Becoming Aware of and Learning How to Navigate

the SBIR Program: The Entrepreneurs' Perspectives

A DISSERTATION
SUBMITTED TO THE FACULTY OF THE GRADUATE SCHOOL
OF THE UNIVERSITY OF MINNESOTA
BY

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IN PARTIAL FULFILLMENT OF THE REQUIREMENTS
FOR THE DEGREE OF
DOCTOR OF EDUCATION

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April, 2011

Acknowledgements

There were many people that supported me on the journey of developing this research project and transforming my experience into learning. In fear of leaving someone out by listing names of family, friends, and colleagues, please know if you are reading this you were part of that support and I sincerely thank you.

I would like to acknowledge and thank my committee members, Dr. Joyce Strand, Dr. Susan Damme, Dr. Kim Riordan from the University of Minnesota Duluth Education Department and Dr. Patricia Borchert from the University of Minnesota Duluth Labovitz School of Business and Economics. The countless hours of guidance, review, and encouragement to reach higher and deeper provided me with a learning experience like no other.

I would like to thank my participants who were willing to share their stories because they recognize the importance of building a strong innovative ecosystem for the benefit of the nation. Your time and stories about becoming aware of and learning how to navigate the SBIR program demonstrated the importance of relationships and the determination it takes to participate and be successful.

And special thanks to Dr. Michael Lalich, director of the University of Minnesota Natural Resources Research Institute for the encouragement to enroll in the Doctorate of Education program. Your valuable years of insights into technological innovation, applied research and development, and leadership provided a perfect “playground” for a doctoral student to bring theory and practice together.

Dedication

Bob, Kevin, Karisa Sarvela—for your unending support, encouragement, and laughter

George and Julianne Daleiden—for believing in me

Abstract

Little is known about how much technological innovation is lost in the United States because technology entrepreneurs do not have the financial capability for the research and development necessary to bring an idea to a commercial level. The Small Business Innovation Research (SBIR) program is part of a national innovation system developed to support research and development efforts for technological innovation by small business. The program is national in purpose, but regionally distributed. The old adage of the *rich get richer and the poor get poorer* seems to hold true with 56% of SBIR awards going to the same handful of states since the genesis of the program. This study explored the phenomenon of how entrepreneurs in Minnesota learned to navigate the SBIR program by interviewing six entrepreneurs who had experienced various levels of success. Intellectual capital—human, social, organization learning—served as the thread woven through all aspects of the participants learning how to navigate the SBIR program. As the stories unfolded, the participants description of learning by "doing it" revealed the complexity of the interrelationships; and an adaptable and flexible learning style which Kolb (1984) refers to as learning in a holistic way.

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Chapter One: Introduction

Have you ever had an idea that you did not pursue only to have someone else come up with it and make millions of dollars? Ideas come easier for some than others; however, it is not the idea but the action to advance the idea to a stage of commercialization that separates the entrepreneurs from the rest of us. The decision to start a new technology enterprise starts with the recognition of an opportunity and mobilization of both financial and human resources. And this is key--technical innovation and business start-up are shaped not only by creativity, but by the "presence of knowledge, financial, and other complementary assets that are available in a region" (Audretsch & Kayalar-Erdem, 2005, p. 107).

Overview

In 1992, Mike Rone and Duaine Miranowski had a vision to utilize membrane pressing technology to manufacture high quality wood composite components to supply the kitchen and bathroom cabinet industry; but they did not have the research expertise nor adequate equipment to move it forward. Rone and Miranowski had extensive experience in membrane pressing, production, and manufacturing, but did not have the financial resources for the research to scientifically develop their concepts. They recognized an opportunity, were motivated, and were ready to risk it all to make their dream become a reality--true entrepreneurs. The common definition of entrepreneur in the literature is an individual(s) who has founded their own firm (Forbes, 2005). Rone and Miranowski brought their idea to the University of Minnesota Duluth Natural Resources Research Institute (NRRI), an applied research facility with the infrastructure

to provide entrepreneurs with the science and technology support needed to take an idea to commercialization. NRRI was able to provide Rone and Miranowski support because of a funding mechanism made possible through the State of Minnesota's Technology Fund to provide entrepreneurs with research and development (R&D) support. The company's name is Northern Contours, Inc., and in 2008 it had over 500 employees with $55 million in annual sales.

Technological innovation and small business, like Northern Contours, Inc., are recognized as key drivers in the United States' economy (Atkinson & Andes, 2009) not only for their value to the nation, but to keep the U.S. globally competitive (OECD, 1997). The concept of technological innovation, for the purpose of this research, is best defined by Myers and Marquis (1969) as "a complex activity which proceeds from the conceptualization of a new idea to a solution of the problem and then to the actual utilization of a new items of economic or social value" (p. 1). Taking a technological idea from concept to commercialization is not a single action but a complex process of interrelated sub-processes. Myers and Marquis (1969) go on to say technological innovation "is not just the conception of a new idea, nor the invention of a new device, nor the development of a new market. The process is all of these things acting in an integrated fashion" (p. 1).

The U.S. Small Business Administration (SBA) (2007) defines small business as companies that employ fewer than 500 employees and generally have sales below $1.5 million, depending on the industry sector. In the U.S., small business represents 99.7 percent of all employer firms and employs roughly half of all private sector employees

(Kobe, 2007). Often small business start-ups begin with technology entrepreneurs like Rone and Miranowski who have an idea but are limited in human and financial resources. Minnesota's technology fund sponsored the R&D support provided by NRRI, and the small business owners contributed intellectual and sweat equity with the end result being a successful small business--one that has a tremendous impact on economic development in the region where Northern Contours resides. This impact includes well paying jobs and all the multiplier effects related to generating $50 million in annual sales. Growth and success of this company did not happen overnight; many technology entrepreneurs like Rone and Miranowski never make it past the idea stage, with only five in 100 business start-ups still being economically viable five years later (Kobe, 2007).

Often a small business start-up consists solely of the original entrepreneurs like Rone and Miranowski. As the small business grows and expands so does the complexity of the role of the entrepreneurs. Rone and Miranowski were entrepreneurs from the private sector who partnered with NRRI as a public resource or what the literature refers to as public/private partnerships (Porter, 1998). The public/private partnership like Rone and Miranowski had with NRRI was critical for their success and growth. Providing the R&D expertise fits with NRRI's mission to foster economic development of Minnesota's natural resources in an environmentally sound manner to promote private sector employment. NRRI is an applied research facility with over 25 years of experience working with industry. Unfortunately, NRRI is limited in the assistance it can provide to small business and entrepreneurs who do not have the financial capability to contract for the services. This is especially significant since Minnesota no longer has the Technology

Fund, which means technology entrepreneurs who do not have adequate financial resources may not be able to get the R&D support critical for technical innovation.

As such, the author is interested in learning about a program which was designed specifically to provide funding to stimulate innovation by small business. This program is called the Small Business Innovation Research (SBIR) program and is part of what is referred to as the *National Innovation System*—a common infrastructure available across the U.S. The remainder of this section will review the SBIR program within three contexts of innovation: the federal level, the state level with an emphasis on Minnesota, and the organization level; and will conclude with a description of the assumptions and focus of this research.

Federal Context: National Innovation System

As a nation, the United States recognizes the connection between innovation and prosperity. Reinforcing the importance of innovation, President Barack Obama issued *The Obama Innovation Strategy*, which lays a foundation for the innovation economy of the future (National Economic Council, 2009). This strategy calls upon our nation to create an innovation ecosystem which (a) encourages innovation by both public and private sectors, (b) supports national priorities, and (c) educates the next generation with knowledge and skills for the 21st century. At the core of Obama's strategy are research, education, technological innovation, and collaboration, which build off decades of investment by the United States in innovation and small business. The Small Business Innovation Research (SBIR) program is an example of this investment.

The SBIR is the nation's largest R&D program aimed at stimulating innovation

by small business (National Research Council, 2000 (NRC)). The SBIR program was established by an act of Congress in 1982 to support long-term economic growth in the United States. The SBIR program "was designed to encourage small business to develop new processes and products and to provide quality research in support of the many missions of the U.S. government" (NRC, 2008, p. xiii). The program makes money available to technological entrepreneurs for R&D of ideas with national interest. It provides an impetus for entrepreneurs and often provides the initial revenue stream for small business start-ups. Roughly 1,500 projects are supported annually through the SBIR program. Elements that play into success in accessing the SBIR program include public/private partnerships, an entrepreneurial climate, scientists and engineers, a tie to universities or research institutions (NRC, 2002, 2008) and most importantly, interactions resulting in knowledge flows between people, enterprise, and institutions (Nelson, 1993; Porter & Stern, 2001). The SBIR program provides: (a) an important source of seed capital, up to $150,000, to explore feasibility through Phase I; (b) the ability to secure up to an additional $1 million through Phase II for technological development; (c) validation of the technology because it came from an SBIR small business; and (d) additional capital investments whether via private sector, venture capital, or mergers and acquisitions. SBIR small business creates high-paying technology jobs, revenue generated through sales, and taxes paid on payroll and revenue. The General Accountability Office (GAO) (2009) reported that between 1983 and 2004, roughly $17 billion was awarded for more than 82,000 projects. In 2010 the SBIR budget allocated to small business for innovative R&D is estimated to be $2.4 billion.

State Context: SBIR Program Results and Minnesota

The SBIR program is evaluated and reported on annually by state with information available according to number of proposals submitted, number of proposals granted, dollar values, number of firms, and granting agencies. In 1999 Congress was concerned about the geographical concentration of awards following an evaluation by the GAO. The GAO found "a small number of states, especially California and Massachusetts, had submitted the most proposals and won the majority of awards" (GAO, 2009, p. 6). The NRC (2002, 2010) found the SBIR awards are also spatially allocated and Audretsch and Kayalar-Erdem (2005) suggest a "winner take all policy may be emerging across regions" (p. 108). The regions which have high technology clusters are already established and benefit from public policy at the federal level--such as the SBIR program. Programs such as the SBIR could prove to have a greater effect in regions that have not yet experienced the same success.

The NRC (2008) indicated states most successful with receiving SBIR Phase I awards were California (20.8% of total awards), Massachusetts (14.5%), Maryland (5.1%), Virginia (5.5%), New York (4.2%) and Texas (4.0%). Phase II award distribution was similar to Phase I except Colorado (4.6%) and Ohio (3.7%) replaced New York and Texas in the top six states for receiving awards.

Eskesen (2010) expressed concern about the Midwestern states' performance in the SBIR program continuing to decline especially during the late 2008 and 2009 recession when these program dollars were most needed. Of interest to this study is the state of Minnesota's participation in the SBIR program, which ranges in ranking between

22nd and 28th out of 51 participants. Small business-wise, only 265 small businesses in Minnesota are considered SBIR companies for receiving SBIR awards, with only a handful being outside of the seven county metropolitan region of Minneapolis/St. Paul, Minnesota (Inknowvation, 2004). Since 2003, Minnesota has only received 1.27% of SBIR allocations. In 2008, only 1% of all applications submitted came from Minnesota.

This performance is a mystery from a state which at one time led the nation in science and technology innovation (Committee, 2010). According to the Minnesota Department of Employment and Economic Development, Minnesota is characterized as having:

- a diverse industry portfolio;
- leadership in education demonstrated as being the highest in the nation for population with a high school graduation rate of 93% and 40% of its population holding a post-secondary associate's degree or higher;
- nearly 200 public and private colleges and universities; and
- international recognition for scientific breakthroughs and medical services that advance human health and serve as a powerful economic engine, which creates and supports tens of thousands of jobs.

Organizational Context

As stated earlier, the SBIR program is part of the common innovation infrastructure of the U.S. National Innovation System (OECD, 1997; Porter & Sterns, 2001). As part of national policy, the SBIR program puts the federal government in the role of a facilitator of innovation (Narayanan, 2001) and entrepreneur as the developer of

innovation. One more piece which is identified as part of an innovation system by Porter and Sterns (2001) is the cluster specific environment in which an organization exists. This environment includes input conditions, demand conditions, a competitive environment, and supporting firms and institutions. The authors go on to say the quality of the linkage--between the common innovation infrastructure and the cluster specific environment--is based on the knowledge flows or interactions among and between all players (enterprises, universities, and public institutions). It is these interactions that diffuse knowledge and technology to firms (Narayanan, 2001; Nelson, 1993; OECD, 1997; Porter & Stern, 2001).

Knowledge is the mechanism that diffuses not just technology, but also makes evident the opportunities for gaining additional support such as through SBIR programs. One of the characteristics of knowledge that may be important is the explicitness of knowledge. Sabri (2005) summarizes knowledge based on the work of multiple authors:

> …knowledge can be tacit or explicit. Tacit knowledge is subconsciously understood and applied, difficult to articulate, developed from direct experience and action, and is usually shared through highly interactive conversation, story-telling and shared experience. Explicit knowledge, in contrast, can be more precisely and formally articulated, more easily codified, documented, transferred, or shared. (p. 114)

Expanding on the concept of tacit knowledge, Drucker (2003) says knowledge is a powerful resource which organizations create. But he further states, “knowledge does not reside in a book, a database, or a software program; these contain only information.

Knowledge is always embodied in a person; applied by a person; taught and passed on by a person; or misused by a person" (p. 287).

Assumptions and Focus of Research

This study assumes there are contextual features of the SBIR environment that systematically influence whether or not the entrepreneur applies for an SBIR award and how successfully an entrepreneur competes for SBIR awards. These influences include how a state is organized around *teaching innovation* to its citizens, and how underlying structures and interrelationships contribute to the *learning process*, the application process, and subsequent success of applicants. The unit of analysis is the entrepreneur through a systems lens. As such, the focus of this research was to explore the knowledge flows between and among developers of innovation (entrepreneurs) and facilitators of knowledge (government, university, research institutions, and public agencies).

Purpose of the Study

Little is known about how much technological innovation is lost in the United States because technology entrepreneurs do not have the financial capability for the R&D necessary to bring an idea to a commercial level. The SBIR program is part of a National Innovation System developed to support R&D efforts for technological innovation by small business. The program is national in purpose, but regionally distributed. The old adage of the *rich get richer and the poor get poorer* seems to hold true with 56% of SBIR awards going to the same handful of states since the genesis of the program. There is lopsidedness in the development of innovative capacity--new technologies, new companies, and new jobs--for the states in which the SBIR entrepreneur resides. Success

is about more than getting federal support; it is about the virtuous cycles of success that develop for the entrepreneur (Audretsch & Kayalar-Erdem, 2005), within the small business, region or state, and the innumerable benefits that go along with building an innovative infrastructure. Therefore, this study explored, interpreted and described the phenomenon of how entrepreneurs became aware of and learned how to navigate the SBIR program. There were two levels of learning that took place in parallel: the first being a technical entrepreneur and the second of navigating the SBIR program. Of specific interest to this study was what Minnesota can learn from its entrepreneurs to enhance participation by more small businesses in the SBIR program.

Potential Significance

The SBIR program is just one tool in a state's portfolio of strategies to enhance technological economic development. In the technological environment, Narayanan (2001), Nelson (1993), and Porter (1998) emphasize the interlinkages that develop which facilitate the flow of information and resources. The short-term outcome of this study was to provide insights into understanding, from an entrepreneur's perspective, how he/she learned about and how to successfully navigate the SBIR program; the long-term outcome is to increase the opportunities for entrepreneurs and the state of Minnesota in the realm of technical innovations. At a broader level, the knowledge gained from this study could mean developing a stronger technical entrepreneurial ecosystem throughout the U.S.

Study Design

This research was conducted as a qualitative case study using grounded theory methodology. Case study lends itself to the exploratory nature of the research. Six Minnesota entrepreneurs with varying experience in navigating the SIBR program agreed to participate in the study. The grounded theory approach was used as a methodology with the intention of letting the data develop the theory.

Primary data were collected through semi-formal interviews with the entrepreneurs. The conceptual framework that guided analysis of the data generated was the construct of innovation within the national, regional, organizational, and entrepreneurial context.

Emphasis was placed on engaged scholarship and theory being grounded by reality (Van de Ven, 2007), which is why the case study format was selected for the study design. Analysis of the data used a *within-case analysis,* with a detailed description of each case and themes within the case, followed by a *cross-case analysis,* i.e., a thematic analysis across the cases (Creswell, 2007).

Summary

In summary, technological innovation with entrepreneurs like Rone and Miranowski has served as a key driver of the United States' economic success both nationally and globally. Although states differ in the infrastructure provided to support entrepreneurial innovation, there are public policies which provide a common innovative system on a national basis. One such public policy established the SBIR program, which "was designed to encourage small business to develop new processes and products and to

provide quality research in support of the many missions of the U.S. government" (NRC, 2008, p. xiii). The SBIR program is national in focus but regionally distributed with 56% of all awards going to the same handful of states since the genesis of the program in 1982. As such, there is lopsidedness in innovative capacity across the nation. Little is known about how much innovation is lost in the United States by technology entrepreneurs without the knowledge of or ability to navigate the SBIR program. Therefore, this study explored the phenomenon of how entrepreneurs become aware of and learn how to successfully navigate the SBIR program.

Definitions and Clarifications

Throughout this research the terms *entrepreneur* and *technological entrepreneur* are used to refer to individuals who have founded their own firm (Forbes, 2005) in an area that requires technological innovation and is eligible for SBIR funding, which means the firm is classified as a small business. It is possible for an entrepreneur to found a firm that would not qualify for the SBIR program either based on size and revenue (greater than 500 employees and revenue exceeding $1.5 mm) or the nature of the firm not having innovative technology that meets national needs. However, because this research focuses on entrepreneurs who learned about and how to navigate the SBIR program, the term small business and entrepreneur or technological entrepreneur are used interchangeably.

Further, several terms within this research have a myriad of definitions and are different than the traditional language within a study of teaching and learning. As such, a glossary of terms was provided with definitions that utilized throughout this research paper. For the most part, the definitions are directs quotes or combinations of definitions

from various authors who have published on the specific terms applicable to the context of this research.

Glossary of Terms and Definitions

Entrepreneurship: Schumpeter (1934), an early writer on entrepreneurship, defines it is a mechanism to create changes in the system through innovation with entrepreneurs as the agents of creative destruction.

Entrepreneurial Self-Efficacy (ESE): an individual's confidence or perception in his or her ability to successfully perform entrepreneurial roles and tasks necessary to launch a new business (Forbes, 2005).

Innovation/Technical Innovation: used synonymously within this paper, "a complex activity which proceeds from the conceptualization of a new idea to a solution of the problem and then to the actual utilization of a new item of economic or social value. [Alternatively] innovation is not a single action but a total process of interrelated subprocesses. It is not just the conception of a new idea, nor the invention of a new device, nor the development of a new market. The process is all of these things acting in an integrated fashion…" (Myers & Marquis, 1969, p. 1)

Innovation Systems: includes all actors, organizations, and institutions whose action and interaction influence innovation processes (Narayanan, 2001; Nelson, 1993; OECD, 1997; Porter & Stern, 2001).

Knowledge: "is about beliefs…can be tacit or explict…tacit knowledge is subconsciously understood and applied, difficult to articulate, developed from direct experience and action, and is usually shared through highly interactive conversation, story telling and

shared experience. Explicit knowledge, in contrast, can be more precisely and formally articulated, more easily codified, documented, transferred, or shared" (Sabri, 2005, p. 114).

Knowledge Flows: "1) interactions among enterprises; 2) interactions among enterprises, universities and public research laboratories, 3) diffusion of knowledge and technology to firms; and 4) movement of personnel" (OECD, 1997, p.12).

Learning Organization/Organizational Learning: terms used interchangeably within this research paper and referred to by Tsang (1997) as an ideal type of organization which has the capacity to learn effectively; and Huber (1991) as the ability to recognize and develop new knowledge or insights that have the potential to influence behavior. "The emphasis is on the accumulation of tacit knowledge through routine processes of learning by doing, learning by using, and learning by interacting" (Diez & Kiese, 2009, p. 246).

Small Business: The U.S. Small Business Administration (SBA) (2007) defines small business as companies that employ fewer than 500 employees and generally have sales below $1.5 million, depending on the industry sector.

Small Business Innovation Research (SBIR): established by an act of Congress in 1982, the SBIR is the nation's largest R&D program aimed at stimulating small business innovation to meet the needs of the nation as identified by the 11 federal agencies administering the program.

Chapter Two: Literature Review

The SBIR program was written into U.S. public policy in 1982 to stimulate small business innovation in areas that meet national needs. Even though the program is national in interest, a handful of states have received 56% of all funding since the genesis of the SBIR program. Assessments by the National Research Council (NRC) (2008) indicate the program is meeting its outreach objectives because over 40% of all applicants are from small businesses which never applied before and 30% of all awards are to small businesses which have never received an award. These assessments are based on quantitative data and may not consider whether the 30% to 40% new business participation is the result of spin offs from previous SBIR small business awardees. This study was not an assessment of the success of the SBIR program or whether there are other methods of outreach to stimulate more participation from the remaining 43 states. Instead, this study explored the patterns and interrelationships of entrepreneurs who had success in learning how to navigate the SBIR program.

Grounded theory was used as a methodology for this study, meaning a theory is developed from the data generated in the process of conducting the research (Glaser & Strauss, 1967). As the researcher, I did not approach the phenomenon as a *tabula rasa* but had a perspective that will help me see relevant data and develop significant categories. As such, the literature reviewed fell within the construct of innovation and was influenced by perspectives generated by my education and experience in economic and business development in northeastern Minnesota over a 25 year period. This review served as the conceptual framework for interpreting and making sense of the data (Glesne

& Peshkin, 1992). Innovation theory in itself has an enormous amount of literature across multiple spectrums. Innovation is linked to entrepreneurship, clusters and networks, knowledge spillover and learning organizations. Innovation, both at a macro and micro level, served as the nexus of multiple levels of analysis. Further, as with grounded theory methodology, this literature review was incomplete and an additional literature search was required on experiential learning as a result of the data generated.

The remainder of this chapter will be laid out as follows: (a) background of the SBIR Program and relevant statistical information; (b) review of literature with the construct of innovation serving as the nexus within a national, regional, organizational, and entrepreneurial context; and (c) summary of the chapter.

SBIR Program

The SBIR program has a tremendous impact in states that have entrepreneurs successful in accessing the program to finance research and development from the feasibility concept to actual development (A. Eskesen, personal communication, April 21, 2010). The rules for success in accessing the program are claimed to be based on scientific merit of the proposals. C. Wessner (personal communication, April 19, 2010) related success in receiving an award to winning the lottery. An entrepreneur cannot be awarded a SBIR grant without submitting an application just like someone cannot win the lottery without buying a ticket. Wessner's metaphor leads to what appears to be an underlying issue for states wanting to increase participation by entrepreneurs–how to increase application submissions.

The following is an overview of the SBIR from the perspective of its history and objectives, the process of access, its impact and geographic information, and Minnesota's performance in comparison to an exemplar state. This is provided prior to the discussion on the construct of innovation to serve as a foundation for the study itself.

SBIR history and objective. The nation's largest single source of early-stage R&D funding for small business innovation is the Small Business Innovation Research (SBIR), which was created in 1982 through the Small Business Innovation Development Act (NRC, 2008). The SBIR program "was designed to encourage small business to develop new processes and products and to provide quality research in support of the many missions of the U.S. government" (NRC, 2008, p. xiii). The policy requires federal agencies with budgets of $100 million or more for extramural research to allocate 2.5 percent of their budgets to operate an SBIR program. Although there are 11 federal agencies which operate and manage their own SBIR programs, 96% of the SBIR funding is allocated by five agencies—the Department of Defense, the Department of Energy, the National Aeronautics and Space Administration, the National Institutes of Health, and the National Science Foundation. The National Research Council (2002) highlights the four principal objectives of the SBIR program:

1. Stimulate technological innovation by small business;
2. Increase small business participation in meeting federal research and development (R&D) needs.
3. Increase the commercialization of technology developed through federal R&D;

4. Enhance outreach efforts to ensure that all qualified small businesses are aware of the SBIR program and the many benefits it provides. (p. 1)

Process for access. Allocation of SBIR funding to small business is through a competitive solicitation process. Each year the federal agencies individually identify various R&D topics for pursuit by small business under the SBIR program. The topics are released to the public in a pre-solicitation, allowing small business to discuss topics with experts. The second release is the final solicitation. Applications are written and submitted by the small business to the federal agency(s). Contracts are awarded to a small business on the basis of competitive merit by an agency's technical and scientific experts (Small Business Innovation Research, 2010). The SBIR program has three independent and distinct phases for which a small business can apply (NRC, 2008) with an emphasis on commercialization as follows:

- Phase I is a feasibility study to evaluate the feasibility and scientific and technical merit of an idea. Phase I awards are for periods of up to six (6) months in amounts up to $150,000 A small business can only access the SBIR program by starting with Phase I, which means if the small business has gotten too far into the development, it will be ineligible to tap into this granting program. If the small business is successful in meeting the objectives outlined for Phase I it can apply for a Phase II grant (some agencies require an invitation to apply for Phase II, one of the nuances of the 11 different granting agencies);
- Phase II is to expand on the results accomplished in Phase I and advance the development of the identified invention. Phase II awards are for periods of up to

two (2) years in amounts up to $1 million. Success in receiving an SBIR award for Phase II is dependent on a reasonably developed commercialization plan.

- Phase III has no funding attached to it but is included to demonstrate the focus on commercialization of the results of Phase II. Phase III requires the use of private sector or non-SBIR federal funding. Receiving Phase II funding is now more dependent on demonstrating a commercialization plan which will result in Phase III or what is considered a *use-condition* of the technology.

Impact and geographic distribution of SBIR awards. Oversight for the SBIR program is provided by the U.S. Small Business Administration (SBA). The SBIR program is evaluated and reported on annually by state by number of proposals submitted, number of proposals granted, dollar values, number of firms, and granting agencies. The General Accountability Office (2009) reported between 1983 and 2004, roughly $17 billion for more than 82,000 projects was awarded. In 2010 the SBIR budget to be allocated to small business for research and development is estimated to be $2.4 billion. In 1999, Congress was concerned about results of an evaluation which found "a small number of states, especially California and Massachusetts, had submitted the most proposals and won the majority of awards" (General Accountability Office (GAO), 2009, p. 6). As a result of the findings, some agencies were reported to broaden the geographic distribution of awards. In 2006 the GAO evaluated the concentration of awards by the Department of Defense and the National Institutes of Health and found the concentration continued for a handful of states with roughly one third of the awards being awarded to firms in California and Massachusetts.

Minnesota's performance in comparison to Massachusetts. The SBIR program can have significant impact on the economic well-being in a state where entrepreneurs have learned to navigate the program successfully. To illustrate this, a comparison is being provided between Minnesota and Massachusetts, which ranks number one in accessing the SBIR program when controlling for Gross State Product (GSP). A snapshot for 2008 is as follows: Minnesota's total population was 5.2 million people with a GSP of roughly $217 billion. Minnesota had a 14% success rate with 274 proposals submitted and 38 SBIR proposals awarded. Minnesota received 1.75 SBIR awards per million GSP. Massachusetts's total population was 6.5 million people with a GSP of roughly $312 billion. Massachusetts had a 21% success rate with the SBIR program with a total of 2,266 proposals submitted and 476 proposals awarded. Massachusetts received 7.06 SBIR awards per million GSP. (Phase I Awards and Proposals for 2008 were taken from the SSTI (2008) website; GSP data were taken from Economic Time Series website)

Since the inception of the SBIR program in 1983, Minnesota has had 265 companies successful in one or more proposals winning an SBIR award. The 265 companies received 1,140 Phase I awards and 425 Phase II awards with a total dollar award of $372,719,767. All but a handful of these companies reside within the seven county metropolitan area of Minneapolis/St. Paul. Accessing the SBIR Phase I and Phase II resulted in additional investments for some of these companies as follows: 15 are now being publically traded, 19 have gone through merger and acquisition deals, and 48 have received funding from venture capital groups. Another indicator of innovation is tied to patents being issued: 1,787 patents have been awarded to the 265 SBIR small businesses.

During the same time frame, Massachusetts had 1,461 companies successful in accessing the SBIR program. The 1,461 companies received 11,504 Phase I awards and 4,402 Phase II awards with a total dollar award of $3,853,711,903. Success with accessing the SBIR Phase I and Phase II awards resulted in additional investments for some of these companies as follows: 92 are now being publically traded, 181 have gone through merger and acquisition deals and 501 have received funding from venture capital groups. Additionally, 12,192 patents have been awarded to the 1,461 companies. Table 1 below illustrates the magnitude of Massachusetts' performance in comparison to Minnesota's performance.

Overall, a total of $17 billion has been allocated from the entire SBIR program to qualified small businesses since the inception of the program, which means Massachusetts received 22% of all SBIR award dollars whereas Minnesota received only 2% of all SBIR award dollars. Statistically, Minnesota has received roughly 10% of Massachusetts' total SBIR award dollar value.

Table 1.

Minnesota and Massachusetts Performance with SBIR Awards (1983-2007)

	Minnesota	Massachusetts	MN as % of MA
Population	~5.2 million	~6.5 million	80%
Gross State Product	~$217 billion	~$312 billion	70%
Total Companies Receiving SBIR Awards	265	1,461	18%
SBIR Phase I Awards	1,140	11,504	10%
SBIR Phase II Awards	425	4,402	10%
Total SBIR Awards	$372,719,767	$3,853,711,903	10%
SBIR Firms Publically Traded	15	92	16%
SBIR Firm Merger & Acquisition	19	181	10%
SBIR Firm with Venture Capital Investment	48	501	9.5%
Total Patents Issued for SBIR Small Business	1,787	12,192	15%

Data provided by Innovation Development Institute (2004)

Innovation and Knowledge Flows

This study rests on the assumption that if a small business has successfully accessed the SBIR program, then the small business is innovative. The innovation process itself was not the focus of this study but is included as the conceptual framework to give perspective on the complexity of macro and micro level factors related to successful innovation.

Innovation is a multifaceted phenomenon that crosses disciplines in both the social and natural sciences. Innovation is dynamic and characterized by information flows with feedback loops (Argyris, 1990) among an array of people—often referred to

as actors—and institutions (Tappeiner, Hauser, & Walde, 2008). Fagerberg (2005) notes the importance of combining insights from several disciplines. As related to the SBIR program, technical innovation is defined by Myers & Marquis (1969) as:

> …a complex activity which proceeds from the conceptualization of a new idea to a solution of the problem and then to the actual utilization of a new items of economic or social value…Innovation is not a single action but a total process of interrelated subprocesses. It is not just the conception of a new idea, nor the invention of a new device, nor the development of a new market. The process is all of these things acting in an integrated fashion. Innovation may be carried from conception to implementation within a single organization, but more commonly it draws on contributions from other sources at different times and places. (p. 1)

A common theme that emerges in the literature is that technical innovation is dependent on knowledge flows. Knowledge flows are the interactions among and between enterprises, universities, public institutions, and the diffusion of knowledge and technology to firms (Nelson, 1993; OECD, 1997; Porter & Stern, 2001). Knowledge is the mechanism that diffuses not just technology, but also makes evident the opportunities for gaining additional support such as through SBIR programs. One of the characteristics of knowledge that may be important is the explicitness of knowledge. Sabri (2005) summarizes the concept of knowledge and distinguishes between tacit and explicit knowledge, based on the work of multiple authors:

> Tacit knowledge is subconsciously understood and applied, difficult to articulate, developed from direct experience and action, and is usually shared through highly

> interactive conversation, story-telling and shared experience. Explicit knowledge, in contrast, can be more precisely and formally articulated, more easily codified, documented, transferred, or shared. (p. 114)

These two definitions --technological innovation and knowledge--illustrate the web of interactions and linkages necessary on a multi-level basis and the complexity of the development cycle to take a concept or idea through to commercialization. The SBIR program is just one piece of this multi-level system. Thus, the remainder of this section reviews the SBIR program within four contexts of innovation: the federal level, the regional level, the organization level, and the entrepreneurial level.

Federal context: National innovation system. From a systems perspective, the SBIR program falls within a larger national innovation system. The performance of this system relies on interactions within and among institutions and developers for knowledge flow (Nelson, 1993; Narayanan, 2001; OECD, 1997; Porter & Stern, 2001). The OECD (1997) defines knowledge flows as: “1) interactions among enterprises; 2) interactions among enterprises, universities and public research laboratories; 3) diffusion of knowledge and technology to firms; and 4) movement of personnel" (p.12).

Porter and Stern (2001) place emphasize on a nation’s capacity to innovate being dependent upon an environment created through fundamental conditions, investments, and policy. The three fundamental elements for a nation’s capacity to innovate include the “common innovation infrastructure, cluster-specific conditions, and the quality of the linkage between the two” (p. 5). The common innovation infrastructure is related to a nation’s public policies which support innovation at a broad level across the nation, of

which the SBIR program would be part. The common innovation infrastructure is at the macro level and includes the social, economic, political, and technological environment (Narayanan, 2001).

The national innovation system is a common infrastructure across the entire nation. How regions or states organize around the infrastructure is unique to each area and may be a factor when considering the uneven distribution of the SBIR awards. The literature discusses the importance of networks or clusters, and generally refers to a regional context of innovation where geography and proximity are a major factor. The next section provides more detail on the regional context of innovation.

Regional context: Networks and knowledge spillover. The U.S. economy is in an era (1990 -2010) defined as the *New Economy,* a term that implies a transformation to our economic structure, function, and rules (Atkinson & Andes, 2008). Research and development is considered fundamental for economic growth in a new economy. The infrastructure of a new economy is dependent upon being global, entrepreneurial, innovative, knowledge-based and tied to networks (Powell & Grodal, 2005). The focus in this section is on networks--in this case a geographic proximity--and knowledge spillover.

Networks develop when public and private institutions agglomerate and serve as sources of knowledge that enhance opportunities for innovation (Feldman & Florida, 1994). The networks or sources of knowledge provide expertise, R&D related to new scientific discoveries, and business services. Four network structures identified by Hoang and Antonicic (2003) include: informal networks (shared experience), project networks

(short-term based on project), regional networks (spatial), and business networks (intentional alliances between organizations/parties). The different forms of networks do not have firm boundaries, can overlap, and can consist of either strong ties or weak ties. Strong ties are defined as interpersonal, with interactions occurring on a regular basis, while weak ties are interactions with people on more of an acquaintance level (Hagedoorn & Duysters, 2002; Powell & Grodal, 2005; Stuart & Sorenson, 2005). These authors explain the terminology being used, *strong and weak*, does not imply the quality of or importance of the relationship with innovation. Strong ties often include persons or organizations having common interests and backgrounds so the information or knowledge diffusion reinforces existing views. Further, strong ties provide in-depth information or knowledge creation but restrict information exchange. Whereas weak ties are noted to include persons or organizations not as closely aligned which introduces novelty and new information to a network. Weak ties may not have the depth of information or knowledge creation as strong ties, but weak ties can provide the critical piece of information to fill what is referred to as a structural hole or gap in an innovative product, process, or business structure. The benefit of networks for an entrepreneurial process is the access they provide to information and advice (Hoang & Antoncic, 2003).

Also related to networks and business start-ups is a literature stream on the importance of an entrepreneur's proximity to universities, institutions, and research laboratories (Audretsch & Keilbach, 2006). Knowledge spillover is the term given to the phenomena where knowledge flows from a university, institute, or research laboratory to an entrepreneur (Audretsch & Keilbach, 2006) which in turn facilitates the "exchange of

ideas, promoting creativity and innovation" (Carlino, 2001). One example of knowledge spillover is of entrepreneurs who have obtained knowledge with limited financial resources invested in R&D. In other words, the entrepreneur starting a new business did not develop the knowledge (Audretsch & Lehmann, 2005). Worth noting is the geographic proximity to sources of knowledge, especially the spillover generated from universities and large laboratories. An example given by Audretsch and Keilbach (2006) is related to the importance of the scientist entrepreneur who leaves the university to start a new business. In this case, the scientist placed more value on an idea and commercial opportunities (innovation) than the employer (university) so the knowledge is transferred out of the university or private laboratory where the knowledge was generated. Whereas if the scientist stays with his or her employer (knowledge-generating university or private laboratory) and the employer does not see commercial value in the knowledge generated there is a filter, i.e., the transfer of knowledge is filtered or impeded.

Audretsch and Kayalar-Erdem (2005) describe the virtuous circle of the success experienced within established networked, high technology clusters. They note how regions which have not developed the knowledge clusters are at a disadvantage to access their fair share of federal dollars for R&D. Knowledge spillovers generate new firm start-ups, particularly in high technology agglomeration clusters. In reviewing earlier studies, Audretsch & Kayalar-Erdem (2005) summarize their findings: "…federal support of innovation, such as…the SBIR, also tends to be spatially concentrated in exactly these areas" (p. 108). They further state programs such as the SBIR could prove to have a greater impact in regions that have not yet established high technology clusters. The

significance of this statement is recognition of 56% of all awards being distributed to only a handful of states does not represent a national innovation system.

In summary, the nation's capacity to innovate is dependent upon the environment created through a common innovation infrastructure. The common innovation infrastructure at the macro level is provided through public policies across the nation. From this infrastructure, clusters and networks develop on regional levels and create knowledge flows between actors and institutions. The actors include the developers of technological innovation or the organizations where the knowledge is spilled over.

Organizational context: Learning, knowledge, and intellectual capital. Learning is related to both technical innovation and organizations, and appears in the literature as *organizational learning* or *learning organizations*. The terms organizational learning and learning organization are often used interchangeably and reflect an ideal type of organization which has the capacity to learn effectively (Tsang, 1997) by recognizing and developing new knowledge or insights that have the potential to influence behavior (Huber, 1991).

Learning in organizations is important in a knowledge economy and usually involves different ways of perceiving, thinking and behaving (Argyris & Schon, 1996). Levitt and March (1988) explain learning in organizations as the process of encoding inferences from history into routines. These routines guide behavior and become what March (1991) refers to as an organizational code. Earlier, Revans (1979) linked *action* to learning as a process founded on the concept that one cannot change the system--or organization (author's emphasis)--unless one is changed in the process. Marquardt (2002)

highlights change in the organization system is action while change in the individual is learning. In other words, learning is both organizational and individual (March, 1991; Zuber-Skerritt, 2002). At the heart of learning organization theory is the transformation of information into knowledge (Senge, 1990) with an emphasis on the accumulation of tacit knowledge through routine processes of learning by doing, learning by using, and learning by interacting (Diez & Kiese, 2009).

The foundation of this research was based on a belief that although the SBIR program is shared through codified knowledge in policies and procedures, how a state organizes around the SBIR program provides entrepreneurs with tacit knowledge that leads to success in learning how to navigate the SBIR program. An example of a state organizing around the SBIR program is the amount of financial and human resources made available for outreach to first make entrepreneurs aware of the program and then to provide the entrepreneurs with information or knowledge not codified in the SBIR policies and procedures. Tacit knowledge is developed as Diez and Kiese (2009) state through learning tied to interacting, doing, and using. Drucker (2003) says knowledge is a powerful resource which organizations create. But, he further states: "knowledge does not reside in a book, a database, or a software program; these contain only information. Knowledge is always embodied in a person; applied by a person; taught and passed on by a person; or misused by a person" (p. 287). In general, when looking at an innovation environment at the micro level or within the organization, the focus is not on fixed assets (building, equipment, inventory, etc.), but on the soft assets or the tacit knowledge within a company (Carmona-Lavado et al., 2010). Tacit knowledge can be considered *know how*

because it is not documented for further distribution within or across organizations. This concept of know how requires a further investigation into the general category of *intellectual capital* (Baron & Markman, 2003; Carmona-Lavodo et al., 2010) and its subcategories of human capital, organizational capital, and social capital (Carmona-Lavado, et al., 2010). These subcategories are introduced starting at the organizational capital level, which refers to the organization as a whole, and then moves to human capital and social capital, which are conceptualized at the individual level.

Organizational capital is explicit or codified knowledge institutionalized within organization processes (Carmona-Lavado, et al., 2010). It can be captured through written language in the form of databases, documents, patents, manuals, etc. This knowledge implies a formal process and creates organizational memory (Huber, 2001) which can serve as a communication mechanism to systemically transmit and disseminate knowledge both within and outside the organization (Wright, Dunford, & Snell, 2001).

Human capital refers to the knowledge and skills that reside within the individual (Carmona-Lavado, et al., 2010; Wright, Hmieleski, Siegel, & Ensley 2007). This knowledge can be codified and/or tacit. Unlike personality traits, human capital can be developed over time and transferred between individuals (Wright, et al., 2007). Wright defines two categories of human capital: general, or breadth and depth of experience and formal education; and, specific, or knowledge of markets, customers, and technology. Entrepreneurship is said to be a component of human capital (Casson, Yeung, Basu, & Wadeson, 2006). How an organization channels human capital is significant because of

the impact human capital has on learning and the development of organizational capital and social capital.

Social capital on the other hand is defined as collaboration and interaction among people who share ideas (Carmona-Lavado, et al, 2010, Wright et al., 2001). The concept of social capital appears in network theory literature and centers on the power of relationships among actors and how the structure influences a variety of outcomes (Baron & Markman, 2003). The social structure considers the level of opportunities available as well as the constraints which bind the actors. There is a fine line between social and human capital as private conversations are considered the conduit to access or awareness of attractive opportunities (Stuart & Sorenson, 2005). Social capital ties back to networks, and the role of both strong ties and weak ties within networks. One example is the value of weak ties in opportunity recognition. Opportunity recognition is one of the four entrepreneur tasks identified in the development of creating or starting a business (McGee, Peterson, Mueller, & Sequeira, 2009). Related to this research, becoming aware of the SBIR program could be considered opportunity recognition. Twenty percent of SBIR small business firms surveyed reported their business was created as a result of an SBIR award – an entrepreneur recognized an opportunity and mobilized resources (NRC, 2000).

Entrepreneurial context: The entrepreneur and self-efficacy. Individuals and teams are the initial driving force for technological entrepreneurship (Wright, et al., 2007). Popular beliefs about entrepreneurship are based on the work of early innovation theorist Schumpeter (1934) who visualized the entrepreneur as an innovator whose work

led to the creation of new industries (e.g., railways, biotechnology). Throughout this research the terms entrepreneur and technological entrepreneur are used interchangeably and refer to individuals who have founded their own firm (Forbes, 2005) in an area that requires technological innovation and is eligible for SBIR funding, which means the firm is classified as a small business. An entrepreneur has a range of characteristics hidden until action is taken--i.e., the action of creating a new business (Casson et al., 2006; Forbes, 2005; Metcalfe, 2003). Forbes (2005) provided a summary of a model first proposed by Stevenson, Roberts, & Grousbeck (1985) which identified four entrepreneurial activities necessary to create a new company: (a) searching, which leads to development or identification of an opportunity; (b) planning, which includes evaluation of the business opportunity, often through a formal business plan; (c) marshaling, which converts what is learned in the planning phase into the action of actually gathering the resources; and, (d) implementing, which takes the business beyond the start-up phase. Becoming aware of the SBIR program would be important to a technological entrepreneur at the first three stages if he/she does not have the financial resources for research and development. Yet these actions, while significant in the process of becoming successful, do not address the personality traits of successful entrepreneurs. The question to be addressed here is what individual characteristics enable a person to become an entrepreneur? One promising area of research links individual characteristics to entrepreneurial action and success is *entrepreneurial self-efficacy* (ESE) with origins in the field of personality and developmental psychology (Chen et al., 1998).

Bandura (1977b) defines self-efficacy as a judgment one has of their own

capability to accomplish a certain level of performance of desired outcome; because it affects an individual's thought patterns it can either enhance or undermine performance, depending on the results. For instance, if a person has high self-efficacy, goals are set higher and the person shows more determination; the reverse is true for a person with low self-efficacy. Of interest for this research is Bandura's emphasis on the reciprocal causation between cognition, behavior, and environment. Each of the three factors is affected by the others (Chen, Greene, & Crick, 1998). The literature on the innovation system emphasizes the quality of the linkage between the national innovation system and the cluster-specific environment and knowledge flows (Nelson, 1993; OECD, 1997; Porter & Stern, 2001). All three factors--cognition, behavior, and environment--are components of the innovation system.

ESE also reflects the confidence an entrepreneur has in his/her own knowledge and skills with respect to starting a business (Forbes, 2005; McGee et al., 2009; Zhao, Seibert & Hills, 2005). While entrepreneurs need to take part in the four activities (Chen et al., 1998) of searching, planning, marshalling, and implementing as the construct of ESE is being advanced, implementing was broken down further to include people-related and financial-related elements (McGee et al., 2009). Tied to this research, all five activities are fundamental to participating in the SBIR program if a technological entrepreneur is successful in receiving an SBIR Phase I (feasibility study which includes searching, planning and marshalling activities) and an SBIR Phase II (development phase with a solid commercialization plan which includes all five activities). McGee et al. (2009) and Zhao et al. (2005) link learning and intentions to business start-up. Wilson,

Kickul, and Marlino (2007) found that ESE is associated with intentions, and education can elevate ESE.

Summary

Based on a review of the literature, the following points stand out as significant and relevant to the topic of innovation and entrepreneurship in the context of the SBIR program:

- National innovation systems use policy to provide resources to stimulate innovation at a national level. The SBIR program is the largest single source of early-stage R&D funding for small business innovation.
- Regional innovation systems develop when universities, venture capital, scientists and engineers, high technology firms and start-ups cluster in spatial agglomerations creating networks. Geographic proximity of the clusters provides a venue for knowledge spillover, supporting opportunity recognition and start-up of organizations.
- Organization and individual learning are interconnected. At the heart of learning organization theory is the transformation of information into knowledge. Tacit knowledge or know how is part of intellectual capital (organization, human, social). How an organization channels human capital is significant because of the impact human capital has on learning and the development of organizational capital and social capital.
- Entrepreneurs become aware of or develop an idea (product or process) through opportunity recognition and resource mobilization. ESE measures a person's

belief in their ability to successfully launch a new business. There is a reciprocal causation between belief and intentions.

This literature review serves as the conceptual framework for interpreting and making sense of the data generated through the case studies. Further, as with grounded theory methodology, an additional literature search may be required as data are generated by exploring the phenomenon of an entrepreneur becoming aware of, learning about, and successfully navigating the SBIR program.

Chapter Three: Methodology and Research Approach

The SBIR, established by an act of Congress in 1982, is the nation's largest R&D program aimed at stimulating innovation by small business and was designed to encourage small business to develop new processes and products in areas that meet a national need. Following an evaluation by the General Accountability Office (GAO) in 1999, Congress was concerned about the geographical concentration of awards going to a handful of states, especially Massachusetts and California.

There are a number of reports available annually which provide statistical data on a states performance in competing for SBIR dollars. This study assumed there were contextual features of the SBIR environment that systematically influenced whether or not an entrepreneur applied for an SBIR grant and how successful an entrepreneur would be competing in the program. Of interest to this study is how underlying structures and interrelationships contributed to the learning process. Therefore, this study explored the phenomenon of how entrepreneurs become aware of and learned how to navigate the SBIR program.

Methodology

This research was conducted as a qualitative case study with grounded theory methodology. The qualitative design was chosen to provide a degree of richness of description (Glesne & Peshkin, 1992) of the phenomena of the entrepreneurs' lived experience (Van Manen, 1998) with becoming aware of and learning how to navigate the SBIR program.

Case study lends itself to the exploratory nature of the research and included six

Minnesota entrepreneurs who have navigated the SBIR program. As grounded theory methodology suggests, if significant themes did not emerge from the six case studies, additional cases would have been added until themes emerged.

The researcher requested exemption from the University of Minnesota Internal Review Board (IRB) and received approval of exemption on October 19, 2010. The interviews are limited to adult subjects.

Selection of Case Study Participants

This study focused on entrepreneurs in the State of Minnesota. Each state has its own infrastructure and organization around the SBIR program. The purpose was not to analyze the state's organization, but how the entrepreneur learned to navigate the SBIR program within the state. Three entrepreneurs were selected initially, but three additional entrepreneurs were added to achieve saturation. The original three entrepreneurs were selected for the various stages of experience they had with the SBIR process: one has over twenty-five years of experience, the second has had success with Phase I and Phase II, and the third just submitted an SBIR application so their success is unknown at this time. The researcher identified the participants through her connection to the University of Minnesota, to the economic development community, and existing research on the SBIR program. The next three entrepreneurs were added to the study after two of the three original interviews were conducted. A contact was made at the Minnesota Science and Technology Authority, the SBIR liaison for Minnesota, for recommendations. Their representative sent an email to three SBIR companies with the researcher's consent form as an attachment to provide a description of what participation would mean. All three

entrepreneurs agreed to participate, making a total of six participants with experience navigating the SBIR program. The Participants' labels (A, B, C, D, E, F) were developed from the order in which the contact was made with the entrepreneur. The following is a general description of each case.

The first case (Participant A) is an entrepreneur who started a company with a colleague scientist in the 1980's. The entrepreneur's new venture grew, changed names, and went public, and eventually became ineligible to participate in the SBIR program. The original technical entrepreneur was allowed to spin out of the parent company in 2004 and start another company which was SBIR eligible. His team of scientists transferred with him, and within three years the new venture had already received 11 SBIR awards. This same scientist is estimated to have participated and succeeded in over 100 SBIR proposals and awards.

The second case (Participant B) is an entrepreneur who is a new player in the SBIR program. Participant B was successful in being awarded an SBIR Phase I in 2009, and because of the success was invited by the granting agency to submit a proposal for Phase II. There is approximately a 40% success rate for proposals submitted for a Phase II award. Participant B received news in 2010 that he was successful with receiving a Phase II award. This participant subcontracts with a university for scientific aspects of the research and development.

The third case (Participant C) was selected because his company was in the throes of just having submitted an SBIR application. The interest in these entrepreneurs as a case study was because of the freshness of their experience; their awareness may be at a

different level due to being in the thick of the experience of applying for the SBIR as well as being in the first phase of a new venture. At this time, Participant C does not know if his company will be successful, but he will have a story about how he became aware of the program and what it took to navigate the system to submit an application.

The fourth case (Participant D) was the only woman participant of the research; she has experienced about a 50% success rate with the proposals she has submitted to the SBIR program. Participant D is the sole founder of her company, but also has served in the role of co-founder in other business start-ups. This participant heard about the SBIR program from a colleague when she worked in Maryland. It was at least 10 years after first hearing about the SBIR before Participant D submitted her first application.

The fifth case (Participant E) is a medical device company. Participant E has experience with the SBIR program and other federal government grant programs. Participant E had also co-founded other business start-ups with successful growth and sale of the companies. Their current venture has been ten years in the making with a new company spinning off as a result of successful research and development through SBIR Phase I and Phase II funding.

The sixth case (Participant F) is an information technology company that has experience with the SBIR program and other federal government grant programs. This participant has had about a 25% success rate with SBIR Phase I proposals and 100% success rate for Phase II proposals. Participant F started this company by licensing technology from a university the co-founder developed as part of his dissertation project.

Data Collection

The hermeneutic phenomenological method was followed to conduct the interviews as well as interpret the data. Van Manen (1998) states that the hermeneutic phenomenological method "tries to 'explicate' meanings that in some sense are implicit in our actions. We know things through our bodies, through our relations with others, and through interaction with the things of our world" (p. xiv). Hermeneutic phenomenology complements grounded theory in that rather than being attentive to how things appear (Van Manen, 1998) this method is interpretive and lets the data tell the story. In this case, the data were based on the lived experiences of entrepreneurs who have navigated the SBIR program and were reflecting on what that experience or process was to them.

Yin (2009) discusses the importance of following three principles in data collection for case studies: Principle one is the importance of utilizations of multiple sources of evidence, which includes an examination of documents, archival records, examination of artifacts, qualitative interviews, and observations; principle two is organization and documentation of data collected; and, principle three is maintenance of the chain of evidence. A description of how each of these was handled is as follows.

The study utilized both interviews and examination of documents and artifacts to address principle one in the data collection process. The primary data for this study were collected through qualitative interviews with the participants. Babbie (2007) describes a qualitative interview as being iterative and continuous. He goes on to say that the interviewer has a general plan with a set of open-ended questions to guide the discussion, and ideally the interviewee will do most of the talking.

Interview process. Entrepreneurs who agreed to take part in the study were emailed the Informed Consent form (Appendix B), and a follow-up phone call was made by the researcher to answer the entrepreneurs' questions or concerns. The interviews took place in November and December 2010. Interviews followed an open ended question format; five of the six interviews were conducted face-to-face at the entrepreneurs' place of business. The sixth interview was conducted via a phone call because extreme weather conditions prohibited travel. The questions were developed to identify actual steps the entrepreneur took in navigating the SBIR program with the intention of understanding the underlying questions of how they learned to take those steps (Appendix C). The purpose was to understand not only how they became aware of the step, but what decision process they used to take that step. Each interview was digitally recorded for transcription, with the participant's permission. Participant B had two entrepreneurs involved in navigating the SBIR process. Immediately following the interviews, the researcher recorded field notes to identify impressions and comments on the flow of the interviews. The digital file of the interview and the researcher's field notes from each interview were managed through the qualitative software Transana. The original copy of the interview was saved externally from the software on a zip drive. The digital recording of each interview was transcribed and saved as a document within Transana as well as saved as a Word file.

Document examination. Examination of documents and artifacts included pamphlets provided by the participants and internet searches on the participants' websites. Participants did not provide any additional documents for examination significant to their navigating the SBIR program.

Organization and documentation of data. The second principle Yin (2009) brings forth is the importance of organization and documentation of the data collected for the case studies. There are two pieces to this for case studies--the transcription of the interviews and the report of the researcher. In order to address this principle, the researcher utilized a qualitative software package called Transana to transcribe the interviews and store the digital recordings. The transcribed notes are stored within Transana and as Microsoft word documents on the researcher's encrypted and password protected computer.

Chain of evidence. The third principle of data collection is to maintain a chain of evidence (Yin, 2009) in order to address the methodological problem of determining construct validity. Because interviews are confidential information, the citations do not provide direct reference to relevant portions of the database as suggested by Yin; however, in the event construct validity would be challenged, the researcher has maintained proper reference points.

Data Analysis and Synthesis

Data analysis began while collecting the data during each interview. "To analyze qualitative data, the researcher engages in the process of moving in analytic circles rather than using a fixed linear approach. One enters with data of text or images…and exits with an account or a narrative" (Creswell, 2007, p. 150). As a qualitative study utilizing conversational interviews, roughly nine hours of recordings were transcribed into 187 pages of text. The analysis process followed a format known as *within-case analysis*, with a detailed description of each case and themes within the case followed by a

thematic analysis across the cases, i.e., a *cross-case analysis* (Creswell, 2007).

In qualitative social research, coding is the primary method to classify or categorize individual pieces of data (Babbie, 2007; Blaike, 2000; Strauss & Corbin, 1998). Strauss and Corbin (1998) describe open coding as follows:

> To uncover, name, and develop concepts, we must open up the text and expose the thoughts, ideas, and meanings contained therein. Without this first analytic step, the rest of the analysis and the communication that follows could not occur. Broadly speaking, during open coding, data are broken down into discrete parts, closely examined, and compared for similarities and differences. Events, happenings, objects, and actions/interactions that are found to be conceptually similar in nature or related in meaning are grouped under more abstract concepts termed "categories." (102)

The authors go on to further explain any piece of data can have several codes. The codes are developed by the researcher as part of the examination and questioning of the data (Babbie, 2007) and taking apart the observation (Blaikie, 2000).

The text in this study were opened by going through each case study first and identifying and breaking down the parts around the questions asked during the interview. The patterns that surfaced included a tie to university or academic background; the participants' confidence in the idea; marketability of product, team, and self; importance of relationships; general small business issues; system support needs; and everything the participants learned about the SBIR process.

The next phase of the coding process was axial coding, i.e., a regrouping or reanalysis of the results of the open coding (Babbie, 2007), or putting the data back together in a new way based on possible causal conditions (Blaikie, 2000). The distinguishing feature of axial coding with grounded theory is the *constant comparative method.*

A combination of software and a manual process for coding and categorizing the narrative text were used to conduct further analysis to identify patterns. A Microsoft Excel spreadsheet was utilized to code text according to patterns of learning associated with: searching, formal program, prior experience, and interacting with people.

Another process described in grounded theory literature is referred to as *memo writing.* Memo writing is utilized during both the data collection process and the analytical process. In the context of the analytical process, a spiral bound notebook was used to capture reflections, suspensions, and links to the literature or areas for further literature review.

Design Considerations

The design of this research project followed four tests to establish the quality of this empirical social research as identified by Yin (2009). Construct validity was addressed by using multiple sources of data, establishing chains of evidence in the data collection phase, and providing the interviewees with an opportunity to review the transcripts. Internal validity was established through the data analysis, in this case using a manual process for coding, categorization and utilizing a qualitative software program for transcription. External validity was addressed in the research design by using replication

logic since there were six case studies. Reliability was addressed by developing and using case study protocol as well as developing and maintaining a database for data collection.

One of the considerations or debates about the validity of a qualitative design is generalizing to the population is not feasible. In qualitative studies such as this, validity is contextual and bound by the individual. As an exploratory case study with six participants, inferences are not made about a population (Yin, 2009). Further, because the interviews and observations took place in five of the six participants' places of business, the insights are presented based on the interpretive skills of the researcher, and verified by the participants.

Communicating Research Findings

The research design was conducted as a qualitative case study using grounded theory methodology to learn about the phenomena of becoming aware of and learning how to navigate the SBIR program through the entrepreneurs' perspectives. The study evolved from learning about lopsidedness in SBIR applications and award allocations in the same handful of states since the inception of the program in 1983. More specifically is a concern for Minnesota's performance and how to increase participation by its entrepreneurs. As a result, the study focused on six Minnesota entrepreneurs and their experiences related to working with the SBIR program in Minnesota. The results are presented in the next chapter.

Chapter Four: Results

The primary focus of this research was to gain an understanding of how entrepreneurs became aware of and learned how to navigate the Small Business Innovation Research (SBIR) program. Ten questions provided a framework for conversational interviews with the participants and focused around their learning processes as they navigated various programs, SBIR and others. It was difficult for the participants to easily outline a process or specific protocol for learning because their learning evolved--they would probably say is still evolving--through experience or better known as “learning by doing” (i.e. experiential learning).

The participants’ knowledge specifically about the SBIR process was gained through a trial and error process. There was neither a defined beginning nor an end. Block’s (1999) description of learning captures the essence of what the participants described:

> Learning is about discovery. It is NOT knowing. Learning organizes itself around telling our story and gaining meaning from our own experience... Learning has to be in dialogue with other human beings...it has to be live action. It's sometimes unpredictable, messy, noisy, and inefficient, but that's when discovery takes place. You can't have a predictable system, which is the essence of order and efficiency, and expect to be surprised. Discovery, surprise, not knowing--this is the essence of learning, especially about things that matter. (G. Belden, personal communication, 1999)

The participants could not separate between how they learned from what they learned. When probing about how they learned to do certain things, the most common statement made was by "doing it." The participants' stories illustrated doing it to include action and interaction around: developing the idea and support, developing and submitting the SBIR proposals, and learning the outcomes. While actions were driven by the need to secure financial resources for development of the idea, the actions most often resulted in interactions which encompassed learning from and with people. Most important, the participants' activities were never linear and the SBIR program was just one activity that could not be isolated from other business activities. So while the illustrations of learning are categorized in this chapter, an emphasis needs to be made that learning to navigate the SBIR program was not an independent activity from the rest of the business activities and there were interrelationships and overlaps between each of the categories.

The remainder of the chapter starts by describing the concepts of confidence in the idea and self-efficacy, which lays the foundations for why the participants wanted to learn how to navigate the SBIR program. Next, there are three sections that capture the participants' learning while: developing the idea and support, developing and submitting the SBIR proposals, and reflection and learning based on the outcomes. Subsequently, a synthesis of what the participants learned is provided for new SBIR applicants.

Confidence in the Idea and Self-Efficacy

The impetus for the participants becoming aware of and learning how to navigate the SBIR program was primarily driven by a desire to develop an idea and, at least initially, not having the financial resources to do so. Marshalling the resources to give the

participants the ability to accelerate ideas into action was grounded in their confidence; the idea had both a utility for society and an economic value to the small business. As such, throughout the participants' stories was a thread about confidence in the idea driving their actions not only to learn how to navigate the SBIR program, but also to develop their ideas to a commercialization level. The participants spoke about being very focused and deliberate about the topics on which they wrote a SBIR proposal. "We do a fair amount of business analysis upfront and if we thought the idea had a compelling business opportunity, we would write a grant to the National Institute of Health (NIH)…my bias on the NIH is that you can write an SBIR in anything you want related to healthcare," said Participant E. Participant F indicated the breakout for company activities is 30-35 percent research and development and 60-65 percent commercial and said, "I think one of the reasons we are so successful at SBIR is we've developed a model here where we commercialize SBIR technologies as quickly as we can; and usually before a Phase II is over, we're selling some form of that technology to the marketplace."

While confidence in the idea was common among all six participants, when asked about their belief in succeeding (self-efficacy) at being awarded an SBIR grant, the answers were quite mixed, from Participant A being absolutely certain of success because "I had done it before," to Participant B saying they had not really thought about success but instead had the perspective "you know what you get if you don't apply." Participant C was new to the SBIR process and first submitted an SBIR proposal within the last year. He learned through discussions with others and some limited experience there was a fair amount of time and effort that went into proposal writing. As a result, they went through

an elaborate calculation and determined their probability of success was high, and thus went forward with writing the application. Participant D shared a perspective on believing she could do it because she had seen this done by a colleague, an "ordinary person" who also owned a very small business, and if he could do it, she could too! Participant E indicated he probably did not think about it, was not aware of the statistics on the probability of success being low, and was not sure if it would have mattered. But, "after getting started with the NIH, I have looked at success rates at different NIH departments and that can have some impact on submission strategy/plans." Participant F knew how competitive the program was but went forward because their collaborators and other employees within the company thought they had a chance.

The participants had mixed beliefs about their ability to win an SBIR award, but all of them had confidence in their idea, both from a need perspective and as an economically viable business opportunity. The next three sections of this chapter describe the richness and the dynamic essence of the participants' experiences of learning around: developing the idea and support, developing and submitting the SBIR proposal, and reflection and learning based on the outcome.

Learning about the Skills Needed for Developing the Idea and Support

Knowledge of the science and technology, and the processes of research and development matter, but these factors alone do not account for success. The SBIR process is "all about innovative research…that really laid the groundwork; that coupled with I think having some solid industrial connections…legitimized us" (Participant F). The participants shared story upon story about interacting with people to develop their

idea and support to highlight the importance of relationships, connections and communication, “because the best idea on the planet is going to be worthless if you can’t sell it, if you can’t market it, if you can’t package it in a way that will address a problem in the marketplace” (Participant F).

Participant D had been a drafter before attaining a master’s degree in biomedical engineering, and had experience in product development through both small and larger companies. This participant intentionally went after experience in her specific field of interest, co-founded a company, worked as a product developer/project manager in another company in the field, and then broke off and launched the existing company in which SBIR awards were applied for--perhaps 10 years of searching, planning, and learning as a service provider, product developer, and from potential end-users. It is not enough to have an idea that an entrepreneur thinks may meet a national need; according to Entrepreneur D, “you have to learn how to present it.” In this case, the participant was searching for ways to learn more about the SBIR program which resulted in attendance at an Annual SBIR Conference, but more importantly, at a smaller SBIR conference in her home state as well. Attending this conference gave her an opportunity to discuss her idea with a program manager over the lunch session. The participant talked about sharing multiple ideas with the representative and “truly listening” to the representative’s thoughts on the idea; it was an interactive conversation resulting in the program manager offering multiple suggestions including a specific contact within the federal agency. The program manager “gave me insights from her perspective as to what they would be looking for…that really helped me.” The participant learned she needed to be able to

speak about the idea but also be able to address the questions of who cares and why it matters.

Beyond developing the idea, Participant A shared his perspective on the importance of making connections to develop an interest in the idea and create awareness about potential and capabilities. “They have to know you and be familiar with your work…they need to be sure, be convinced that you will give them more for their money than anyone else they know.” This participant was fortunate as his reputation resulted in the federal agency requesting a visit to learn more about his organization. This was before SBIR was a formal program. The participant talked about relationships and knowing the people. He admitted his company has not recently been as successful in winning awards within the Department of Defense (DOD); “I’m going to have to invest more in it before I write the proposal…meaning communicate, get acquainted with the DOD person who wrote the topic.” In this case, the players had changed and the participant had not taken the time to get to know the new players. Personally knowing the federal agency program managers or those individual authors writing a solicitation for the agency was brought up by all six participants. Participant F stated, “I’ve never seen a case where an SBIR topic was awarded when there wasn’t some connection between the author on one end and the PI on the other side.”

Another theme that surfaced was for entrepreneurs to recognize the need to establish communication well before developing the SBIR application. “Our process starts a couple of years earlier because now, since we do have some relationships, we try to plant seeds with our ideas” (Participant F); and then the small business may be asked

to draft a solicitation. Four of the six participants mentioned they did not put the mental strain into writing an SBIR application without some kind of contact with the agency because "topics very frequently come out of a relationship" (Participant E) depending on the SBIR federal agency program. For instance, at the Department of Defense it is a must for an agency relationship. For NIH, Participant E emphasized the importance of the relationships that will impact the reviewers and this is most likely the research collaborators. Further, a relationship with the program manager is important if the score for receiving an award or not is on "the bubble" and as awardees execute the research. The other two participants indicated they had not made contact prior to submitting their proposals, but in the future would make this connection; according to Participant C, "we did go it ourselves and there were consequences to that."

As described by the participants, the ideas stem from both the knowledge they developed from formal education and experience but also through the relationships with colleagues or people in the field. The complexity is described by Participant E as follows:

> Well, we've just been working in the area for awhile…we have a relationship with… doctors … one time we walked in with one idea and as we started talking about it, he said, well you know…is a real problem area for us and so…it [the idea] comes from conversations with collaborators in the areas that we are working …the invention came later... we prefer to have the need drive the solution versus trying to push.

Also, some of the participants expanded on the ideas for technology development as a result of knowledge spillover from a university with three of the six participants having

exclusive license agreements. One example was given by Participant F about licensing a technology their co-founder personally developed as part of the research attached to his dissertation, with the license and company being launched the day of the co-founder's defense. Participant C was able to license a technology that had fifteen years worth of research by two professors with the professors serving in an advisory capacity for the small business. Participant B had a license with the University for a specific product; and based on their experience in the marketplace over several years, went back to the inventing department to develop a new idea with the same raw materials.

Developing the idea and gaining support motivated the participants to take actions which resulted in interactions with people from other organizations, Universities, successful SBIR firms, customers, state representatives, SBIR program managers, and topic authors. Developing ideas was a social process and stemmed from prior experience, formal education, and collaborative relationships. The participants described storytelling as a way to solicit input from decision makers and potential end users about the merits of their ideas. How they incorporated and adapted their ideas in developing the proposal played a role in generating support from SBIR program managers, topic authors, and potential customers.

Learning the Knowledge Needed for Developing and Submitting the SBIR Proposal

By the time the participants arrived at the stage of developing the proposal, they had an idea(s) and generated support as described above. The participants elaborated on the actions they took in developing the proposal but could not further define how they learned about the actions needed to be taken. Participant A said, "I had done it before,"

working as a professor at a university and writing proposals for federal grants to support his research. Participant E said, “do you have feasibility data, that’s one of our biases, we always try to get preliminary data; they say you don’t need it, but we always include it!” Again, the participants relied on confidence in their idea because of the interactions they had with various people in addition to literature searches and market assessments to understand the landscape or sector in which an application should be submitted. Participant C elaborated on learning how to position their technology to demonstrate how it can best meet new standards being set by the regulatory environment of a government agency. In order to pursue an SBIR award, this participant wanted to understand “how does our product meet that mission better than anything else for this specific topic that we are addressing?” The participants had conversations with people whom they trusted to review their approach and could help them determine what agency to apply with and under what topic. In some cases they may have helped the agency draft the solicitations, “of course we still compete for those solicitations and we don’t get them all the time either which kind of frustrates me,” said Participant F.

Before sitting down to write the proposal, all the participants attributed much of their learning to reviewing multiple proposals in the federal government database. The analysis of SBIR proposals awarded provided an understanding where agency or reviewers placed value, and what they liked or did not like about a specific proposal. The analysis helps the participants learn about the audience, referring to the agency, topic author, and review committee--a factor all participants identified as being important when developing a proposal. The composition of the review committee can vary, but a common

perspective is that the majority of the members tend to be academics from a University or federal research facility. Keep in mind who the audience is and, “just give them what they ask for…that’s one of the rules you learn,” said Participant E.

Developing the proposal also encompasses developing the team. The importance of relationships surfaced once again as the participants described putting their team together for the SBIR proposed project itself. The small businesses’ organization structures were not the boundary. The formation was based on an analysis of what capacity the participants’ small business had and who else was needed to fill the gaps, not only to demonstrate the capabilities to complete the research, but also related to developing the proposal itself. Participant E and F shared their perspectives on developing teams that included someone reviewers would know because they have been published or are well known in the field. The participants described failed attempts on some SBIR proposals being the result of not demonstrating the capability of the team to accomplish the research. According to Participant E, it is important to “find collaborators that will lay their brand on your project.” If possible, when the applicant did not have an academic on their team or someone familiar with writing federal grants, every effort was made to include someone who had the credentials to give the project the scientific merit that would provide credibility from an academic reviewer’s perspective. It was a common belief by the participants in this study that proposals including a principle investigator with academic experience could have an advantage over a principle investigator without academic experience.

When this was explored further, the general theme was "writing," i.e., academics know how to write. But more than writing, the academic background also includes being published on a scientific topic in peer reviewed journals, thus bringing more credibility to the team. Further, the academic tie was equated to understanding how to write federal grants; how to develop and document experiments; where to put emphasis and in what sections of the application; and how to "present it in a way that 'these people' are used to reading." While four of the six participants had someone within their team who had a Ph.D., the other two participants talked about subcontracting with a University for certain aspects of their research when they did not have the expertise, not only to lend credibility, but to write and develop the scientific portions of the application. While the need to learn how to write was significant and mentioned by all participants, for some participants, the learning was more about knowing how to bring in people who could articulate their tacit knowledge in a scientific written format that would stand up to the rigors of an academic review committee. "Not all entrepreneurs with good ideas know how to write," stated Participant D as she shared how Minnesota Project Innovation provided support during the participant's infancy with the SBIR program which resulted in a successful SBIR award (after two failed attempts).

In addition to the writing, the participants talked about the importance of having others review their proposal prior to submittal. A couple of the participants have formal review processes with Participant F describing:

> One of the key things that we do as part of our process is we have our proposal written up, we have it reviewed internally, but then we usually have a third party

> review it and edit it …just to make sure it's grammatically perfect and it looks good, and the graphics are professional ... you need good writing, but then the proposal needs to look good and have a professional feel to it. And the other thing is that we always incorporate the feedback from the topic author…we don't submit a proposal unless we can… this gets back to the relationship.

Once the application is written, reviewed, modified and reviewed again, it is critical to "quadruple check the submission details of the application," explained Participant B. There was general consensus the SBIR program is so competitive with a large volume of applications that those who volunteer to serve as a reviewer are looking for reasons to reject. Do not make them work too hard to determine what you are trying to demonstrate, was the advice of the participants. The first page has to grab them, with Participant B saying, "it was disappointing however to learn, based on the reviewers' comments, that none of them read more than half of the first page of the application. The project was not funded."

Before actually being able to submit a proposal to the SBIR agency, an administrative component of registering with the federal government must be considered in the timeline. One of the participants was a first time SBIR applicant and was disqualified based on the administrative component of registering with www.grants.gov. Although it appeared the registration was accepted, there was a disconnection between this piece of the registration process and requirements of the specific federal agency where the proposal was being submitted. By the time the participant became aware of the error, "I didn't have time to correct that issue." The participant shared how the "first

failed attempt based on the administrative component was due to confusion." The participant thought he knew the process, but failures due to such small details once again emphasized the importance of learning by doing—only so much could be anticipated and planned ahead of time.

When the participants were asked if they did anything once the application was submitted, there was a unanimous voice that there is nothing to do—at least related to contacting the agency. An emphasis was placed on the rules strictly forbidding contact and not wanting to compromise the project or an agency official by trying to make contact. There are tracking methods on the government website which indicate when committees are meeting if an applicant wants to follow when they might get notice. Some of the participants talked about writing more applications to get ready for another round, or submitting to another agency for a different solicitation. "We are always looking for better opportunities" (Entrepreneur F).

Reflection and Learning Related to the Outcome

Whether the participants received notice of success or failure for a submitted proposal, they talked about a process that involved reflection and feedback. The participants received the results of the SBIR proposal and reflected on their process and what could be learned from the outcome. Yet it was not the outcome but the actions they took that drove their learning. The stories were most vivid around learning from failed attempts with emphasis on the participants not viewing an unsuccessful proposal as failure. All the participants mentioned learning from the reviewers' comments. Participant D had the following reflection, "I figured I didn't quite understand something

about what they needed to see, wanted to see, and maybe really, they weren't as compelling…they wanted things that I wasn't really savvy with." As such, this participant searched for people that could help her to become "savvy" in the areas in which she was lacking. Searching led her to a representative from Minnesota Project Innovation (the SBIR support organization in Minnesota at the time). The representative reviewed the failed proposal and provided both advice and support services to help this participant learn how to develop proposals that would gain attention from the SBIR program. Participant E says, "there are a number of things…we made mistakes." In this case it was the participant's second try with the same proposal. More time and effort were put into the proposal responding to the reviewers' comments; and the proposal came back with even a lower score than the first attempt. He was convinced the idea had merit and decided his company needed help on this one, and brought in a consultant with extensive experience working in the SBIR program. In-depth discussions with multiple parties led to a discovery that the application had been reviewed by the wrong committee. The problem was not easily identified nor changed but through interactions with people at higher levels within the federal agency itself, the proposal was reviewed a third time by a different committee, one with expertise in the field of the technology. "I was ignorant of this but the right review committee can make a difference of life or death to an idea." In this case and with the right review committee the idea received both Phase I and Phase II awards. Instead of losing this technological advancement in the medical field, a new company was recently launched to bring the successful development to commercialization. And Participant B stated, "I screwed it up and it got kicked out…but

it was not the USDA's fault!" Based on the reviewers' comments, the participants went on to share their story of how they did not listen to advice they received from collaborators on the importance of grabbing the review committee's attention on the first page.

Participant B shared perspectives on the perceived bias the review committee and the SBIR system have, "it really favors educational research institutions." Although they had a relationship with the University for a proposal submitted, Participant B felt the formal relationship was not communicated strongly enough because they did not receive the award. With the next round, they were successful in receiving an award with comments from the review committee emphasizing the value of the relationship between the small business knowledge of the marketplace and the University's scientific capabilities. In this case, the University scientists involved with the project wrote the technical section of the application.

The responses shared by the participants were reflective, yet matter of fact. There was no humiliation associated with the number of SBIR proposals submitted and not funded, nor did rejection deter any of the participants from applying again and again, "because there is learning that can be taken away from each effort" (Participant D). Four of the six participants applied three or more times before they were successful in receiving their first award. Consequently, the participants gained knowledge about the SBIR program through what they describe as a trial and error process. While the learning was not linear, the next section provides a list that synthesizes what the participants learned.

What Participants Learned: Advice for New SBIR Applicants

The participants of this study were asked what advice they would have for entrepreneurs with a good idea and who appeared to have the skill base necessary to participate in the SBIR program. The following section is a synthesis of the participants' perspectives:

General Advice

- Participating in the SBIR program takes a tremendous amount of time and resources, both financial and human.
- It is very difficult to run a business on grants alone. "Watch the cash, watch the money all the time; people don't like hearing that their paycheck's not going to come so it's maintaining a stable environment for employees."
- Know the agency requirements for the specific program for which an application is being written. Each agency has different requirements and formats. There is not one template that meets all agency requirements.
- Get out there and learn about the program anyway possible, i.e., web searches, review the documented rules and specifics, ask questions of people who have been involved.
- Target both the appropriate federal agency and the topic.

Preparation (before writing anything)

- Critically analyze funded and not funded grant proposals from the government agency where the application is being submitted. The process for reviewing the archived proposals essentially means going paragraph by paragraph and

learning what the reviewers liked and what they did not like—get into the details.

- Make sure the information reviewed is current—there are volumes of dated material in the database. Using dated information for a template can prove a detriment in the end.
- Conduct patent searches and literature reviews in the field the technology falls within. The applicant must be able to address the current state of the art and demonstrate that they are in the best position to conduct the research and development being proposed.
- Communicate with the SBIR agency early in the process. Explain the research and development project and be able to address questions that will arise. Listen to the representatives' questions carefully as they may provide recommendations on how to present the topic in a manner that would receive more favorable results.
- It is not uncommon for a solicitation to be the result of a relationship between the federal agency and a small business. Develop the relationship.
- Plant seeds with the ideas early and often, telling the story and listening to colleagues, collaborators, potential customers, and federal agencies. The process is interactive and developing a good proposal evolves as the story is told and built upon based on multiple sources of input. Allow time to solicit and incorporate input.

Administrative Processes

- Each small business must register with the federal government to be able to submit a proposal for any SBIR grant. It is a tedious, time consuming process. Consider submitting a blank grant proposal to www.grants.gov months before the submittal due date to allow time to confirm all the necessary pieces.
- Recognize that the grants.gov process is one piece of the registration; there may be separate requirements for the federal agencies where the SBIR proposal is being submitted.

Pulling Together the Team

- Entrepreneurs from academia understand the value of collaborators; they know their field and who the players are and how to write a grant. The entrepreneur engineer that comes out of industry may not know anything about academics but knows how to build a business.
- Consider the gaps in the capabilities of the team. Go beyond the structure of the small business as up to 30% of work can be subcontracted to outside entities for SBIR projects.
- Communicate any formal relationship with collaborators. Do not assume the reviewers will connect the dots.

Putting the Application Together

- Writing

- Address how the idea meets the agency's mission better than anything else for a specific topic. This includes how it stacks up with the current method or accepted industry standard.
- Learn how to focus the topic, position it, and what to say upfront to grab the reviewers' attention in the first page of the application.
- Know the audience or reviewers.
- If using a technical writer, look for expertise in the technical field and experience in grant writing to federal agencies.
- Use clear, concise writing. Answer the questions. Do not make the reviewers have to work to figure out what is being proposed.
- Follow the format supplied in the application instructions in great detail.

- Technical Presentation
  - There is value in providing preliminary data, even though it is not required.
  - Provide adequate scientific detail to describe the experiments and justify why the experiments are necessary for success.
  - Clearly articulate how the team has the technical capacity to conduct all aspects of the research and development. Document credentials and the formal relationship.
- Commercialization
  - Emphasis is placed on commercialization of the technology. Think through and develop a solid commercialization plan.

- "Best idea on the planet is going to be worthless if you can't sell it, if you can't market it, if you can't package it in a way that will address the problem in the marketplace."

Submittal Advice

- Allow time in the submittal process for a review internally and by a third party. Proposal should be good writing, be grammatically correct and look professional. Incorporate any feedback received from the topic author.
- Quadruple check the submission details of the application.
- Do not attempt to make an agency contact once the application is submitted. Contact after submission can compromise your application and the agency officials.

Miscellaneous Input

- Unsuccessful application—no such thing—take time to learn from reviewers' comments.
- The best way to learn how to navigate the SBIR program is through experience or the school of hard knocks, along with a mentor with considerable experience to help with the process from day one.
- The SBIR program is one of several funding mechanisms for technical entrepreneurs. Consider research and development funding from customers, joint ventures, and support from federal agencies independent of the SBIR.
- Credibility of the principle investigator and other team members may be as important as the scientific merit of the idea.

Summary

During the conversational interviews for this study the six participants reflected on their becoming aware of and learning how to navigate the SBIR program. They had a difficult time separating what they learned from how they learned. However, a consistent thread in all of their stories was a confidence in their idea. While there were mixed perspectives about their belief in receiving an SBIR award, their actions were driven by confidence in the idea. Through a trial-and-error process, the participants described as doing it, they gained knowledge that could not have been gained by reviewing the written rules. There were stories about the importance of developing the idea and support, developing and submitting the SBIR proposal, and reflection and learning related to outcomes. They reflected on the dynamics of the SBIR program, such as each federal SBIR agency (11 of them) having their own mission, submission rules and procedures, topic authors, topics, and program managers. They learned the players changed with each solicitation, not only the topic authors and SBIR program managers but also the applicants—capabilities and ideas—which the participant was competing against. Success with one application does not guarantee success with the next one, with statistics showing the probability of a successful award being less than 15% of all proposals.

The participants' stories highlighted a reflective practice within their organization when they had confidence an idea had both a utility for society and an economic value to the small business. The participants' illustrations revealed entrepreneurs who have an intellectual capacity to generate: ideas that meet a national need; support from collaborators, SBIR program managers, topic authors and customers; and, an application

that articulates the scientific underpinnings of the idea, the capability of the research team, and why this research and development proposal merits the SBIR award more than competing applications. They had an indestructible belief in themselves and their ideas. Their optimism and therefore positive approach to what others might perceive as failure caused them to take more action—which led them to people, connections, and relationships.

Chapter Five: Summary of Results and Discussion

This chapter discusses the results of this study in the context of the literature reviewed, and adds supplemental literature based on the findings. In addition, educational implications for future applicants of the SBIR program are discussed as well as implications for economic development professionals interested in developing an infrastructure to increase participation in the SBIR program within their region or state. Finally, recommendations for future research are provided.

Discussion

A quote by Sir Winston Churchill (1874-1965) eloquently captures the essence portrayed by the participants in this case study, "success is the ability to go from one failure to another with no loss of enthusiasm" (http://www.quotationspage.com). The emphasis is not on failure but instead is on the actions and learning processes of the participants. The idea was the impetus that set into motion a complex web of interactions. The following section will overlay the results of this study with the literature review within the domain of intellectual capital and ESE, networks, and knowledge spillover.

Intellectual Capital and ESE

Intellectual capital literature covers three different areas and includes human capital, social capital, and organizational learning. All three areas were key factors for the participants in this study and cannot be looked at individually, but instead systemically. Without one, there would have been a breakdown in the learning described.

As stated earlier, human capital refers to the knowledge and skills that reside within the individual (Audretsch & Keilbach, 2004; Carmona-Lavado, et al., 2010;

Wright, Hmieleski, & Siegel, 2007). The participants were highly educated individuals with bachelor, masters, and doctorate degrees in chemistry, multiple disciplines of engineering, psychology, and business administration. Their experience ranged from working for other private companies as employees, a public university as professor and students, co-founders of multiple companies prior to the participants' existing SBIR companies, and public health services. All participants described prior experience as a foundation for their initial ideas, business ventures, and knowledge of markets, customers, and collaborators. Some of the participants referred to previous experience providing a basis for understanding how to navigate federal programs and write grant proposals.

Another dimension to human capital which supports the findings in this study is Coleman's (1988) concept of the individuals' knowledge and abilities that allow for changes in action and economic growth. The changes in action included the participants' ability to adapt their ideas based on interactions with people whom they sought out for advice and knowledge (social capital), whether it was related to the idea, the necessary capabilities of the team, or specifics of writing the actual proposal. The change in economic growth occurred when they transformed the information they acquired (Kolb, 1984) into knowledge of the SBIR program and how to develop relationships that resulted in gaining resources to conduct the research and development for their idea (Kim & Aldrich, 2005). The ideas were the impetus for the participants to take action; the action was the participants exploiting their previous knowledge and idea by telling their story and, exploring and learning from those that had knowledge of or power to influence

whether an SBIR award would be granted. Shane and Venkataraman (2000) explain knowledge diffusion and informed action are elements of the *exploitation* process of entrepreneurship, and in this study refers to the entrepreneur positively framing information around their idea to gain support for an SBIR award.

The ideas of the participants in this study were not described as individual "ah ha" moments but instead were the result of developing their human capital over time and space, and as Argyris (1990) believes, the process was dynamic and characterized by information flows with feedback loops, bringing in the organizational learning aspect of intellectual capital. When reflecting on the six participants' stories, what surfaced was a continuous learning process; although they felt a commitment to their idea, their interactions with others caused the participants to morph their idea in a manner that would gain support from the SBIR program manager, topic authors, collaborators and potential customers. The tie to the original idea was only in how the idea aligned with the strategic vision for their company; this was the platform in the participants' decisions on which solicitations to go after, what agencies to talk with about their ideas, and who potential collaborators might include.

Months of prior research and interactions occurred before the participants went through the effort of putting a proposal together. If they did not receive an SBIR award for the submitted proposal, the participants did not respond with blame, negativity about the process, or general excuses as to why the award was not granted. Instead, they analyzed the reviewers' comments to determine what further action should be taken, even though the comments were not always considered helpful. The participants were open to

feedback that challenged the assumptions that went into their proposals (Argyris, 1990). They were open to learning in all aspects of their business, with accessing SBIR program dollars being a small part of the whole picture. To illustrate, Participant F asked to be provided with a copy of this final research report because, "we are just going through that process to say, how are we doing internally with SBIR's and other government programs and what can we do differently to maybe improve our success rate." This participant enjoys a 25% success rate with SBIR Phase I awards and near 100% success rate with SBIR Phase II awards—a significant fact when the overall average success rate is roughly 12% for all applications submitted.

Huber (1991) defined learning organizations as having the ability to recognize and develop new knowledge or insights that have the ability to influence behavior. The SBIR program is about research and development—providing financial support for an idea that meets national needs. But it really is not as simple as having an idea. For the participants, learning how to navigate the SBIR program was not a step-by-step process, it was "not just a skill or a cognitive process that can be described and then learned" (Van Manen, 1997) by any entrepreneur looking for a grant to advance the research and development of an idea. Yes, there were written policies and procedures for applying that the participants reviewed, but this did not provide the participants with the knowledge or insights in learning and understanding the whole process involved. It was not that simple. The written rules did not provide the participants with insights on what to do when a proposal was reviewed by the wrong committee (or how to figure out it went to the wrong committee), how to put the right team together, how to tell their story and adapt

the ideas, the importance of having face-to-face interactions with the SBIR program manager, or the problems one can encounter during the administrative process. More importantly, there was a breadth and depth of human capital development that provided the participants with grounding before they entered the SBIR arena. The participants did not let the fear of failing stop them from taking action. It was as if the word failure was a challenge to rearrange the pieces to see if there was a way to change the odds. But they also knew how to let go—when not to continue pursuing an idea that did not receive support from their peers or SBIR review committees.

Intellectual capital—human, social, organization learning—served as the thread woven through all other aspects of the participants learning how to navigate the SBIR program. While much of the literature teases out individual aspects of intellectual capital, the results of this study show all three of the factors were intertwined and could not be separated. Further, the development of intellectual capital was linked to ESE and influenced the participants' confidence in their ability to succeed at getting an SBIR award, as described next.

Bandura (1994) defines self-efficacy as "people's beliefs about their capabilities to produce designated levels of performance that exercise influence over events that affect their lives" (p. 71). What was evident with the participants were high assurances in their capabilities which allowed them to approach the complexity of learning how to navigate the SBIR program as something to be mastered rather than avoided. Evidence from the participants included the following about their beliefs: they had received one before, they saw someone else get one (if he can do it, so can I), and being convinced by

credible people (in this case both collaborators and federal agency personnel) that it was possible. This finding supports the importance of a state establishing a network with role models in varying fields and experiences to technical entrepreneurs if they are interested in increasing both the number of SBIR applications submitted as well as success in receiving SBIR awards.

Another interesting finding demonstrating ESE was how the participants dealt with what some people would perceive as failure or set-back. Not receiving an award did not diminish their ESE. Bandura (1994) indicates people with a "strong sense of self-efficacy attribute failure to either insufficient effort or deficient knowledge and skills which are acquirable. They also heighten and sustain efforts in the face of failure" (p.71). The participants did not perceive a non-reward as a reflection on their idea in its entirety but rather how to better communicate their idea and modify the application. Modification of the application required additional effort and communication with collaborators, which leads to the discussion on networks and the knowledge spillover from universities.

Networks and Knowledge Spillover

Additional literature searches on networks support what the participants described as they talked about learning how to navigate the SBIR program. Anderson, Park, and Jack (2007) describe the complexity inherent in the concept of a network as:

> …an operating medium through which resources are articulated, obtained and exchanged…individuals can only draw on the social capital that resides within a particular network by being part of that network, either directly or indirectly….The network facilitates the interaction. Thus, networks of connected individuals can

> apply the social capital present in the network to unlock or gain access to other resources. Seen this way, social capital is more akin to a key rather than the resource itself. Consequently social capital is a network phenomenon. Furthermore, it resides in the network as connections and interaction that take place between individuals. (p. 264)

The participants utilized all four networks identified by Hoang and Antonicic (2003) as informal (shared experience), project (short-term based on project), regional (spatial), and business (intentional alliances). The participants expanded beyond the boundaries of their organization when putting together a team that would lend credibility to their SBIR proposal, something they learned was important as they navigated the SBIR program. In general, the participants did not refer to networks but instead referred to relationships. For example, one participant emphasized over and over that business in general and the SBIR programs specifically are all about relationships. Relationships were at the intersection of every action taken by the participants.

The university connection was one of the resources within the participants' network described as having value. Three of the participants obtained knowledge--spilled over--from the university through exclusive license agreements for technology. At least originally the knowledge these three participants accessed was the result of knowledge developed at the university rather than a direct research and development investment by their company. For example, Participant C licensed a technology from a university that had been in the research and development phase over a 15 year period of time with two professors and federal funding. Further, some of the participants talked about tapping into

knowledge from universities by subcontracting for technological experience that did not reside within their company.

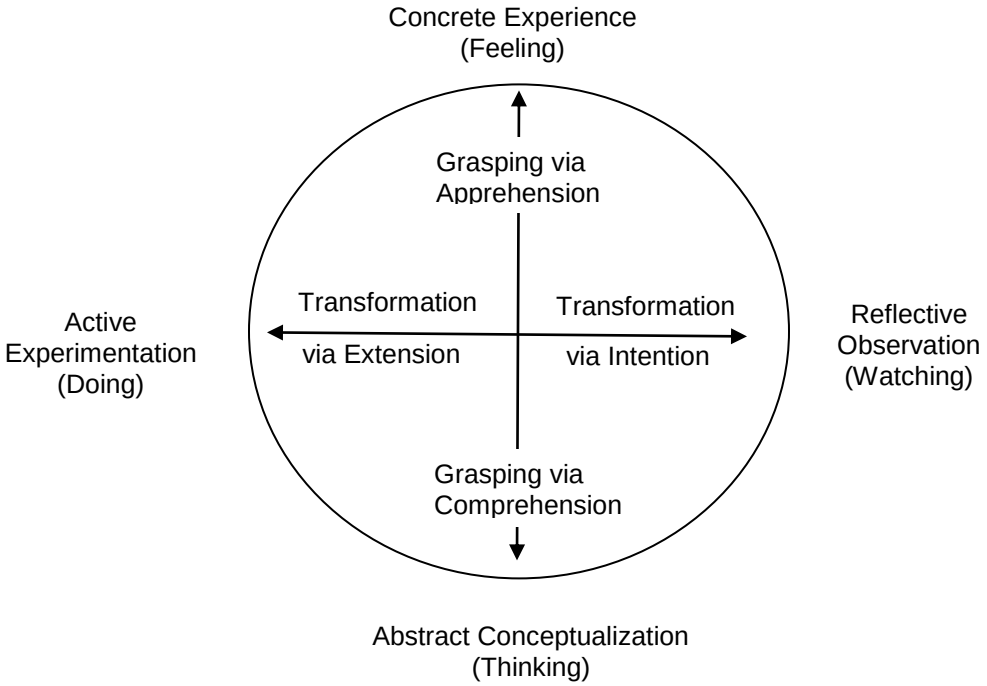
Intellectual capital, ESE, network, and knowledge spillover were relevant theories when analyzing the data for this study. The participants' stories reflected the importance of these factors, but that was not how they described their learning. When asked how they learned to navigate the SBIR program, all participants indicated "by doing it." Thus, the next section provides a review of experiential learning theory.

Experiential Learning

Kolb (1984) summarized the characteristics of experiential learning theory by offering a definition of learning as "the process by which knowledge is created through the transformation of experience…being continuously created and recreated" (p. 38). Kolb's theory acknowledged ties to the work of William James, John Dewy, Kurt Lewin, and Jean Piaget and described experiential learning as "a holistic integrative perspective on learning that combines experience, perception, cognition, and behavior" (p. 27). There are two dimensions of Kolb's model, acquisition (grasping information) and transformation (information into knowledge). The model uses a circle metaphor with the acquisition dimension including concrete experience (twelve o'clock) and abstract conceptualization (six o'clock) being diametrically opposed and the transformation dimension including active experimentation (nine o'clock) and reflective observation (three o'clock) also diametrically opposed (Figure 1). Kolb goes on to explain the learner's cycle through all four activities in the learning process and labels various combinations of acquisition and grasping as accommodator (concrete experience and

active experimentation), diverger (concrete experience with reflective observation), assimilator (abstract conceptualization and reflective observation) and converger (abstract conceptualization and active experimentation).

Figure 1. Kolb's Model of Experiential Learning



Adapted from *Experiential Learning: Experience as the Source of Learning and Development* by A. D. Kolb, 1984, p 42. Reprinted with permission.

Corbett (2002) expands on Kolb's model by examining experiential learning within the context of opportunity identification and exploitation to understand the process of entrepreneurship. He cites the literature about theories of learning falling within three broad categories (behavioral, cognitive, situative) and argues experiential learning theory is cognitive and situative because "individuals transform (using cognitive properties) their experiences (situative) into new knowledge" (p. 483). Corbett (2002) juxtaposes Kolb's model of experiential learning with Lumpkin, Hills, and Shrader's (2004) model of opportunity recognition and exploitation process of entrepreneurship which identifies

the opportunity recognition portion of the entrepreneurial process as having four active steps of preparation, incubation, evaluation, and elaboration. Transposing the two models illustrates the importance of understanding learning as part of opportunity identification and exploitation (Corbett, 2002). While Corbett (2002) primarily focuses on opportunity identification in the entrepreneurial process, the element that aligns with the results of this study is about exploitation process of entrepreneurship, i.e., why individuals with the accommodative learning styles (concrete experience and active experimentation) excel—because they are doers! Kolb (1984) describes the greatest strength of accommodators, "lies in doing things, in carrying out plans and tasks and getting involved in new experiences" (p. 78). Kolb, Boyatzis, and Mainemelis (2001) analyzed previous research on experiential learning theory and learning styles, with the diverger, assimilator, converger, and accommodator described above being considered basic learning styles. One learning style is developed and the other three underdeveloped, depending on a learners preference. When a learner's orientation integrates at least two learning styles, second- order learning occurs. Third-order learning styles are balanced and effectively integrate the abilities associated with all four learning modes. Kolb, et al., (2001) state not much is known about the second- and third-order styles because few related empirical studies have been systematic in their approach. Of interest to this study is Kolb's (1984) description of the person in basic, second- and third-order styles and how the participants in this study align. Learners using basic learning styles are described as being immersed in the world. Learners falling in the second-order learning styles are described as interacting with the world. Finally, learners using third-order learning styles are described

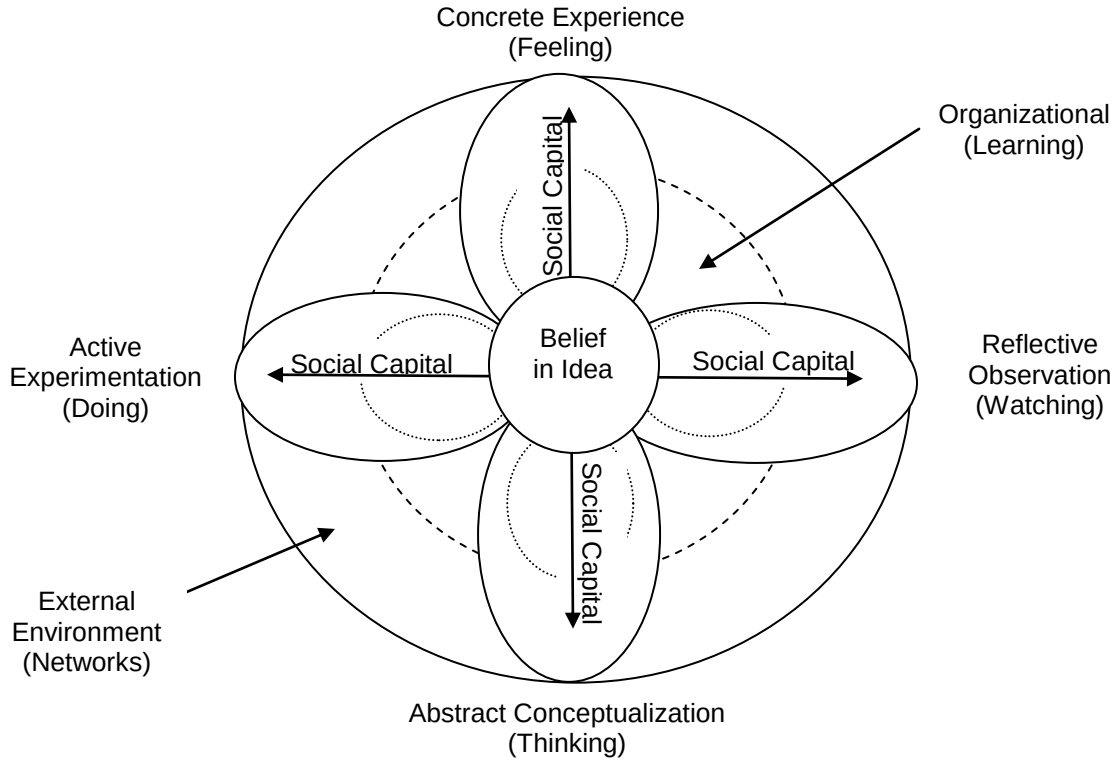
as process orientated or transacting with the world. The participants definitely fell within the third-order learning style. The next section will demonstrate how Kolb's (1984) experiential learning model could be adapted to include intellectual capital, ESE and networks to provide a more complete picture of how the participants became aware of and learned how to navigate the SBIR program.

Exploitation related to the entrepreneurial process of starting a business may be slightly different than the exploitation process the participants of this study go through when taking actions to learn how to navigate the SBIR program, whether it is the first time or one hundredth time. They are exploiting their idea to those who potentially can help them or have control of financial resources, the resources necessary to go from the idea (opportunity recognition) to the commercialization phase. Kolb's model of experiential learning and Corbett's further contributions overlaying experiential learning with the entrepreneurial process provide a basis for additional research on experiential learning and the exploitation phase of the entrepreneurial process. A piece that Corbett (2002) fails to tease out in his analysis, although he references the work of Kolb et al., (2001), is whether success as an entrepreneur is the result of being a third-order learner and having the ability to transact with the world by capitalizing on all learning modes. However, he does indicate that because people tend to favor one learning mode over another it is better to have a team of people and make sure all learning modes are present so all tasks are performed well.

Stevenson et al. (1985) identified four entrepreneurial activities that are necessary in creating a new company and include searching, planning, marshaling, and

implementing. While one of the six participants was a new start-up company, the remaining five participants have been in business for ten years or more, yet they described their process of learning how to navigate the SBIR program involving the same activities, although in a slightly different manner. Kolb (1984) described experiential learning as a process where the learner enters the cycle anywhere, depending on their learning preferences but the learner cycles through all modes in a circular manner. The participants described a messier process as they learned and continue to learn how to navigate the SBIR program. Learning was not necessarily sequential in nature and perhaps could be visualized more as a figure eight or as petals on a flower with the center being belief in their idea which also represents the participant or individual learning (Figure 2). The next layer of the circle is the organization, and the outer layer is the environment. One petal represents each of the learning modes, concrete experience, reflective observation, abstract conceptualization, and active experimentation. The participants were searching for the financial resources needed to develop a proof of concept and if successful, the funding for development of their ideas. Both human capital and social capital were utilized as they looped between the accommodator (concrete experience with active experimentation) and the converger (abstract conceptualization and active experimentation) modes as they learned about the program, shared their ideas, and sought collaborators. This is reflected in the emphasis that the participants placed on the importance of talking with people through the various stages, from understanding how the program works, to telling their story in order to garner support. At times the

Figure 2. Role of Intellectual Capital, ESE, and Experiential Learning in Learning How to Navigate the SBIR Program



Adapted from *Experiential Learning: Experience as the Source of Learning and Development* by A. D. Kolb, 1984. Reprinted and adapted with permission.

transactions or acquisition of information is between the participant and their organization and other times it is between the participant and the external environment. However, reflection was a continuous piece of their grasping, not as separate as what Corbett (2002) posits. The participants did not just go out and talk with people and then change their idea based on what was said; instead, reflection was constant. Transformation was doing, but within the doing was reflection. Having said that, there were times where the reflective observation was more dominant and the participants stopped the active experimentation with regard to social exploitation of their ideas; for example, when the participants moved to the phase of proposal writing, their

actions were indicative of looping back and forth from the diverger (concrete experience and reflective observation) and assimilator (abstract conceptualization and reflection observation) in order to articulate what they learned in a written document which cycled back again to doing. If the application was not funded, the participant analyzed the reviewers' comments and had conversations with collaborators on what, if anything should be done for another submittal, demonstrating a strong sense of ESE. The participants described adaptability and flexibility in integrating a learning style appropriate to the situation at hand as they navigated the SBIR program, which Kolb (1984) refers to as a third-order learning style. Figure 2 is provided as a visual representation of the participants' learning for simplicity. But in reality, as the participants looped back and forth from acquiring and transforming information into knowledge, the lines would not follow the same path as learning was taking place, but would instead expand, grow, and spiral. The same would hold true at the organization and external environment level. In other words, if Figure 2 were set into motion, there would be an expansion and movement of the images as a system of knowledge flowing among and between all players.

Practical Implications – State Support Valued by Participants

As the participants shared their process for learning to navigate the SBIR program, they shared their thoughts on the support they valued most which primarily came from a previous organization that existed in Minnesota called Minnesota Project Innovation. From their descriptions, the financial and human resources available to support their learning were beyond what may be available today. Support valued by the

participants included: presentations from government agencies about their particular branch of government, testimony from participants of the SBIR program, and consultants who assisted with writing and reviewing proposals. Although the State of Minnesota's resources are not the focus of this research, Minnesota Project Innovation is mentioned because four out of six participants referenced this organization when describing how they learned to navigate the SBIR program.

The concrete skills identified as being of most significance for entrepreneurs interested in learning to navigate the SBIR program were described as technical writing and market research. Participant A stated, "even though I have experience in federal grant writing, for newcomers who are not familiar with the process, they need a specialist with experience." While there was belief a technical writer would be of value, the participants also cautioned an entrepreneur has to have "skin in the game." Furthermore, even though a technical writer might have experience with grant writing, they may not have experience or education in the field of technology that a proposal is being written about—the entrepreneur has to be involved. Participant B elaborated on support they received when invited to apply for a Phase II with the US Department of Agriculture. This agency contracts with Purdue University to assist the participant with a commercialization plan for Phase II applications. The support included webinars to understand the components of a commercialization plan and a review of the plan once it was written by Purdue's MBA students. Participant E indicated the school of hard knocks in combination with an SBIR experienced mentor could help applicants with learning by doing while also learning from other's experience.

What can federal, state, and regions do to enhance the capacity of their networks to support technological entrepreneurs in learning how to navigate the SBIR program and have greater success in receiving awards? The findings of this study would suggest establishing an infrastructure that intentionally facilitates interaction and knowledge flows, not just within the boundaries of a metropolitan area but throughout the state and nation. Proximity made a difference for the participants as they described the personal conversations that contributed to their learning. While the SBIR is a national system, there is a concentration of SBIR firms in a handful of states. Can the federal government facilitate a more level playing field across the nation by providing more people resources to facilitate a wider representation of participation?

One last point, some of the participants discussed the importance of the academic infrastructures and business climate in states more successful in accessing the SBIR program. The state hires hundreds of people in academia, "universities should be front and center in providing support to entrepreneurs," says Participant B. The sentiment was expounded upon by another participant who cited statistics that demonstrate the return on investment for small business innovation technology programs are significantly higher than innovation from university research laboratories. Can universities, which receive federal and state support through tax dollars, play a more prominent role in supporting entrepreneurs with team and proposal development?

Educational Implications: Teaching and Learning for Innovation

The findings from this study contribute to the literature with regard to the role played by all aspects of intellectual capital in the learning process. While the science,

technology, engineering, and math (STEM) education provided a foundation for the participants, “one kind of knowledge, namely, scientific knowledge, occupies now so prominent a place in public imagination that we tend to forget that it is not the only kind that is relevant” (Hayek, 1945, p. 522). Human capital is recognized and measured in the United States through many different mechanisms, but the importance of social capital and organizational learning receive less attention. Intellectual capital as a whole system served as the nexus for the participants in this study to exploit and adapt their idea during a process the participants described as learning by doing. There was interplay between cognition, behavior, and environment (Chen, et al., 1998). Doing was active in the present tense, not about past experiences. Success or failure resulted in a process of reflection and feedback or what they learned and what they could take away from the experience. Learning was not in isolation but was a social interaction that resulted in subsequent action. There was never really a right or wrong mentality. All three pieces of intellectual capital were integral to the participants’ learning how to navigate the SBIR program and also played a role in the participants perceived ESE in their confidence to succeed at getting an SBIR award.

Based on the results of this study, how can our education system prepare technological entrepreneurs across the United States and particularly in Minnesota to take part in the national innovation system? The literature is extensive on the importance of interactions and knowledge flows for innovation. There is a push at the federal level for more support of STEM programs to compete globally and remain competitive. But one without the other does not result in success, “because the best idea on the planet is going

to be worthless if you can't sell it, if you can't market it, if you can't package it in a way that will address a problem in the marketplace" (Participant F). The bridging concept is a system approach to teaching and learning, the classroom is the learning organization which encourages interaction and knowledge flows to challenge our assumptions while developing human and social capital. How do we transform our teaching and learning to a system that intentionally takes into account all three aspects of intellectual capital in developing a strong sense of efficacy for its students? Ideologically, through a system which does not define failing, unless failure is measured as learners no longer having interest in taking action.

Second, experiential learning has received more attention in the early 21st century (Audretsch & Keilbach, 2004; Corbett, 2005; Politis, 2005) in relation to understanding the entrepreneurial process. A vast amount of the literature has focused on opportunity recognition and also looks at intellectual capital individually rather than as a whole system, i.e., human capital and entrepreneurship, social capital and opportunity recognition. The participants demonstrated a strong sense of self-efficacy in how they reacted to success or failure in receiving an SBIR award. They described a process where they looped between learning modes to create a better application based on input from reviewers as well as collaborators or what Kolb et al., (2001) refer to as a third-order learner. Self-efficacy is important for persistence and can be enhanced through education (Bandura, 1994) as found in this study, through role models and suggestions from credible others. There is a gap in the literature with regard to a systemic approach for

research that studies all aspects of intellectual capital, ESE, experiential learning, and the entrepreneurial process, especially related to the exploitation process of entrepreneurship.

Recommendations for Future Research

Access to networks with capacity to support potential SBIR small businesses was critical to the participants learning how to navigate the SBIR program. Interactions with people were the primary method in which they acquired information and learned the various components of putting together a solid SBIR proposal. When they were asked how they learned, just "doing it" seemed to describe best their process, in the absence of any formalized guidance about navigating, interacting, networking in general or specific. From this study, further research could be conducted on how the network structure varies in a state with minimal success with the SBIR program in comparison with one of the handful of states that receive over 50% of all SBIR awards on a continual basis. What role do the various actors play in knowledge diffusion that could contribute to their states' success? Further, how do universities and federal laboratories in those states interface with the small business entities?

The SBIR program is a dynamic system with a myriad of players from both the public and private sector. Studying entrepreneurs while they are navigating the SBIR program would provide a perfect backdrop for more in-depth research on intellectual capital development and the acquisition and transformation of experience into knowledge (Kolb, 1984) for the exploitation phase of entrepreneurship. Kolb has developed what is called a Learning Style Inventory (LSI) which could be utilized to understand whether

there is a link between entrepreneurship and third-order learning or the ability to balance and develop all four modes associated with the experiential learning theory.

Additional questions to explore include a topic specific to the state of Minnesota—how can this information be transferred to potential SBIR companies to help bridge the gap between the complexity of the policies and procedures with what it actually takes to develop a good proposal? Also, 150 miles north of where only a handful of Minnesota's 265 SBIR companies reside, how can the University of Minnesota Duluth develop a network to increase SBIR proposal generation for the innovative capacity in its region? Could Minnesota as a whole develop more successful applications if a network of credible mentors was available across the state? Recently Minnesota hired an additional support person to serve as a liaison for the SBIR program (2010) and is now offering a webinar on developing an SBIR application by the same expert referenced by Participant E. Monitoring the results of providing the additional people resources could gauge whether the investment by the state equates to more success and what additional support to provide.

Conclusions

The focus of this study was the entrepreneurs' perspectives on learning about and how to navigate the SBIR program. The research was designed as a qualitative case study using grounded theory methodology. The results are an interpretation of the participants' lived experience (Van Manen, 1990) as they reflected on their stories primarily about what they learned. Descriptions of how they learned were summed up with the phrase "doing it." The impetus for their learning was belief in an idea that resulted in them

taking action—this is what the participants refer to as doing it. They presented their idea through a storytelling process. If they were persuasive enough, they developed a relationship with someone who was willing to provide guidance without a fee. They kept telling the story, reshaping the idea(s) based on bits and pieces of information they acquired through interactions with people who would take the time to informally teach them through conversations. The participants used every relationship they thought would provide value to strengthening their ability to receive an SBIR award. They acquired the information through actively gathering information and transformed what they learned through the experience into a solid SBIR proposal.

In summary, the learning the participants described—what it was and how it was acquired—was a continuous, interactive process because the SBIR program is dynamic, with the world changing and players changing every round of solicitations. What the participants learned about the process today will help guide them for the next idea; however, tomorrow is a different day, with different SBIR program managers, topic authors, national needs, and entrepreneurs generating ideas. Success with one applicant does not guarantee success with another one.

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Appendix A - Internal Review Board (IRB) Approval

TO : jstrand1@umn.edu, psarvela@umn.edu,
The IRB: Human Subjects Committee determined that the referenced study is exempt from review under federal guidelines 45 CFR Part 46.101(b) category #2 SURVEYS/INTERVIEWS; STANDARDIZED EDUCATIONAL TESTS; OBSERVATION OF PUBLIC BEHAVIOR.

Study Number: 1010E91593

Principal Investigator: Pamela Sarvela

Title(s):

Becoming Aware of and Learning How to Navigate the SBIR Program: The Entrepreneurs' Perspective

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This e-mail confirmation is your official University of Minnesota RSPP notification of exemption from full committee review. You will not receive a hard copy or letter.

This secure electronic notification between password protected authentications has been deemed by the University of Minnesota to constitute a legal signature.

The study number above is assigned to your research. That number and the title of your study must be used in all communication with the IRB office.

Research that involves observation can be approved under this category without obtaining consent.

SURVEY OR INTERVIEW RESEARCH APPROVED AS EXEMPT UNDER THIS CATEGORY IS LIMITED TO ADULT SUBJECTS.

This exemption is valid for five years from the date of this correspondence and will be filed inactive at that time. You will receive a notification prior to inactivation. If this research will extend beyond five years, you must submit a new application to the IRB before the study?s expiration date.

Upon receipt of this email, you may begin your research. If you have questions, please call the IRB office at (612) 626-5654.

You may go to the View Completed section of eResearch Central at http://eresearch.umn.edu/ to view further details on your study.

The IRB wishes you success with this research.

Appendix B – Consent Form

HOW DO ENTREPRENEURS BECOME AWARE OF AND
LEARN HOW TO NAVIGATE THE SBIR PROGRAM

You are invited to be in a research study of how Minnesota entrepreneurs become aware of and learn how to navigate the SBIR program. You were selected as a possible participant because you are an entrepreneur who has participated in the SBIR program either through an application and/or a SBIR Phase I and/or Phase II award. Please read this form and ask any questions you may have before agreeing to be in the study.

This study is being conducted by: Pamela M. Sarvela, University of Minnesota Duluth Doctoral Candidate and Business Development Manager for the UMD Natural Resources Research Institute.

Background Information

The purpose of this study is to understand from your perspective how you became aware of and learned how to navigate the SBIR program.

Procedures:

If you agree to be in this study, I would ask you to participate in a conversational interview which should take less than two hours. I will provide you with a list of my questions one week in advance of the interview to give you an opportunity to reflect on your answers as well as the ability to discuss the questions with anyone else either within or outside your organization that may lend depth or breadth to your perspective. If there are two or more entrepreneurs that were actively involved in navigating the SBIR program in your company, I will hold a joint interview regarding your organizations process, but will then interview each of you individually for more personal information, like formal education, work experience, etc. I will digitally record the conversation so that I am not distracted by taking notes. I may also follow-up with a phone call if I have further questions after transcribing the conversation. Once I have transcribed and interpreted our discussion in a written format, I will provide you with a copy to review and request modification or approval of my interpretation.

Risks and Benefits of being in the Study

The study has minimal risks – any risks are associated with confidentiality of proprietary business information. When summarizing the data I will use a coding technique so that the names of the interviewees are not identified. The likelihood of the interviewee's identity being revealed is minimal.

The benefits to participation may be minimal to you as the interviewee – but could provide the State of Minnesota and current and/or future entrepreneurs with an important understanding about how to go about participating in the SBIR program.

Compensation:

You will not receive any kind of payment for participating in this research.

Confidentiality:
The records of this study will be kept private. In any sort of report I might publish, I will not include any information that will make it possible to identify a subject. Research records will be stored securely; recordings will only be heard by the researcher and will be destroyed within two years of completion of the research.
Further, I will not disclose any proprietary data about your company or intellectual property or trade secrets and am willing to sign a separate confidentiality agreement if necessary.
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Voluntary Nature of the Study:
Participation in this study is voluntary. Your decision whether or not to participate will not affect your current or future relations with the University of Minnesota. If you decide to participate, you are free to not answer any question or withdraw at any time without affecting those relationships.

Contacts and Questions:
The researcher conducting this study is: Pamela M. Sarvela. You may ask any questions you have now. If you have questions later, **you are encouraged** to contact her at 5013 Highway 53, Duluth, MN 55811, 218-393-2619, psarvela@nrri.umn.edu. Or, you can contact Pamela's advisor, Joyce Strand at 218-726-7233, jstrand1@d.umn.edu.

If you have any questions or concerns regarding this study and would like to talk to someone other than the researcher, **you are encouraged** to contact the Research Subjects' Advocate Line, D528 Mayo, 420 Delaware St. Southeast, Minneapolis, Minnesota 55455; (612) 625-1650.

You will be given a copy of this information to keep for your records.

Signature of Investigator:_____Date: _____

Appendix C – Interview Protocol

1. In order to learn about the nature of your company, would you provide an overview of your company and position(s) within the company?

2. Before going on to the SBIR program specifically, would you share your experience with any federal, state, or local programs that you are aware of, how you learned about them and the steps that you took based on that knowledge.
    a. SBA 7(a) loan guarantees
    b. SBA 504 loans (long-term, fixed-rate financing for major fixed assets, such as land and buildings.)
    c. SBDC Training programs (entrepreneurship training, software, accounting)
    d. SBDC Consulting (business plan development, financial analysis, etc.)
    e. Other programs that you have pursued or explored, whether utilizing or not?

3. Moving on to the SBIR program, how did you learn about it and from whom?
    a. What decision making process did you go through to determine that the effort was worthwhile, what did you believe your chances of success were?

4. When you learned about the SBIR program, what are the circumstances that led you to apply for SBIR funding?
    a. What steps did you take along the way towards applying?

5. After the application was submitted, what did you do?

6. As you think back to the beginning, what do you think were the most important factors that were critical to your success in learning how to navigate the SBIR program?

7. Were there any paths that you went down that were not helpful? How did you learn about the step that turned out not to be helpful?

8. What role has the SBIR award played in the viability of your company?

9. If you were mentoring an entrepreneur who does not have experience with the SBIR program, what would be the three most important things that you would feel are critical for them to know?

10. Anything else that I haven't asked that you think is important for me to know?

Appendix C - Additional Information Gathered on Individual Entrepreneurs

Time of Interview:
Date:
Place:
Interviewer:
Interviewee(s):
Position of interviewee(s):

1. Please tell me about your professional background, including formal education, training, and certifications.

2. Please tell me about your work experience.

3. If not given, discussion on any family history with entrepreneurship, whether directly through immediate family or extended (grandparents, uncles)?

4. Is there anything in your individual experience that you would consider a critical piece for learning about and how to navigate the SBIR program? (i.e., education, mentors, networks, people)

Appendix D – Interview Protocol with Researchers Prompts

Time of Interview:

Date:

Place:

Interviewer:

Interviewee(s):

Position of interviewee(s):

1. In order to learn about the nature of your company, would you provide an overview of your company and position(s) within the company? (if not provided, information on originating idea for start-up, organizational structure)

2. Before going on to the SBIR program specifically, I would like to understand other federal, state, or local programs that you are aware of, how you learned about them (from whom?) and the steps that you took based on that knowledge (whether you pursued them or not).
    a. SBA 7(a) loan guarantees
    b. SBA 504 loans (long-term, fixed-rate financing for major fixed assets, such as land and buildings.)
    c. SBDC Training programs (entrepreneurship training, software, accounting)
    d. SBDC Consulting (business plan development, financial analysis, etc.)
    e. Other programs that you have pursued or explored, whether utilizing or not?

3. Moving on to the SBIR program, how did you learn about it and from whom? (Awareness: conducted own research for financial resources, referred to SBIR through colleague or network, read an article about program for success of someone else within the program, attended conference with exposure to SBIR program, experience with other SBA programs, knowledge spillover, intellectual capital, etc.)
    a. What decision making process did you go through to determine that the effort was worthwhile, what did you believe your chances of success were?

4. When you learned about the SBIR program, what are the circumstances that led you to apply for SBIR funding? What was the trigger that made you apply?
    a. what steps did you take along the way towards applying (how/why you took that step, looking for them to volunteer who gave them advice, suggestions, what they did with that info, etc),

5. After the application was submitted, what did you do? (Was there something that they did as follow-up that could have been part of the success?)

6. As you think back to the beginning, what do you think were the most important factors that were critical to your success in learning how to navigate the SBIR program? (experience with grant writing, experience with federal programs, support from MN DEED, SBDC, SCORE, relationships with others who have utilized the SBIR, just doing it, talking with administrators of the SBIR program, learning from applying and finding out what you did wrong, reflective, questioning assumptions, sharing information throughout the organization, keeping track of what's been learned in a systemic way and incorporating into new process, etc.)

7. Were there any paths that you went down that were not helpful? How did you learn about the step that turned out not to be helpful? (again, why and who lead you to pursue, not to pursue)

8. What role has the SBIR award played in the viability of your company?

9. If you were mentoring an entrepreneur who does not have experience with the SBIR program, what would be the three most important things that you would feel are critical for them to learn and how should they learn it?

10. Anything else that I haven't asked that you think is important for me to know?