it is like to use the product under conditions in the field.
Robustness of design	Second iteration was much more modular than the first to reduce damage during shipping. Final enclosure will be drop tested	Built with durable materials and designed to function even in harsh environments	Portability was a key design criterion and the product was designed to function in rough field conditions
Addressing lack of infrastructure and supporting technologies (electricity, water, available parts, human resources, etc)	Product was designed to work with multiple sources of energy, manufactured with all locally available materials, designed for a user with 4 to 5th grade level of education, requires less labor than present practice, and has a built in training module	Product was designed with all locally available materials, designed to be intuitive to use, and does not require any consumables. Co-designed the manufacturing process with local engineers to ensure that quality can be sustained	Product was designed to work without electricity, be portable, and be easy to use. Used durable packaging to prevent damages during shipping
Cultural Context	Interviews with distributors revealed that best selling products had high perceived quality (from design, color, touch, weight, and country of manufacture). Product was re-designed with a local industrial designer	Conducted extensive field observations and interviews with users and service providers to prevent any cultural clashes with using the device	Prototype received criticism for the handmade look and feel and non-professional packaging. Final product is being redesigned for a more professional feel

parties perceived the product to fill a need and provide creative solutions to developing world's problems. Table 6 lists challenges in achieving appropriate design as discussed by Donaldson (2002) and Free (2004) and how each founder addressed the challenges.

An advantage of being an academic spin-off is that, a founder has access to not only leading researchers in the field but also to current research and past projects. All three founders certainly took advantage of this. The idea for the product came from previous research projects, and founders utilized their network within the university to find funding and human resources. From classes and from other research projects, the founders learned the importance of appropriate design and what the best practices are. All three companies have a heavy focus on usability and conducted multiple field trials to test and improve appropriateness of design.

7.5 Challenges in Business Development

A great design that meets user needs does not necessarily translate into great business ideas, and a great product designer does not necessarily translate into great businessmen. Table 7 lists challenges in developing a sustainable business model catering to developing markets as discussed by Donaldson (2002) and Free (2004) and how each founder addressed these challenges.

All founders took extra steps to create a sound business plan. Founder A found team members with skills and previous experiences who can be great businessmen. As a team, they took the iterative design approach to creating a sustainable business model—each draft of the business plan was reviewed by advisors who were active investors and the

next iteration of improved with their feedback. Even with a product with favorable media coverage and existing demand, Founder B was overwhelmed with the business challenges given that she was new to it all, but she quickly found helpful advisors and mentors through her network that provided her with much needed guidance and even support services at times. Founder C used all available resources from the start up accelerator her company was part of, her alma mater, and her co-founder's academic institution.

All of these founders lacked the necessary business experience to start a company, but they utilized all available resources they had and dedicated time and effort into developing those skills; when asked to describe what motivated them, all founders at responded along the lines of "if I did not do [this], no one else would have done it and this solution, this cause, these people would be forgotten." What distinguishes ID start-up founders from other start-up founders is that ID start-ups were not founded for financial gains or the founder's drive for control, but for the noble mission of improving the quality of life for those living in developing countries and facing extreme poverty.

Table 7: Common Challenges in Business Development

	Company A	Company B	Company C
Conducting Market Research	Study of existing practices, conducted analysis of competing products' features, price, perception, and market penetration, interviewed distributors and buyers to gauge interest	Conducted analysis of competing products' features, usability, and price. Interviewed users to record satisfaction with the product and interviewed buyers to gauge interest	Founder used some of the competing products and conducted an analysis of features, usability, and price. Interviewed potential buyers to gauge interest
Creating a Business Plan	Co-founders have been working on the business plan along side the product from early on. Incorporated feedback from market research, investors, advisors, and competition judges. The business plan is still a work in progress	Started working on the business plan when the founders agreed to transition into a company. Actively sought advice and incorporated feedback from advisors and experts within founder's extended professional network	Started working on the business plan when the founders agreed to transition into a company. Wrote a plan to apply to a start up accelerator, were accepted, received feedback, and improved this plan for the next funding round
Funding Strategy	Early stage development and field trials were funded through research grants, fellowships, and competition awards. Future funding strategy is to fuel R&D with research grants and business development with angel investments and donations	Early stage development and field trials were funded through research grants, fellowships, and competition awards. Current activities are funded through competition awards and grants. Currently pursuing more grants from various sectors	Early stage development and field trials were funded through research grants, fellowships, and competition awards. Business development was funded by seed capital from a start up accelerator and is currently seeking angel investments

Table 7: Common Challenges in Business Development (Continued)

	Company A	Company B	Company C
Distribution Strategy	Bid for government contracts and go through NGOs to use their existing distribution networks	Sell to NGOs who will sell or donate to existing customer base using their distribution network	Sell to US/Canada based NGOs to use their global distribution network and to avoid import/export tax
Centralized vs. Local Manufacturing	Co-founders have strong belief that centralized manufacturing is necessary to control high product quality and consistency in quality especially for medical devices. Started looking for a manufacturer during the first field trials	Started off with local manufacturing to utilize existing infrastructure and human resources but will move on to centralized manufacture to be able to produce at scale	Started off with local manufacturing to utilize existing infrastructure and human resources but will move on to centralized manufacture to be able to produce at scale
Finding a Manufacturer	Introduced to an established manufacturer in the industry in India through professional network, worked with the manufacturer beginning with the second iteration. Visited the facilities twice, agreed to manufacture for the pilot program at cost (20% overhead for supplies)	Continued to work with the network of local manufacturers found during the advisor's field trip to assess the state of technology in East Africa. Actively searched for manufacturers in India, visited a few facilities, currently working out the agreements with one	Found two suitable manufacturers in the US after actively searching and receiving quotes. Have not visited the facilities and will decide on a manufacturer after seeing a product prototype. Manufacturer will be a paid contractor
Managing Intellectual Property	Currently seeking legal counsel for patents and trademarks	Received pro bono legal service for patents	Hired legal counsel on a deferment plan for patents

Table 7: Common Challenges in Business Development (Continued)

	Company A	Company B	Company C
Regulatory Barriers	None in the countries where the company conducts business	None in the countries where the company conducts business	None in the countries where the company conducts business
Pricing Strategy	Co-founder has experiences in product pricing and will test various strategies when pilot program launches	In the works	Tested with early adopters by using "early adopter," "NGO," and "academic" discounts.
Dealing with NGO Subsidies	Have not faced this challenge yet	Hard to compete with low quality products purchased in bulk by NGOs and distributed for free.	In early stages, products were sold to NGOs at an "early adopter" discount. Company now faces challenges in selling at full price
Generating Demand	Increasing awareness by crowdfunding and winning competitions, publishing findings from clinical study to persuade buyers	Leveraging existing demand from media spotlight and attending conferences, expos, and tradeshows.	Attending conferences to present the product and meeting potential new customers, cold calls
Human Resource Strategy	Plans to hire a full time CEO and business associate by reaching out to company's network when funding is available. Plans to attract graduate students on fellowships for R&D	Plans to hire full time business development associate when the company has enough funding. Hard to attract talent because the non-profit compensations are known to be low	No plans to recruit full time employees beyond founding team. Plans to staff further field trials with students and volunteers by reaching out to partnering academic institutions

6. CONCLUSION

The case studies reveal that formation of academic spin-off, ID start-ups are not different from other research based academic spin-offs. Further empirical study surveying a large number of ID focus academic spin-offs and other academic spin-offs is necessary to conclusively state that there is no distinguishable difference.

To understand the effect of ID start-ups in developing economies, it would be interesting to see the comparison between economic effects of aid provided from international NGOs and intergovernment agencies and start-ups.

As revealed by the case studies, founders would not have continued to work on commercializing their products at the risk of forgoing other career opportunities if funding for the company was not available. ID start-ups are primarily funded by competition awards and research grants. Given that literature on entrepreneurship shows that start-ups that receive venture capital show higher growth than start-ups not backed by venture capitalists, a comprehensive study of different types of funding and their effect on the growth of ID start-ups will be useful information for founders and entrepreneurs looking to found ID start-ups.

REFERENCES

Amit, R., Muller, E., Cockburn, I., 1995. Opportunity costs and entrepreneurial activity. J. Bus. Venturing 10 (2), 95-106.

Barringer, B.R., Jones, F.F., Lewis, P.S., 1998. A qualitative study of the management practices of rapid-growth firms and how rapid growth firms mitigate the managerial capacity problem. J. Dev. Entrep. 3 (2), 97-122.

Bass, B.M., Stogdill, R.M., 1990. Bass & Stogdill's handbook of leadership: Theory, research, and managerial implications. New York: Free Press.

Begley, T.P, Boyd, D.P., 1987. Psychological characteristics associated with performance in entrepreneurial firms and smaller business. J. Bus. Venturing 2, 79-93.

Bird, B., 1989. Entrepreneurial Behavior. Glenview, IL: Scott Foresman & Company.

Birley, S., 1985. The role of networks in the entrepreneurial process. J. Bus. Venturing 1 (1), 107-117.

Braggs, S.M., 1999. Managing Explosive Corporate Growth. New York: Wiley.

Brockhaus, R.H., 1980. Risk taking propensity of entrepreneurs. Academy of Management Journal 23 (3), 509-520.

Brockhaus, R.H., 1987. Entrepreneurial folklore. Journal of Small Business Management, 25 (3), 1-6.

Brockhaus, R.H., Horwitz, P.S., 1986. The psychology of the entrepreneur, in Sexton, D.L. and Smilor, R.W. (Eds.), The Art and Science of Entrepreneurship. Cambridge MA: Ballinger, pp.25-48.

Carsud, A.L., Krueger, N.F. Jr., 1995. Entrepreneurship and social psychology: Behavioral technology for the new venture initiation process. In J. A. Katz & R. H Brockhaus, Sr. (Eds.), Advances in entrepreneurship, firm emergence, and growth (pp. 73-96). Greenwich, CT: JAI Press.

Chesbrough, H., Ahern, S., et al., 2006. Business models for technology in the developing world: the role of non-governmental organizations. California Management Review 48 (3), 48-61.

Cooper, A.C., 1971. The founding of technologically-based firms. Milwaukee, Wis.: The Center for Venture Management.

Cooper, A.C., Artz, K.W., 1995. Determinants of satisfaction of entrepreneurs. J. Bus. Venturing 10 (6), 439-455.

Cooper, A.C., Dunkelberg, W.C., Woo, C.Y., 1988. Entrepreneur's perceived chances for success. J. Bus. Venturing 3 (2), 97-109.

Davidsson, P., 1991. Continued entrepreneurship: ability, need, and opportunity as determinants of growth. J. Bus. Venturing 6 (6), 405-429.

Donaldson, K., 2002. Recommendations for Improved Development by Design. 2nd International Conference on Open Collaborative Design of Sustainable Innovation, Bangalore, India.

Douglas, E.J., Shepherd, D.A., 2000. Financial capital, human capital, and the transition to self-employment: evidence from intergenerational links. Journal of Labor Economics 18 (2), 282-305.

Duchesneau, D., Garner, W., 1990. A profile of new venture success and failture in an emerging industry. J. Bus. Venturing 5 (5), 297-213.

Fesser, H.R., Willard, G.G., 1990. Founding strategy and performance: a comparison of high and low growth high tech firms. Strateg. Mange. J. 11 (2), 87-98.

Free, M.J., 2004. Achieving appropriate design and widespread use of health care technologies in the developing world. Int. J. Gyn. Ob. 85 (1), S3-S13.

Gartner, W.B., 1989. "Who is an entrepreneur?" is the wrong question. Entrepreneurship Theory and Practice 13, 47-68.

Hammond, A.L., Prahalad, C.K., 2004. Selling to the Poor. Foreign Policy. 142 (May/June), 30-37.

Hansen, E.L., 1995. Entrepreneurial networks and new organizational growth. Entrep. Theory Pract. 19 (4), 7-19.

Harrison, J., Taylor, B., 1997. Supergrowth Companies. Oxford: Reed Educational and Professional Publishing.

Hisrich, R.D., Peters, M.P., 1995. Entrepreneurship: starting, developing, and managing a new enterprise. 3rd ed. Chicago: Irwin.

House, R.J., Shamir, B., 1993. Toward the integration of transformational, charismatic, and visionary theories of leadership. In M. Chemer & R. Ayman (Eds.), Leadership theory and research: Perspectives and directions (pp. 81-107). San Diego, CA: Academic Press.

Iyigun, M.F., Owen, A.L., 1998. Risk, entrepreneurship and human capital accumulation. American Economic Review 88 (2), 454-457.

Johannisson, B., 1990. Economies of overview—guiding the external growth of small firms. Int. Small Bus. J. 9 (1), 32-44.

Johnson, B.R., 1990. Toward a multidimensional model of entrepreneurship: the case of achievement motivation and the entrepreneur. Entrepreneurship Theory and Practice 14 (3), 39-54.

Kirzner, I.M., 1973. Competition and Entrepreneurship. Chicago, IL, University of Chicago Press.

Levy, M., 2006. Charity meet ingenuity. USA TODAY. Retrieved May 10, 2012 from http://www.usatoday.com/news/nation/2006-12-18-wheelchair_x.htm

Locke, E.A., 2000. The prime movers. New York: Amacom.

MacMillan, I.C., Day, D.L., 1987. Corporate ventures into industrial markets: dynamics of aggressive entry. J. Bus. Venturing 2 (1), 29-39.

McClellnad, D.C., 1965. Achievement and entrepreneurship: A longitudinal study. Journal of Personality and Social Psychology. 1, 389-392.

Malkin, R., Anand, V., 2010. A novel phototherapy device, the design community approach for the developing world. IEEE Engineering in Medicine and Biology Magazine 29 (2), 37-43.

Pandey, J., Tewary, N.B., Locus of control and achievement values of entrepreneurs. Journal of Occupational Psychology 52, 107-111.

Prestero, T., Cantor, N., 2004. Design that matters: connecting engineering students with underserved communities. American Society for Engineering Education Annual Conference & Exposition.

Roberts, E.B., 1969. Entrepreneurship and technology. Factors in the transfer of technology (eds. W. Gruber & D. Marquis), Cambridge, Mass.: MIT Press.

Roberts, E.B., Wainer, H.A., 1971. Some characteristics of technical entrepreneurs. IEEE Transactions on Engineering Management. EM18 (3).

Rich, J.T., 1999. The growth imperative. J. Bus. Strategy 20 (2), 27-31.

Sapienza, H., Grimm, C., 1997. Founder characteristics, start-up process and strategy/structure variables as predictors of shortline railroad performance. Entrep. Theory Pract. 22 (1), 5-24.

Sapienza, H.J., Korsgaard, M.A., et al., 2003. The self-determination motive and entrepreneurs' choice of financing. Cognitive Approaches to Entrepreneurship Research. J.A. Katz and D. Shepherd. Burlington, MA, Elsevier Science & Technology Books. 6, 105-138.

Schumpeter, J., 1942. Capitalist, Socialism, and Democracy. New York, NY, Harper & Brothers.

Sexton, D., 1989. Growth decisions and growth patterns of women-owned enterprises. In: Hargan, O., Rivchun, C., Sexton, D. (Eds.), Women-Owned Businesses. New York: Praeger, pp. 135-150.

Sexton, D., Bowman, N.B., 1986. Validation of a personality index: comparative psychological characteristics analysis of female entrepreneurs, managers, entrepreneurship students, and business students. In R. Ronstadt, J. A. Hornaday, R. Peterson, & K. H. Vesper (Eds.), Frontiers of entrepreneurship research (pp. 40-51) Wellesley, MA: Babson College.

Shapero, A., 1971. An action program for entrepreneurship. Austin, Texas: Multi-Disciplinary Research, Inc.

Shapero, A. 1982. The social dimensions of entrepreneurship. In: C. Kennt, D. Sexton and K. Vesper (Eds.), Encyclopedia of Entrepreneurship. Englewood Cliffs, NJ: Prentice Hall, pp. 72-90.

Siegel, R., Siegel, E., MacMillan, I.C., 1993. Characteristics distinguishing high-growth ventures. J. Bus. Venturing 8 (2), 169-180.

Singer, B., 1995. Contours of development. J. Bus. Venturing 10 (4), 303-329.

Stuart, R., Abetti, P.A., 1987. Start-up ventures: towards the prediction of initial success. J. Bus. Venturing 2 (3), 215-230.

Susbauer, J.C., 1969. The technical company formation process: a particular aspect of entrepreneurship. Ph.D. Dissertation, Austin, Texas: University of Texas.

Timmons, J. A., 2000. New venture creation: entrepreneurship 2000 (5th ed.). Homewood, IL: Irwin.

Wasserman, N., 2003. Founder-CEO succession and the paradox of entrepreneurial success. Org. Sci. 14 (2), 149-172.

Watson, W., Steward, W., BarNir, A., 2003. The effects of human capital, organizational demography, and interpersonal processes on venture partner perceptions of firm profit and growth. J. Bus. Venturing 18 (2), 145-164.